Chapter 1
Introduction

1.1 Research Background

The Bretton Woods agreements, which were negotiated mainly between Britain and the United States and signed by forty-four countries in 1944, were extraordinary in the momentous reopening of the international economy, abjuring local currency and trade blocks in favour of a liberal multilateral system, and also making rules and building institutions for post-war monetary and financial relations (Ikenberry, 1993, p. 155). However, the Bretton Woods regime was not a fixed exchange rate regime throughout its history: the preconvertibility period (1946-1958) was close to the adjustable peg, and the convertible period (1958-1967) was close to a de facto fixed dollar standard. Finally, although the period since 1973 has been featured as a floating exchange rate regime, at various times it has experienced varying degrees of management (Bordo, 1993, p. 6).

Due to problems such as adjustment, liquidity and confidence the Bretton Woods system became less stable over time (Bordo, 1993, p. 28). After the formation of the two-tier agreement, the international monetary system was on a de facto dollar standard. The Bretton Woods system became increasingly unstable until it collapsed with the closing of the gold window in August 1971 (see Table 1.1). The accelerating inflation in the international economy resulting from the earlier acceleration of inflation in the United States triggered the collapse of a system, which was plagued by the terminal shortcomings of the gold exchange standard and the adjustable peg (Bordo, 1993, p. 74). The survey also indicates why the Bretton Woods system was so short lived. First were the two fatal drawbacks in its scheme: the gold exchange standard and the adjustable peg. Second was that the United States failed to keep steady price after 1965. Moreover, the other major developed countries were hesitant to follow US direction when it infringed upon their domestic pursuits (Bordo, 1993, p. 83).

Table 1.1: The collapse of the Bretton Woods system

Time	Events
1958 Dec.	Fourteen European countries start convertibility of their currencies for current account transactions
1959 Mar.	The Triffin plan proposed
1961 Mar.	Basle Agreement among central banks to hold each other's currency and to lend to each other
Oct.	Establishment of the London Gold Pool
1962 Jan.-Mar.	Start of persistent French gold purchases from the United States
Feb.	Beginning of the swap facilities to provide reciprocal lines of credit among central banks
Oct.	Beginning of the GAB
1963 Oct.	Start of technical studies and discussions that would lead to the establishment of the SDR
1965 Feb.	President de Gaulle and d'Estaing propose a return to the gold standard
1967 Oct.	End of persistent French gold purchases from the United States
Nov.	The United Kingdom devalues the pound sterling from US$2.80 to US$2.40
1968 Mar.	Gold Pool interventions end; the two-tiered market for gold begins
May	SDR amendments are sent to IMF members for approval
June	Exchange pressure on the French franc because of internal political crisis
Nov.	Exchange crisis closes markets in France, Germany and the United Kingtom
1969 July	SDR amendments are in force
Aug.	The French franc is devalued from .18 grams of gold per franc to .16 grams
Sept.	The deutsche mark floats
Oct.	The deutsche mark is revalued from US$0.25 to US$0.273
1970 Jan.	First SDR allocation
1971 Jan.	Second SDR allocation
May	The deutsche mark and the Dutch guilder float
Aug.	The United States suspends convertibility of the dollar into gold for official transactions, suspends the use of swaps, and imposes price controls and a 10 per cent import surcharge; all countries with major currencies except France start to float, impose exchange controls, and undertake major interventions to buy dollars
Dec.	In the Smithsonian Agreement, the G10 realign currency exchange rates in a revised fixed rate system; the United States agrees to devalue the dollar to $38.00 per ounce of gold; average devaluation of the dollar against other currencies is 10 per cent; dollar convertibility into gold by the United States was not restored, and the US made no commitment to support the dollar
1972 June	The pound sterling starts to float against the dollar
1973 Feb.	The dollar devalued to US$42.22 per ounce of gold; all major currencies therefore revalued against the gold dollar by 10 per cent
Mar.	After massive interventions by foreign exchange authorities, the system of fixed exchange rates collapsed into generalised floating

Source: de Vries (1976, pp. xviii-xxii, pp. 190-205), Pauls (1990, pp. 891-898).

Table 1.2: Treatment of disequilibria by pegging countries under the Bretton Woods regime

Policy options open to authorities in the pegging countries	Strong currency (Exchange rate would rise unduly above parity in the absence of official action)	Weak currency (Exchange rate would fall unduly below parity in the absence of official action)
1. Intervention in the foreign exchange market	a. If the dollar was strong, its rise in the market was checked by the dollar sales of the weak-currency countries b. If any other currency was strong, its rise in the market was checked by dollar purchases by the strong-currency country	a. If the dollar was weak, it was supported in the market by the strong-currency countries b. If any other currency was weak, it was supported by dollar sales by the weak-currency country
2. Exchange control or equivalent regulations	Controls on capital inflows	Controls on capital outflows
3. Adjustment via fiscal and/or monetary policy	Reflation, e.g. tax cuts, lower interest rates	Deflation, e.g. a tough budget, higher interest rates
4. Change of parity	Revaluation (as with the Deutsche Mark (DM) in 1969)	Devaluation (as with the £ in 1967)

Source: Tew (1997, p. 166)

During the gold standard period, foreign exchange rates were stabilised by gold. Domestic currencies could be changed into gold in transactions with domestic monetary administrators, and vice versa. Gold parities of individual domestic currencies indicated bilateral exchange rates. Monetary administrators should be ready to exchange gold at the stated parity according to the essential gold standard monetary rule (Giovannini, 1993, p. 125). The Bretton Woods system served fairly well until the early 1960s to assist national goals within an outline of orderly exchange-rate adjustment and increasing trade. Its plan proved progressively inappropriate with changes in the international economy during the 1960s; however, stability was damaged further due to a critical revision of the initial design of the two-tier gold market (Obstfeld, 1993, p. 247).

Exchange rates became more unstable after the collapse of Bretton Woods in 1971 (see Table 1.3). Table 1.3 compares the volatility of exchange rate changes in the Bretton Woods and flexible rate periods. The exchange rate changes are computed over three-month holding periods according to the maturity of the interest rates. The computations for the Bretton Woods period started whenever Eurocurrency rates first became accessible for that currency and concluded in January 1971. Table 1.3 displays that the standard errors of the exchange rate changes are from two to fifteen times bigger under flexible rates than under fixed rates. Notice that two of the exchange rates, the dollar/pound and the deutsche mark/dollar, have substantial standard errors even in the Bretton Woods period due to both currencies being realigned before 1971 (Marston, 1993, p. 516).

Exchange rate variability has been aggravated since the mid-1970s. Indeed, when exchange rates are largely unstable and close to being determined at random, much of the resulting exchange risk cannot be efficiently hedged. As a consequence, governments tend to offset such risk by enforcing quantitative restrictions, for example, import quotas on trade between currency regions. Because they protect the domestic economy from exchange fluctuations with lesser constraint on the trade volume, quotas are much more active than 'equivalent' tariffs for agricultural markets, 'voluntary' export restriction in automobiles and steel, market-sharing agreements in textiles and semiconductors, sliding-scale export subsidies and the like. Mainly due to exchange rate fluctuation among trading areas, the industrial economy reverted to this quite risky mercantilistic competition in the 1990s (McKinnon, 1993, p. 598). The advantage of floating exchange rates is to protect the domestic economy from foreign shocks, whereas the disadvantage is the lack of fixed exchange rate rules about inflation that monetary administrators can follow (Bordo, 1993, p. 6).

Table 1.3: Volatility of changes in exchange rates: standard errors of percentage changes (in %/annum)

	\$/£ Rate	DM/\$ Rate	Dfl/\$ Rate	SF/\$ Rate
	1961-1989	1963-1989	1962-1989	1963-1989
Bretton Woods period				
(to 1971)				
No. of obs.	118	97	109	97
Sample mean	-1.46	-1.19	-0.05	-0.08
Sample SE	4.57	2.64	0.76	0.8
Flexible rate period				
(1973-1989)				
No. of obs.	199	199	199	199
Sample mean	-2.6	-2.68	-2.04	-4.26
Sample SE	11.89	12.67	12.41	14.02

Sources: For the dollar/pound rate, Bank of England, *Quarterly Bulletin*; for other spot rates, International Monetary Fund, *International Financial Statistics*.

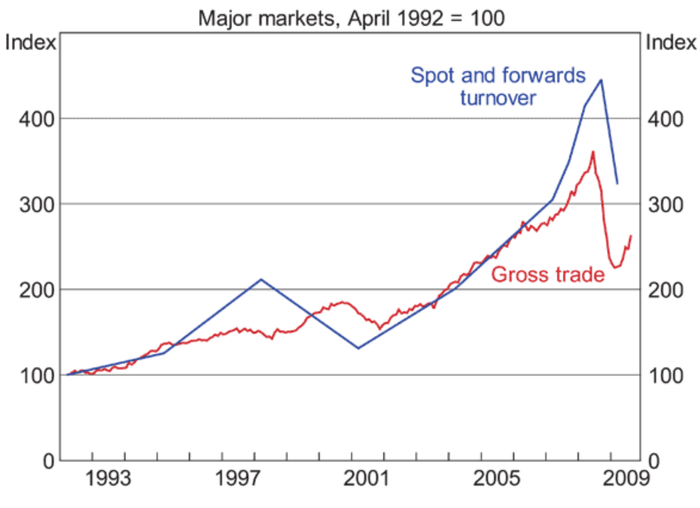
Note: The percentage changes in exchange rates have been calculated over three-month holding periods (since all interest rates used in the study are for three-month maturities), then annualised (Marston, 1993).

The Australian dollar was announced as the official currency in Australia in 1966. A noted feature of the performance of the Australian dollar since the float in December 1983 has been the increase in volatility—daily and monthly percentage changes in the AUD/USD bilateral rate and Trade Weighted Index (TWI) have doubled in size in comparison to the immediate pre-float period. However, the post-float experience is dominated by the high volatility resulting from the considerable exchange rate depreciations of 1985 and 1986 (Bureau of Industry Economics, 1991, p. 80). A second aspect of the recent performance of the Australian dollar is the question of whether it has demonstrated greater volatility than other currencies. Looking at relative exchange rate volatility experience in terms of bilateral rates against the US dollar, the Australian dollar emerges as having been somewhat less volatile since the float than four other important currencies (the Yen, DM, Pound sterling and New Zealand dollar). However, in the early 1990s, the real effective exchange rate of

Australia was much more volatile than that of the United States, Japan, Germany or the United Kingdom, though somewhat less volatile than that of New Zealand (Bureau of Industry Economics, 1991, p. 80).

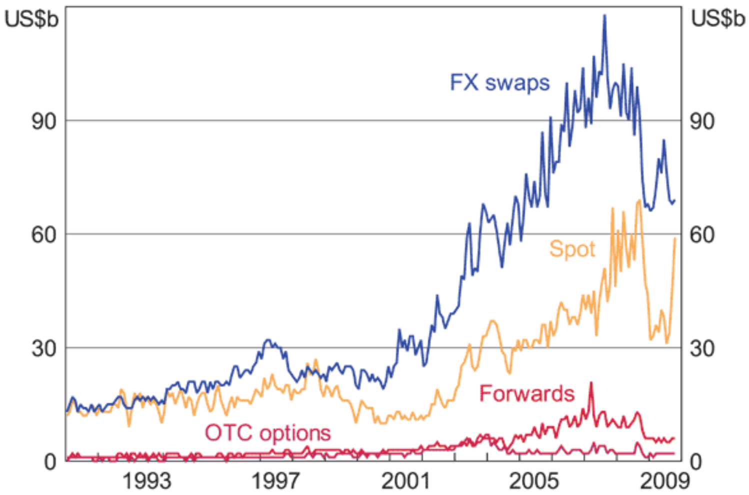
The greater short-term volatility of the Australian dollar after the float is likely to have expanded the risk associated with international trade, and displayed the need for firms to manage their foreign exchange exposure. Moreover, exchange rate volatility in the medium to longer term creates uncertainty which cannot be adequately hedged because importers and exporters cannot predict the magnitude and timing of all their foreign exchange transactions over an extended period. However, it is not clear that the floating of the Australian dollar has been linked with a rise in the longer-term variability of the exchange rate. This probably shows the fact that the Australian dollar is, to an important extent, a commodity currency—the world commodity price cycle has traditionally been the most important influence on long-term movements in the real exchange rate (Bureau of Industry Economics, 1991, p. 80).

Figure 1.1: Australian trade and foreign exchange turnover



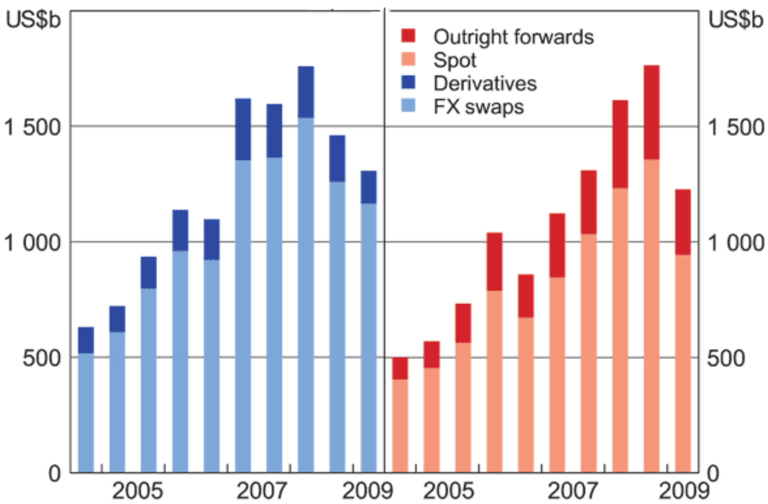
Source: RBA, 2012a, Foreign exchange committees, Thomson Reuters. www.rba.gov.au/speeches/2009/sp-ag-101209.html.

Figure 1.2: Australian foreign exchange turnover (daily average)



Source: RBA, 2012b, www.rba.gov.au/speeches/2009/sp-ag-101209.html.

Figure 1.3: Foreign exchange turnover by instrument (average daily turnover, major markets, April and October)



Source : RBA, 2012c, Foreign exchange committees, www.rba.gov.au/speeches/2009/sp-ag-101209.html.

The Australian foreign exchange market has grown rapidly since it floated in 1983, with average daily turnover growing from around $3 billion in late 1984 to about $70 billion by late 1990, and to roughly $300 billion by late 2010 (see Figure 1.1, Figure 1.2 and Figure 1.3). The volatile nature of the currency results in the Australian dollar being traded heavily. The Australian foreign exchange market, as a whole, is ranked as the seventh largest in the world in terms of global turnover, while the Australian dollar now ranks the fifth most actively traded foreign currency in the world, after the

US dollar, Euro, Yen and the Great Britain Pound Sterling, with the AUD/USD being the fourth most traded currency pair (ASX Group, 2012). The Australian foreign exchange market constitutes a considerable portion of all the foreign exchange transactions happening around the world. The reason behind the high volume of trading of the Australian dollar is its global recognition and high liquidity (Finance, Maps of World, 2012).

1.2 Research Problem

Exchange rates floated worldwide after the collapse of the Bretton Woods system in the early 1970s (see Table 1.4). Research both theoretically and empirically on the trade effect of exchange rate volatility has been an issue in international economics for the past forty years. From a theoretical point of view, the effect of exchange rate volatility on international trade is not unambiguous. On the one hand, it may be argued that a rise in exchange rate volatility increases the uncertainty of profits on contracts denominated in a foreign currency because this risk leads risk-averse and risk-neutral agents to redirect their activities from higher risk foreign markets to the lower risk local markets. On the other hand, higher exchange rate volatility and, therefore, higher risk represent a greater opportunity for profit and might increase trade (Égert & Morales-Zumaquero, 2008).

Table 1.4: The shift to floating rates

Country	Date float begins
British pound	June 1972
Canadian dollar	May 1970
Dollar floats	March 1973
Dutch guilder	May 1971
French franc	March 1973
German mark	May 1971
Italian lira	February 1973
Japanese yen	February 1973
Spanish peseta	January 1974
Swiss franc	January 1973

Source: Aldcroft & Oliver, 1998, p. 115, Table 4.8.

Early theoretical papers, such as Ethier (1973), Clark (1973), Baron (1976), Hooper and Kohlhagen (1978) and Gagnon (1993) find a negative effect of exchange rate volatility on trade to some extent, whereas other theoretical papers, Viaene and de

Vries (1992), Franke (1991), Sercu (1992), Sercu and Vanhulle (1992), Dellas and Zilberfarb (1993) and Broll and Eckwert (1999), conclude that there is a positive effect of exchange rate volatility on trade. Also, some other papers, for example Willett (1986), conclude that there is no impact of exchange rate volatility on international trade (Bahmani-Oskooee & Hegerty, 2007).

It is useful to note that in most theoretical models, what is being studied is the volatility of the real exchange rate against the nominal exchange rate. The two are obvious conceptually but do not differ much in reality: prices of goods tend to be sticky in local currency in the short-to-medium run. In such cases, real and nominal exchange rate volatilities are almost the same for practical purposes. Therefore, Clark et al. (2004) do not give a separate discussion on the trade effect of nominal exchange rate volatility after they review the literature in this regard. But when high inflation occurs and nominal exchange rate volatility tends to be larger than real exchange rate volatility, Clark et al. (2004) assess whether nominal versus real exchange rate volatilities have different effects on trade or not.

Meanwhile, numerous empirical works have been conducted to investigate whether trade is influenced by exchange rate volatility, but the results from the empirical studies remain mixed as the results are sensitive to the choices of sample period, model specification, measurements of exchange rate volatility and countries considered. Most of the empirical works indicate that the increased volatility of the exchange rate in general has an adverse effect on the growth of foreign trade (McKenzie, 1999; Ozturk, 2006). Such empirical works have been undertaken by the following researchers: Abrams (1980), Akhtar and Hilton (1984), Kenen and Rodrick (1986), De Grauwe and de Bellefroid (1987), Corbo and Caballero (1989), Asseery and Peel (1991), Pozo (1992), Chowdhury (1993), Arize and Ghosh (1994), Caporale and Doroodian (1994), Arize (1995), Arize (1996), Bahmani-Oskooee (1996), Arize (1997), Doroodian (1999), Arize et al. (2000), Sukar and Hassan (2001), Bahmani-Oskooee (2002), Doğanlar (2002), Esquivel and Larrain (2002), Taglioni (2002), Vergil (2002), Arize et al. (2003), Baak et al. (2007), Grier and Smallwood (2007), Simwaka (2007), Arize et al. (2008), Byrne et al. (2008), Hondroyiannis et al. (2008), Chit et al. (2010), Wong and Tang (2008) Verheyen (2011) and Tang (2011).

However, studies conducted by Coes (1981), Brada and Mendez (1988), Giovannini (1988), Klein (1990), Asseery and Peel (1991), Franke (1991), Sercu and Vanhulle (1992), McKenzie and Brooks (1997), Doyle (2001), Bredin et al. (2003), Kasman and Kasman (2005), Awokuse and Yuan (2006), Choudhry (2008), Baum and Caglayan (2010) and Shehu and Zhang (2012), indicate that there is a positive effect of exchange rate volatility on trade. On the other hand, Hooper and Kohlhagen (1978), Chan and Wong (1985), Gotur (1985), Bailey et al. (1986, 1987), Bailey and Tavlas (1988), Medhora (1990), Bahmani-Oskooee et al. (1993), Bahmani-Oskooee and Payesteh (1993), Gagnon (1993), McKenzie (1998), Lee (1999b), Aristotelous (2001), De Vita and Abbott (2004b), Singh (2004), Herwartz and Weber (2005), Bahmani-Oskooee and Ardalani (2006) and Tenreyro (2007), among others, do not find any significant relationship between exchange rate volatility and trade. In addition, Bailey et al. (1987), Koray and Lastrapes (1989), Klein (1990), Kroner and Lastrapes (1993), McKenzie (1998) and Chou (2000) have found that the exchange rate volatilities may have both positive and negative impacts on trade flows.

Meanwhile, the techniques used in the empirical studies evolved over time, including the measurements of exchange rate volatility, techniques for cointegration test and dynamics test, etc. In early studies, the measurement of exchange rate volatility was based on the standard deviation of percentage changes in the exchange rate, for example Lanyi and Suss (1982). There are also some recent studies using it, for example, De Vita and Abbott (2004a), Bahmani-Oskooee and Wang (2007), Bahmani-Oskooee and Kovyryalova (2008), and Bahmani-Oskooee and Mitra (2008), But employing the standard deviation of exchange rate changes as a proxy of exchange rate volatility may incorrectly specify the stochastic process that generates the exchange rate (Qian & Varangis, 1994). In addition, requiring a two-step process may result in inefficient estimators (Kroner & Lastrapes, 1993).

Later empirical studies use the (G)ARCH-type method to proxy the exchange rate volatility more often, for example, Agolli (2004), Clark et al. (2004), Choudhry (2005, 2008), Baum and Caglayan (2010`), Benita and Lauterbach (2007), Wang and Barrett (2007) and Arize et al. (2008), Also, other measures such as the Linear moment (LM) model (Antle, 1983) and Log range (Cotter & Bredin, 2007) are employed. All in all,

all measurements suffer various kinds of both conceptual and statistical problems (Lanyi & Suss, 1982; Wang & Barrett, 2007).

Some apparent drawbacks exist in the empirical research done so far. First, most empirical research estimating the relationship between exchange rate volatility and bilateral trade employ the gravity model (e.g. Dell'Ariccia, 1999; Rose, 2000; Baak, 2004; Clark et al., 2004; Tenreyro, 2007), which is augmented with other factors that can affect trade flows such as sharing a common border, common language, membership of a free trade area and exchange rate volatility. According to Dell'Ariccia (1999), the gravity model is more suitable for the estimation of intra-industry trade flows between developed-country pairs since the theoretical framework of the model assumes identical and homothetic preferences across countries and depends heavily on the concept of intra-industry trade. Another issue is that using the gravity model in studies will lead to mixed samples of developed and developing countries which might have different structural circumstances and trade patterns (Chit et al., 2010).

It should be noted that the vast majority of past studies examined aggregate trade flow data. Bini-Smaghi (1991) argues that the conflicting empirical evidence on the impact of exchange rate uncertainty on trade may be due partly to the use of aggregated data since using aggregate data unnecessarily, and perhaps erroneously, assumes that income, price and exchange rate elasticity estimates are equal across sectors. If this assumption is incorrect, then the examination of aggregate trade data is likely to dilute the true nature of the relationship and reduce the probability of obtaining accurate empirical results. It is more plausible to assume that the impact of exchange rate volatility will differ across various tradable goods sectors or commodities (Awoku & Yuan, 2006).

More recent empirical studies employ either bilateral trade data or sub-sectoral trade data to avoid the possible risk of aggregation bias and to catch the sub-sectoral effects which may occur at the industry level. These recent studies include Broda and Romalis (2003), Péridy (2003), Larson et al. (2005), Baum and Caglayan (2010), Bonroy et al. (2007), Baak et al. (2007), Simwaka (2007), Wang and Barrett (2007).

Bahmani-Oskooee and Mitra (2008), Byrne et al. (2008), Wong and Tang (2008) and Md-Yusuf (2009).

Another drawback of previous studies is the stationarity of data. Although panel data analysis has a particular advantage in examining the impact of exchange rate volatility on trade, the longer time dimension of the panel data, as shown by Dell'Ariccia (1999) and Baak (2004), may lead to the problem of non-stationarity and spurious regression. Baltagi (2001) notes that for a macro-panel with large N (number of cross-sectional observations) and large T (length of time series), non-stationarity deserves more attention. None of the existing published papers utilising panel data, except Chit (2008), conduct panel unit-root and cointegration tests to verify the long-run relationship among the variables. Thus, previous studies might be affected by the problem of spurious regression (Chit et al., 2010).

Whether the data is stationary or non-stationary is another concern in the model used. Some new techniques are developed to adapt to the need of various types of time series data, such as the bounds testing (ARDL) approach by Pesaran et al. (2001), which allows the regressors in the model to be purely I(0), purely I(1) or mutually cointegrated (Fosu & Magnus, 2006). Tang (2006) examines Japan's long-run aggregate import demand function using a variety of cointegration tests and concludes that data frequency does not affect estimates of Japan's aggregate import demand function, but that the choice of cointegration techniques does.

All in all, the contrary and inconclusive results from the empirical studies depend largely on the proxies of exchange rate volatility, trade data used, i.e. aggregate data, bilateral data or sectoral data, etc., models and techniques employed for the cointegration test in the long-run and dynamics test in the short-run. While some studies found a positive relationship between exchange rate volatility and trade, others argue for the opposite. A large number of past studies only focused on aggregate trade flow data. The lack of extensive literature on studies based on disaggregated and sector level data may unilaterally account for the equivocalness in previous empirical evidence (Awokuse & Yuan, 2006).

In terms of the impact of Australian exchange rate volatility on its trade flow, McKenzie (1998) analyses the effect using ARCH models to generate a measurement of exchange rate volatility which is then tested in a model of Australian imports and exports. Both aggregate trade data and disaggregate sectoral trade data are analysed. The results indicate that the impact of exchange rate volatility does differ between traded good sectors although it remains difficult to firmly establish the nature of the relationship. But McKenzie (1998) selects real US GDP and the US-Australian exchange rate for inclusion, which is not suitable for the current international environment, especially with a group of countries like China, Japan and South Korea becoming Australia's major trading partners. Also, McKenzie (1998) employs one measure of exchange rate volatility generated from the ARCH model. A potential problem may exist with the use of ARCH—based measurements of exchange rate volatility.

Given research circumstances regarding the exchange rate volatility on Australian trade performance, this study firstly uses four measures generated from ARCH and MSD methods based on both real and nominal exchange rates to explore the impact at the aggregate trade level with Australia's eight major trading partners, China, Japan, South Korea, Singapore, New Zealand, Germany, UK and US, representing the rest of the world. Secondly, analysis is conducted at the sectoral trade data level. In addition, estimation at the bilateral trade data level is performed between Australia and its seven major trading partners, China, US, Japan, New Zealand, Singapore, South Korea and UK, with two measurements of exchange rate volatility generated from GARCH and MSD methods.

1.3 Objectives of the Thesis

This study aims to investigate the relationship between exchange rate volatility and Australian trade performance through estimating export and import models for three trade data levels, that is, aggregate trade data, sectoral trade data and bilateral trade data. To this end, the specific objectives are:

1. To review various volatility measurements and estimation techniques used in the empirical literatures.

2. To estimate the trade effect of Australian exchange rate volatility at three trade data levels, aggregate, sectoral and bilateral. This study also divides Australia's export products into three groups—Manufactures, Resources and Rural Goods, and Australia's import products into three groups—Capital, Consumption and Intermediate Goods, to test whether volatility has a different effect on them.
3. To generate volatilities of both the real and nominal exchange rate by employing GARCH and MSD methods, to see whether there is a different trade effect between different volatility measurements and between real and nominal exchange rates.
4. To empirically investigate the long-run relationship between exchange rate volatility and Australia's trade performance by applying the ARDL bounds testing approach proposed by Pesaran et al. (2001) for cointegration analysis.
5. To conduct an Error Correction Model (ERM) to test short-run dynamics, and also to run diagnostic tests by applying the CUSUM and CUSUMQ tests to prove whether the models estimated are stable during the study period.

1.4 Outline of the Thesis

This study begins with an overview of Australian exchange rate policy and statistical analysis of merchandise trade in Chapter two. Chapter three discusses trade theory and the impact of exchange rate volatility on trade, mainly on exports. Chapter four reviews the empirical literature of the impact of exchange rate volatility on trade, including measures of exchange rate volatility, specifications for trade equations and techniques used in empirical studies. Chapter five describes the research model, methodology, data sources and variable specification. Chapter six discusses the empirical results of the impact of exchange rate volatility on Australia's trade performance at the aggregate trade data level. Chapter seven reports the empirical results at the sectoral trade data level. Chapter eight presents the empirical results at the bilateral trade data level. Chapter nine presents the conclusion of the study, the policy implications and suggestions for further research directions.

Chapter 2
Australian Exchange Rate Policy and Trade Direction

2.1 Introduction

The outcome of the Bretton Woods Conference in 1944 was that the fixed exchange rates period known as the Bretton Woods system started, in which currencies were pegged to the US dollar on the basis of the gold standard, reflecting the widespread view at that time in both academic and policy-making circles favouring such a system (Sarno & Taylor, 2002, p. 170). With the signing of the Smithsonian Agreement in 1971, the Bretton Woods system ended and was replaced by a floating exchange rate regime, and the member countries of the Group of Ten agreed to revalue their currencies against the US dollar. From 1973, most industrial countries started to float their exchange rates but the Australian dollar did not float until December 1983.

As one of the industrial countries, Australian authorities implemented various exchange rate policies at different stages by combining the world's trends and its particular domestic economic environment so that "the 'right' exchange rate will help to keep the economy in reasonable internal and external balance" (Fraser, 1992).

This chapter attempts to present the evolution of Australia's exchange rate system from a fixed to a floating stage and then up to the present, including a description of some relevant institutional developments, such as the removal of capital controls, and the development of Australia's foreign exchange market. The chapter is divided into four sections. An introductory overview is followed by section two which documents Australian exchange rate policy and briefly examines the different exchange rate regimes in terms of their impact on Australia's overall economic performance during that period. The rationale behind the evolution is revealed with reference to both international and domestic perspectives. Section three is concerned with Australia's changing trade direction both geographically and contents over the past two decades. Concluding remarks end the chapter in section four.

2.2 Australian Exchange Rate Policy

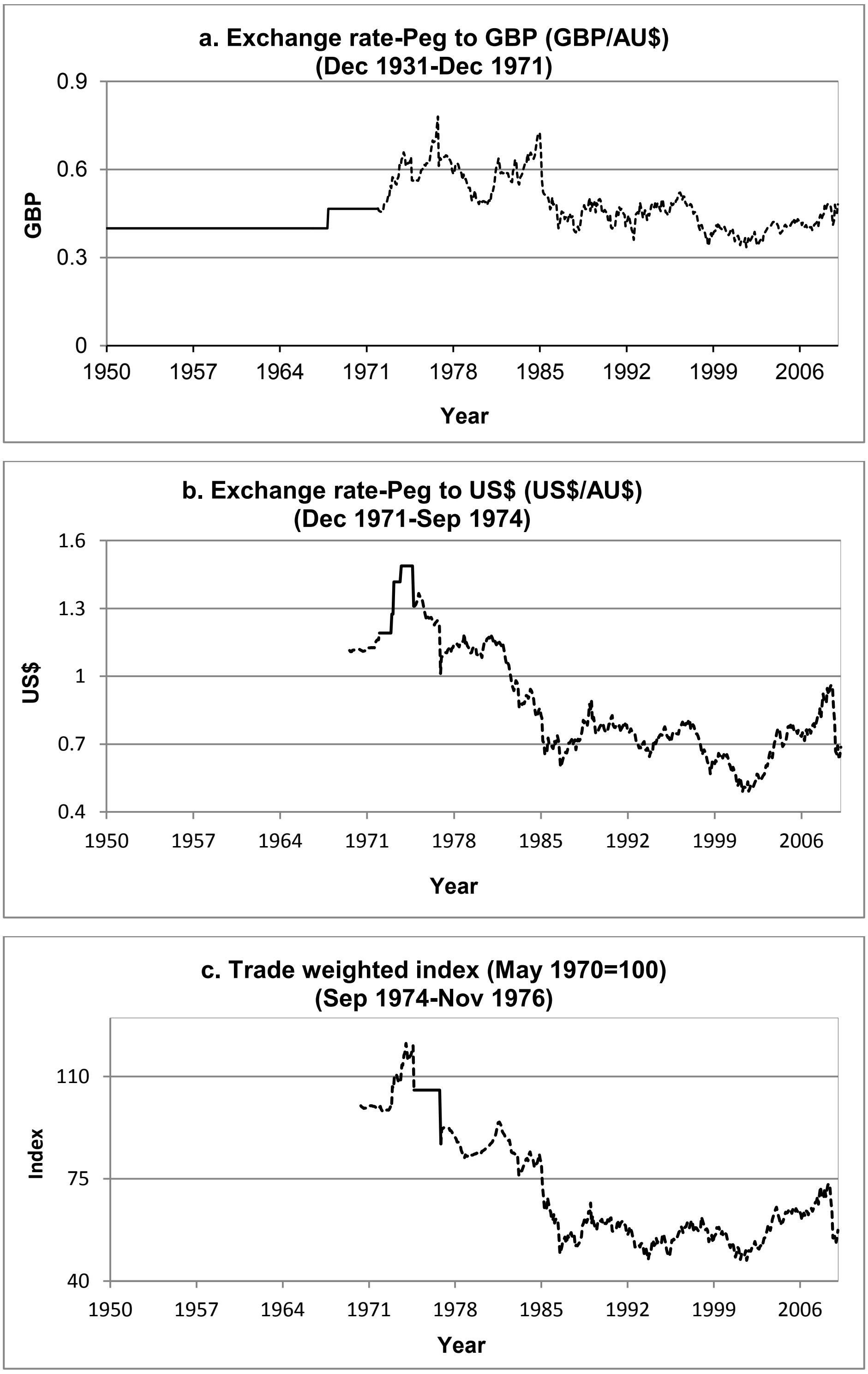
Given the significant role of the exchange rate in the economy's adjustment to terms of trade and other external shocks such as foreign indebtedness, domestic resource booms, interest differentials, and market speculations (Fraser, 1992), Australian authorities have implemented different exchange rate policies at different stages. There are three exchange rate regimes that Australia has experienced so far. The first can be called the absolutely-fixed regime, and includes three sub-regimes: Australian dollar pegging to the British pound from 3 December 1931 to 18 December 1971, pegging to the US dollar from December 1971 to 25 September 1974 and pegging to the fixed effective exchange rate (TWI) regime from 25 September 1974 to 29 November 1976. The second regime was the Crawling Peg regime which was in force from 29 November 1976 to December 1983, and the third was the pure-floating regime which began on 13 December 1983 and is still current. With each regime, the authorities took different approaches to exchange rates to reach different economic objectives.

Figure 2.1 (a, b and c) depicts the movement of the Australian dollar from January 1950 to March 2009 according to the different regimes.

2.2.1 Australian exchange rate policy before 1983

Before floating entirely in December 1983, the Australian exchange rate had experienced the absolutely-fixed regime and the fixed but adjustable (Crawling Peg) exchange rate regime. The various exchange rate regimes were accompanied by capital controls and financial regulations in the domestic financial system (Blundell-Wignall, Fahrer & Heath, 1993). During the period December 1931 to November 1976, the Australian dollar was absolutely fixed under three different arrangements separately, with the first two pegged to particular currencies of the British pound and the US dollar, and with the third arrangement pegged to an effective exchange rate, also called a trade-weighted basket of currencies (Manuell, 1986, p. 84). The fixed but adjustable regime—(the Crawling Peg regime) took effect between November 1976 and December 1983.

Figure 2.1: Movement of Australian dollar, 1950-2009, monthly data



Source: RBA, 2008a, *Bulletin*, Table F. 11.

The following describes the various changes occurring in the Australian exchange rate system from 1931 to the end of 1983, particularly relevant institutional developments and the economic surroundings.

2.2.1.1 The peg to the British Pound (1931-1971)

In the 1930s, world trade experienced contraction following the financial collapse of 1929 and the subsequent economic slump. Also, bank failures in the US, where gold convertibility was abandoned in August 1971 with part of the banking functions still existing (Hoffmeyer, 1992, p. 50), and the chronic international payments problems were widespread, leading to the dismantlement of the gold standard by the UK. Consequently, a series of exchange rate devaluations happened to attempt to restore a favourable balance of payments and to stimulate exports in order to strengthen the competitiveness of the home industry in the international market. At the same time, more home employment was expected to be created. There was a need to establish an international payment and exchange system in order to prevent deflationary downward spirals and to stimulate international trade (Morrell, 1981, p. 33).

Given the role of sterling in international transactions as the primary currency and the close relationship between Australia and the UK, the Australian dollar started to peg to the British pound in December 1931 and continued its pegging until December 1971. The Australian dollar against the British pound was at a constant exchange rate of AU$1=GBP£0.3992 until the British government devalued the pound in 18 November 1967 by 14.3 per cent against the US dollar from US$2.8000 to US$2.4000. For some reason, the Australian dollar did not devalue along with the pound against the US dollar. On the other hand, it was effectively revalued against the pound by 16.7 per cent, achieving the exchange rate of AU$1=GBP£0.4657 (Manuell, 1986, p. 85).

Table 2.1 shows the reserve position of the UK and the US during the period 1949 to 1970. At the beginning of the period, the US had both a comfortable holding of gold and moderate dollar liabilities. Also the US was the only country in the system at that time to attempt a partial obligation to exchange foreign official dollar holdings into gold at a price of US$35 per ounce (Hoffmeyer, 1992, p. 33). The UK had quite small reserves and large sterling liabilities.

Table 2.1: US and UK reserves and external monetary liabilities (US$billion)

	1949	1960	1970
United States			
Total Reserves	26.0	19.4	14.5
Of which gold	24.6	17.8	11.1
External Monetary Dollar Liabilities	6.9	21.0	47.0
United Kingdom			
Total Reserves	1.8	3.7	2.8
Of which gold	1.3	2.8	1.3
External Monetary Sterling Liabilities	9.1	12.0	11.1

Source: Hoffmeyer, 1992, p. 33, Table 4.

For the sterling-area countries, it was obvious that the UK had drawn greatly on international borrowing facilities with its obligations to repay official assistance around equal to its current reserves level. Therefore, if there were further increasing foreign exchange demands among the sterling-area countries, the UK's ability to meet its obligations may be in doubt. In such a situation, any shifting from sterling balances to other assets by the sterling-area countries would result in the equivalent loss in the UK's reserves (Hoffmeyer, 1992, p. 44).

The current account of the major OECD countries showed imbalances in the early 1970s indicating that these countries had fundamental disequilibria. As a result, there were remarkable changes in worldwide monetary arrangements in 1971. Although there were many attempts to try to enhance the Bretton Woods system and to improve confidence in sterling, among the European countries the British was the first to float its currency in June 1972 after a critical loss of its reserves (Hoffmeyer, 1992, p. 50). The major OECD countries finally decided to float their currencies in 1973 (Blundell-Wignall, Fahrer & Heath, 1993).

The situation for Australia's foreign exchange reserves changed as well. The percentage of the Australian banks' foreign exchange transactions in US dollar rose to 33 per cent in 1968/69 from 22 per cent in 1963/64, whereas the proportion of

Australia's foreign exchange reserves held in sterling reduced to 45 per cent in 1968 from 90 per cent in 1950 (Manuell, 1986, p. 86-87). Therefore, Australian authorities revalued the AUD. In December 1971, the Australian dollar started pegging to the US dollar rather than the British pound.

2.2.1.2 The peg to the US dollar (1971-1974)

Compared to the decreasing use of the British pound, the US dollar had been increasingly used as the major international currency since World War II. By 1971, the US dollar had flooded the world (Parboni, 1981, p. 38). Table 2.2 shows that the US official liabilities to foreign central banks and international institutions went up by US$12 billion during the period 1951 to 1969. During the subsequent period of 1970 to 1978, the US liabilities rose rapidly by US$134 billion, reflecting a sizeable increase in comparison to the previous period. At the same time, there was a substantial growth in world reserves resulting largely from the US deficits. The proportion of the US official liabilities to the world reserves rose from 10 per cent to 50 per cent, indicating greater strength in American seigniorage (Parboni, 1981, pp. 39-40). All in all, the 1970s witnessed a new stage, both quantitatively and qualitatively, "in the exercise of American seigniorage over the supply of reserves" (Parboni, 1981, p. 49).

The Smithsonian Agreement in 1971 (see Table 2.3) reflected the breakdown of the fixed exchange rates system at that time with the details of the realignments of the major currencies and the Australian dollar. According to the agreement on realignment, the Fund provided a temporary regime where members could permit their exchange rates to fluctuate against their intervention currencies within margins of 1 per cent to 4.5 per cent from both sides of the parity relationship based on par values or central rates, "which might be communicated to the Fund by members temporarily not maintaining their exchange rates on the basis of par values" (Manuell, 1986, p. 21).

Table 2.2: Evolution of official US liabilities and world reserves (US$billion)

	a	b	c	d	e
1951/1969	-19.40	7.30	12.10	30.00	40%
1970	-10.70			15.70	
1971	-30.50			32.80	
1972	-11.10			26.90	
1973	-5.30			7.00	
1974	-8.30	8.30	134.30	33.00	50%
1975	-3.50			17.40	
1976	-8.70			32.20	
1977	-33.50			47.10	
1978	-31.00			52.60	
Total	-162.00	15.60	146.40	294.70	49%

Note: a. Deficits on the basis of official settlements of US balance of payments.
b. Liquidation of official US assets abroad.
c. Rise of official US foreign liabilities (column b minus column a).
d. Increase in official world reserves.
e. Share of increase in world reserves composed of official US liabilities (column 3 divided by column 4).
Source: Parboni, 1981, p. 39, Table 1.

In the case of Australia, there was no change in the par value of the Australian dollar against gold, but the Australian dollar was revalued against the US dollar when the sterling appreciated at that time. This reflected the increased significance of the US dollar as the major currency dominating world trade and international payments.

In March 1973, several major countries finally decided to float their exchange rates. The rationale behind the floating exchange rates system is that the US dollar depreciation does not cause serious inflationary consequences, whereas the devaluation of other currencies accelerates their respective domestic inflation. The dollar depreciation continued throughout 1973, particularly compared with the stronger currencies (Parboni, 1981, p. 84). In 1971 and 1973, the US tried to expand the money supply in order to devalue the dollar sufficiently to remedy the US balance of payments while keeping the dollar's international role simultaneously (Parboni, 1981, p. 86). The US dollar was devalued twice in December 1971 and February 1973, but the required targets were not reached.

Table 2.3: Exchange rate realignments resulting from the Smithsonian Agreement

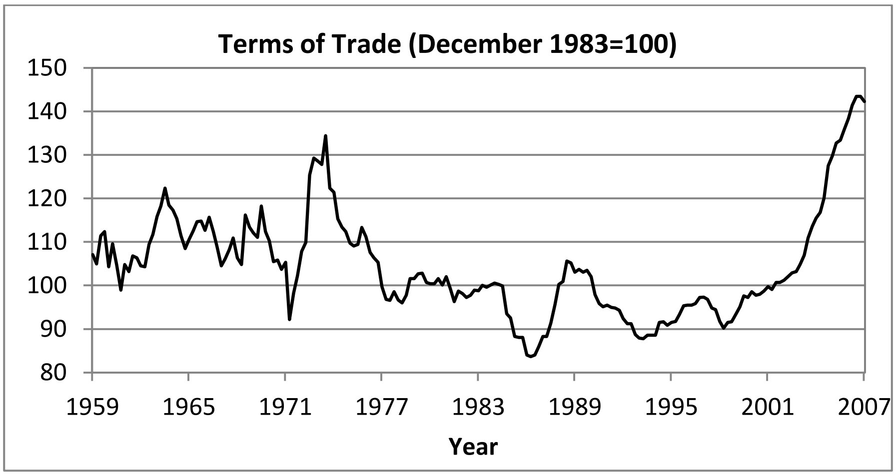
Country	Change against gold (%)	Change against USD (%)	New central or middle rate for USD (=USD1)	Exchange rate action	Effective date
Belgium	+2.76	+11.57	44.8159	central rate	21-12-1971
Canada				floating rate	continued
France	—	+8.57	5.1157	par value	maintained
Germany	+4.61	+13.58*	3.2225	central rate	21-12-1971
Italy	-1.00	+7.48	581.5	central rate	20-12-1971
Japan	+7.66	+16.88	308.0	central rate	20-12-1971
Netherlands	+2.76	+11.57*	3.2447	central rate	21-12-1971
Sweden	-1.00	+7.49	4.8129	central rate	21-12-1971
UK	—	+8.57	2.60571**	par value	maintained
USA	-7.89	—		new par value	08-05-1972
Australia	—	+6.34	1.1910	par value	maintained

Note: * Based on par value in effect to 9 May 1971.
** USD per GBP1.
Sources: Manuell, 1986, p. 21, Table 1.3.

During the 1960s, the US dollar was already encountering serious problems. The US deficits were made up of capital movements, but because the current account was generally in surplus, this partially contributed to financing the capital movements. Thus, in the early 1970s, settling the balance of payments for the US meant attempting to achieve a consistent current-account surplus so as to finance capital movements (Parboni, 1981, pp. 87-88).

During this period, Australia initially tried to maintain its peg to the US dollar. However, with the sharp rise of Australia’s terms of trade (see Figure 2.2) caused by the world commodity price boom in the early 1970s, there were some changes in the parity between the Australian dollar and the US dollar. While a positive real income was transferred from a sharp rise in the terms of trade which was equal to between 4 and 5 per cent of gross domestic product (GDP) between 1972 and 1974, Australia imported exacerbating inflationary pressures with fixed exchange rates and growing international reserves. The Australian dollar was revalued three times to avoid an evident acceleration of inflation but failed to avert the inflation (Blundell-Wignall, Fahrer & Heath, 1993).

Figure 2.2: Australia's terms of trade, December 1983=100, 1959-2007, quarterly data



Source: Reserve Bank of Australia, 2008b, *Bulletin*, Table G4.

In March 1973, the US abandoned the par value for the dollar and floated the dollar. More than fifty currencies were linked to the US dollar and a number of others were linked to special drawing rights (SDR) whose dollar value changes at a moderate level. Marked fluctuations in the dollar exchange rates are restricted to the industrial countries' currencies, and the degree of fluctuation varies significantly among these currencies (Bernstein, 1978).

At the end of this period, there were pressures in foreign exchange markets; the US dollar came under severe pressure due to the increase in the oil price, which increased from an average of US$3 a barrel in the early 1970s to an average of US$20 a barrel at the end of the 1970s and has climbed past US$30 since then. The permanent deflationary element introduced by the increasing oil prices in the world economy could be conquered only by a thorough and courageous rearranging of the entire international financial system (Parboni, 1981, p. 101).

Meanwhile the US dollar fluctuated largely which led to the weakness of the Australian dollar since they had the fixed link; most developed economies were moving to managed floating exchange rate regimes; and the huge price increase of OPEC oil led to the turndown of the world economy which altered the Australian economy from the upper activity levels in 1973 to recession in 1974 (Manuell, 1986, p. 92). The Australian domestic economy started to expand with the spending and production at a rapid growth rate. Domestic sources of finance were getting tightened due to new controls on overseas borrowings, such as raising the Variable Deposit Requirements (VDR) to 33.3 per cent in October 1973, which resulted in the shrinking of capital inflow and the rise of interest rates. On 25 June 1974, the VDR declined from 33.3 per cent to 25 per cent, and further to 5 per cent on 8 August, in order to compensate for the outflow of the banks' liquidity.

Table 2.4 highlights that international issues of dollars decreased compared with those of strong currencies although the US opened its financial market completely to foreign borrowers during the 1970s. Since the issues made in the financial markets, such as in Germany, Japan and Switzerland, must be converted into dollars before they can be exported from the country, the fact that the strong currencies are denominated by bonds does not indicate that these currencies were in active circulation. In fact, these issues were helpful for countries to partially reduce the surplus in their own payments, which were perhaps excessive between 1976 and 1978, partly due to the uncontrolled inflow of speculative capital (Parboni, 1981, p. 67).

Table 2.4: New issues of international bonds*, 1973-1978 (US$million)

	Total	US$	(%)	DM	SF**	Yen**
1973	7,779	3,407	43.8	1,387	1,526	_
1974	6,857	4,287	62.5	597	911	_
1975	19,913	10,200	51.2	3,367	3,297	67
1976	32,518	19,729	60.7	4,001	5,359	226
1977	33,976	19,055	56.1	6,312	4,970	1,271
1978	34,279	13,085	38.2	9,040	5,698	3,862

Note: *International bonds include both Euro-bonds and foreign bonds issued on national markets.
**Issues in Swiss francs and Japanese yen are foreign bonds only, since there are no Euro-bonds in these currencies.
Source: Parboni, 1981, p. 67, Table 4 New Issues of International Bonds.

Table 2.5 shows to what degree the proportion of these currencies grew to the detriment of the US dollar, although the increase in these shares was caused mostly from the revaluations of these currencies compared with the U.S. dollar (Parboni, 1981, p. 68).

Given the above situations both internationally and domestically, Australian authorities devalued the Australian dollar by 12 per cent against the US dollar on 25

September 1974, from USD1.4875 to USD1.3090. Meanwhile, the Australian dollar ceased its fixed link with the US dollar and instead pegged to a fixed trade-weighted basket of currencies.

Table 2.5: Evolution of the currency composition of Eurodeposits in European Banks* (%)

	US$	DM	SF	Other
1968	79.7	8.9	6.8	4.6
1969	81.4	8.2	7.1	3.3
1970	77.9	10.7	7.6	3.8
1971	72.4	15.0	7.9	4.7
1972	73.3	14.8	6.7	5.2
1973	68.4	16.7	8.9	6.0
1974	70.8	15.6	8.3	5.3
1975	73.2	15.4	5.9	5.5
1976	74.0	15.2	5.1	5.7
1977**	70.4	17.3	5.7	6.6
1978	68.2	18.2	5.4	8.2

Note: * US dollars, German marks, Swiss francs, and other currencies.
** Including, for the first time, the deposits of Austrian, Danish, and Irish banks.
Source: Parboni, 1981, p. 69, Table 5 Evolution of the currency composition of Eurodeposits in European Banks.

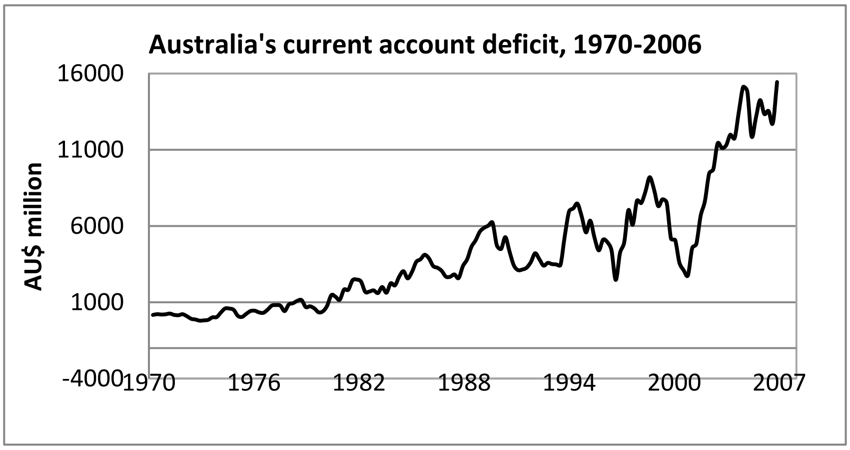
2.2.1.3 The peg to an effective exchange rate (1974-1976)

From 25 September 1974, a trade-weighted exchange rate commenced in Australia, with an index constructed from the currencies of Australia's major trading partners and being weighted according to their relative significance in Australia's international merchandise trade from a base date of May 1970 = 100. This policy change reduced the risk the Australian dollar was facing as a result of the fluctuations of the US dollar. Also the external value of the Australian dollar underwent changes to neutralise the movements of other currencies against the US dollar (Blundell-Wignall, Fahrer & Heath, 1993). The Trade Weighted Index measuring the overall value changes in the Australian dollar remained unchanged until November 1976 (Manuell, 1986, p. 94).

As a result of the devaluation in September 1974, the effective exchange rate of the Australian dollar went back to the same level as the December 1972 revaluation. The RBA increased the gold price from AU$28.38 to AU$32.25 per fine ounce. Export industries and those sectors experiencing undue pressure from import competition were particularly expected to benefit from the Australian dollar devaluation. Also, the devaluation supported the restoration of the general level of economic activities and the maintenance of the employment environment.

The trade weighted exchange rate index (TWI) was implemented as a fixed effective exchange rate in volatile conditions. At this time, the current account deficit stood at a historically high level (see Figure 2.3), being AU$594 million in the June quarter of 1974. Also, Australia's foreign exchange reserves had been going down from extremely high levels (Manuell, 1986, p. 99). Government took some instruments to deter capital inflow, such as suspending the VDR and reducing the borrowing embargo in November 1974, furthermore easing non-resident investment in fixed interest securities in January 1975.

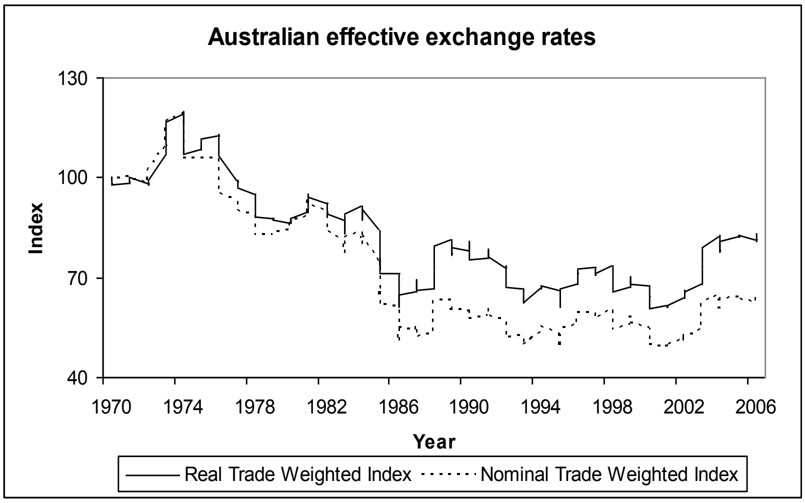
Figure 2.3: Australia's current account deficit, 1970-2006, quarterly data



Source: ABS, 2008a & 2008b. Australian National Accounts: National income, expenditure and product (5206.0), Balance of payments and international investment position, Australia (5302.0).

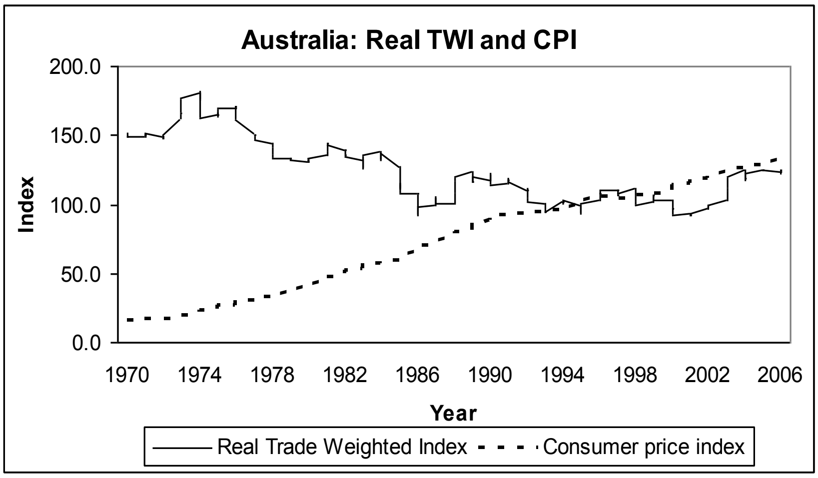
During the implementation of the constant effective exchange rate between September 1974 and November 1976, the Australian real effective exchange rate appreciated quickly in 1975 and a bit more slowly in 1976 (see Figure 2.4). This was caused by Australia's higher inflation rate and inappropriate domestic policies. But Australia's terms of trade (see Figure 2.2) did not become as bad as that indicated by movements in the real effective exchange rate. The Australian dollar also fluctuated against individual currencies with some severe movements (Manuell, 1986, p. 100).

Figure 2.4: Australian effective exchange rates, June 1970-December 2006, quarterly data, June 1970=100



Source: RBA, 2008a, *Bulletin*, Table F11.
Note: quarterly data for nominal effective exchange rate (NEER) calculated from monthly data which are averaged to achieve a quarterly series.

Figure 2.5: Australian real TWI and consumer price index (CPI), March 1995=100, June 1970 to December 2006



Source: RBA, 2008c, *Bulletin*, Table G2.
Note: Original data for CIP with base year of 1989/1990=100.

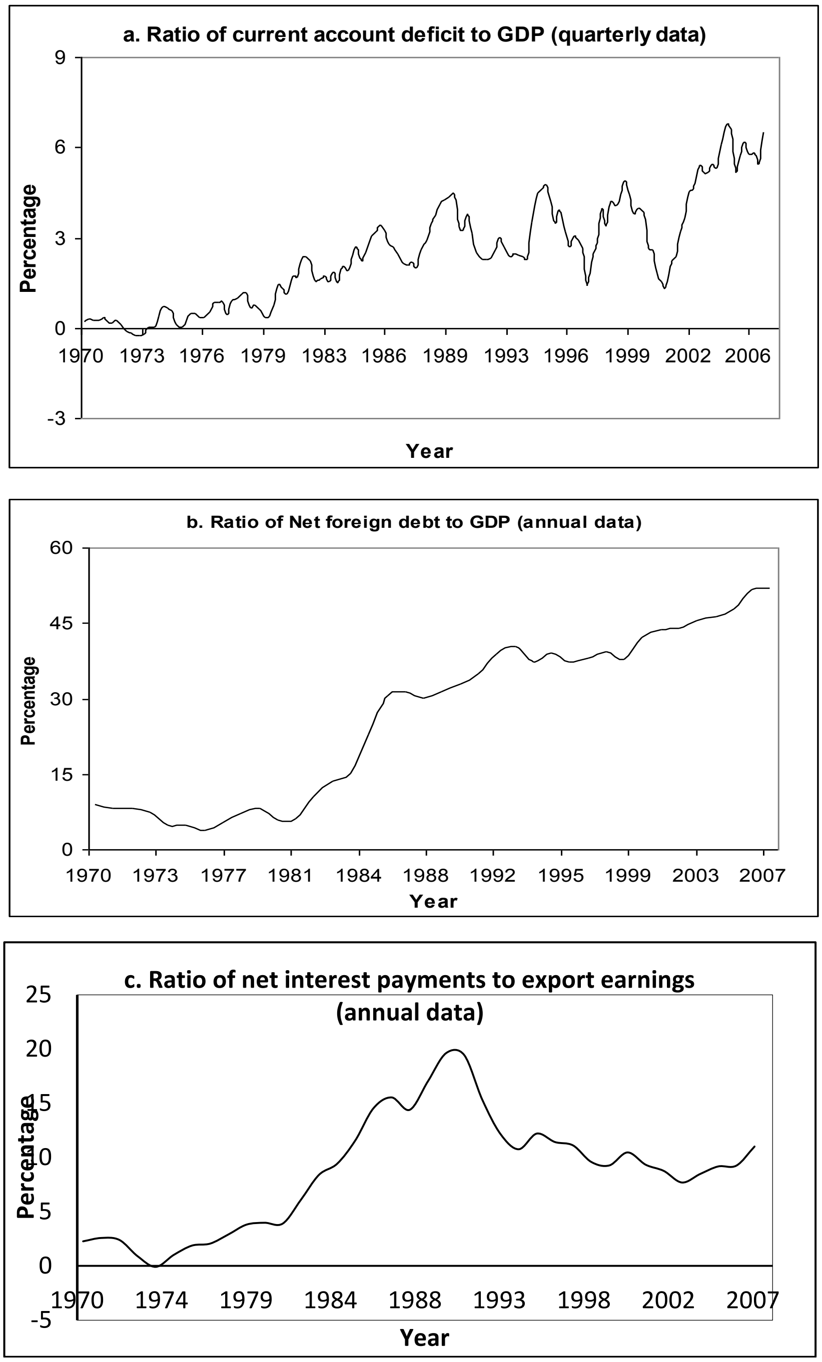
The trade weighted exchange rate regimes appeared to be unsatisfied with the terms of trade under downward pressure since 1976 (see Figure 2.2), while the Australian dollar seemed overvalued due to the fixed nominal exchange rate together with comparatively high national inflation (see Figure 2.5) (Blundell-Wignall, Fahrer & Heath, 1993). Consequently, private capital inflow decreased and foreign exchange reserves went down suddenly. The Australian dollar was then devalued by 17.5 per cent in November 1976. Under such circumstances, the fixed effective exchange rate system was abandoned and instead the Australian dollar started a crawling peg against the US dollar.

2.2.1.4 The crawling peg regime (1976-1983)

With the devaluation of the Australian dollar on 29 November 1976, the fixed effective exchange rate regime was replaced by the flexible peg regime, also called the Crawling Peg (Laker, 1988). With the new management, the level of the exchange rate was under daily review which allowed frequent small adjustments in the peg. At the beginning, daily changes in the TWI were small, but it became large in 1983, at the end of the flexible effective exchange rate regime. This period can be called the fixed but adjustable exchange rate regime, which was used by Australian authorities at that time as a nominal anchor to slow down the domestic inflation rate (Corden, 2002, p. 17).

Due to the tight monetary policy in some OECD countries and the rising world energy prices in the early 1980s, there was an investment boom in Australia since Australia was quite rich in energy resources. The terms of trade in Australia held up relatively well during this period (see Figure 2.2). At that time, the current account deficit widened (see Figures 2.3 and 2.6 (a)). Meanwhile, Australia already had a high inflation rate at approximately 10 per cent, with both short-term and long-term interest differentials moving in Australia's favour (see Figure 2.8 (a & b)). Consequently, there was a sustainable appreciation of the Australian dollar in real terms until the middle of the 1980s (Blundell-Wignall, Fahrer & Heath, 1993).

Figure 2.6: Australian external position, 1970-2007



Note: 1, Data for net foreign debt prior to 1976 were calculated by decumulating the stock of foreign debt with the flows of the current account balance.
2, GDP data (quarterly) for Part a of the Figure is from RBA Bulletin Table G10.
3, GDP data (annual) for Part b of the Figure is from ABS 5206.0 Table 30 (current prices).
4, Data for c from ABS Cat.No.5302.0 Balance of Payments and International Investment Position, Australia, June 2007 and ABS Cat.No.5204.0 Australian System of National Accounts, 2006-07.

Source: ABS, 2008a, 2008b; RBA, 2008d. Australian National Accounts: National income, expenditure and product (5206.0), Balance of payments and international investment position, Australia (5302.0), Table 2.

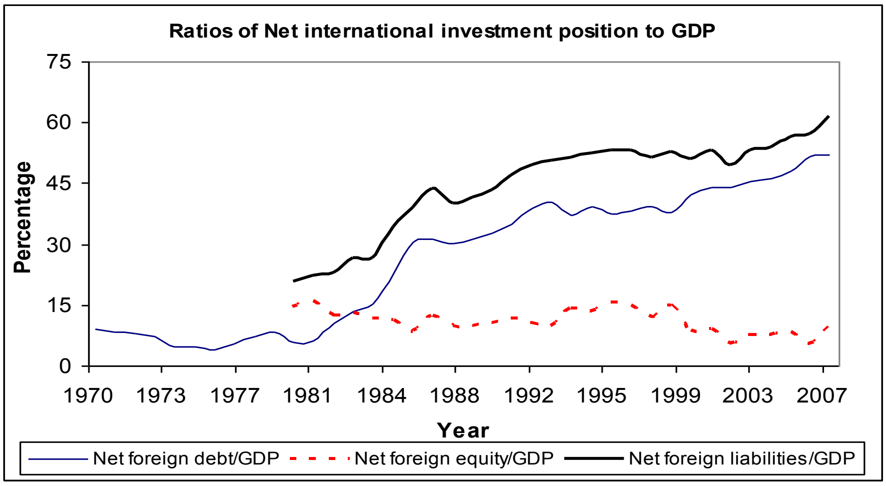
From the viewpoint of Australia's fundamentals, Australia's net external debt is cumulated from its current account deficits during the years. Since the export earnings are not sufficient to pay for the imports, the fund raisings from overseas are helpful in reducing these deficits; certainly debt is one of the important instruments along with equity and property (Edgar & Mercer, 1987, p. 6). As shown in Figures 2.3 and 2.6, Australia has almost always been in current account deficit since 1970. From the early 1980s, the deficit as a proportion of GDP was increasing rapidly, from less than 1 per cent of GDP before 1980 (except in 1978) to a fluctuation of between 1 and 3 per cent during the first half of the 1980s, between 3 and 5 per cent before 2003 and then towards a peak of 6 per cent in 2005.

In the meantime, the decline of Australia's terms of trade (see Figure 2.2) during the crawling peg regime exhibited some consequences. First of all, there were not the expected export earnings from the large investment funded with overseas capital in energy and minerals projects, and there was also continued debt servicing outflow (see Figure 2.6 (c)). Secondly, since Australia's foreign debt is in currencies other than AUD, the loss in export revenues from commodities resulted in the decrease in the Australian exchange rate. Furthermore, the Australian dollar depreciation led to the automatic expansion of Australian foreign debt in AUD.

In addition, the dramatic rise in debt-equity ratios (see Figure 2.7), similar to the general worldwide trend, contributed to the escalation of the size of Australian foreign debt. Compared to the investment instruments of equities and property, debt allowed capital to flow into Australia (Edgar & Mercer, 1987, p. 7). Also the loss of confidence in the domestic economy stimulated the increased reliance on debt.

Figure 2.7 illustrates some relative perspectives of Australian foreign debt. First, the ratio of net foreign debt to GDP shows that Australia had a relatively small foreign debt problem before the early 1980s. The situation has deteriorated rapidly until the present period. Secondly, the ratio of net interest payments to export revenues (see Figure 2.6(c)) indicates the cost for servicing the debt. Furthermore, the trend of these ratios continues to deteriorate before they become stable at quite high levels.

Figure 2.7 Ratios of net international investment to GDP, 1970-2007



Source: ABS, 2008a & 2008b. Australian National Accounts: National income, expenditure and product (5206.0), Balance of payments and international investment position, Australia (5302.0), Table 2.

In comparison with international standards, Australia's external position is reasonable, with the net foreign debt to GDP ratio just over 50 per cent, despite the dramatically increasing trend in the 1980s. However, compared with the other industrial countries, Australia's external non-equity assets are at a very low level. Therefore, although Australia has a relatively low level of gross external debt compared with other industrial countries, it has net indebtedness which is relatively high. Australia is among a group of nine industrial countries with net external debt in excess of 30 per cent of GDP (Rider, 1994).

In the early part of the flexible peg regime, Australia had considerably higher interest rates than the US (see Figure 2.8 (a, b)), sterilisation was fulfilled efficiently due to the complementary use of exchange and capital controls. During the whole regime, the Australian exchange rate experienced nine index adjustments in total, the TWI (May 1970 = 100) went up from 86.9 in November 1976 to 92.5 in February 1977 and stayed at 92.5 till August 1977 in order to give effect to the flexible peg regime (RBA, 2008a). After that, the Australian exchange rate was determined by the basket of currencies.

The capital account of the balance of payments was the major factor in the exchange rate management in this period. As shown in Figures 2.3 and 2.6(a), Australia's current account worsened at a rapid pace throughout the 1980s. Imports grew strongly due to the resources boom while export receipts remained relatively stable. The exchange rate encountered some upward pressure from the overall recorded balance of payments surpluses due to the substantial capital inflow. This reasoning may explain why the huge private capital inflow of AU$2.43 billion in the March quarter 1981 contributed to the faster appreciation that occurred at that time (Manuell, 1986, p. 118).

In response to the substantial capital inflow, Australia's nominal effective exchange rate appreciated rapidly in 1981, therefore to some extent falling within Corden's second policy alternative (Manuell, 1986, p. 120) which says that "when the aim is to reduce inflation a common alternative to fixing the exchange is to have an exchange-rate-based stabilization program with a 'crawling peg' exchange rate regime" (Corden, 2002, p. 24).

In the early 1980s, the OECD countries faced a major recession which resulted in a declined demand for minerals and energy from Australia. Domestically, Australia faced inflationary pressures generated by large wage claims. There was a perception that the exchange rate had become overvalued in early 1983. Combined with the domestic political circumstances, there was heavy speculation and significant capital outflow which led to a 10 per cent devaluation of the exchange rate during the first half of 1983. Finally, during the second half of the 1983 there was heavy capital inflow caused by the expectation of an appreciation of the Australian dollar. Eventually, the authorities decided to float the dollar instead of only reducing distortions in financial markets. Foreign exchange controls were virtually removed at the time (Blundell-Wignall, Fahrer & Heath, 1993).

At the end of this period, with the speculative capital inflow, monetary policy was destabilised further, also the outer limits for the exchange rates were ceased. All in all, in the crawling peg regime there were large capital inflows resulting in Australian dollar appreciation, and heavy speculative activities. Authorities tried to devalue the Australian dollar against the TWI and reduced interest rates in order to frustrate speculators, but this move failed, and the Australian dollar appreciated. On 9

December 1983, Australian authorities announced the float of the Australian dollar and dismantled exchange controls, all of which took effect on 12 December 1983.

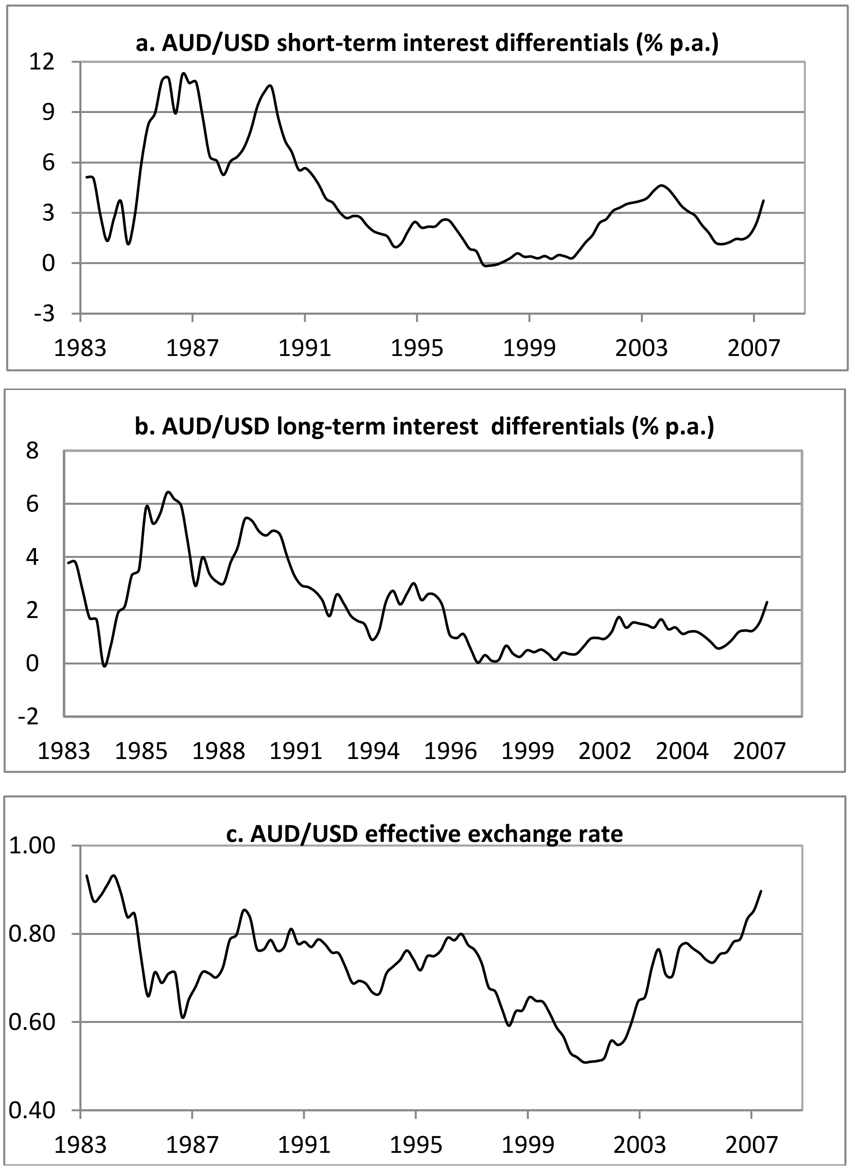
2.2.2 The floating exchange rate (1983-present)

Under the new system of the floating of the Australian dollar, there were no requirements for commercial banks to settle their foreign exchange positions with the Reserve Bank every day. The Reserve Bank discontinued providing either midrate for the AUD against the USD or the TWI (Debelle & Plumb, 2006; Manuell, 1986, p. 130), therefore exchange controls were abandoned.

The fluctuations of the exchange rates enabled them to react to the changes in underlying economic fundamentals properly and to maintain an appropriate current account and balance of payments (Bernstein, 1978), also responding both to market expectations and to the impact of monetary policy on interest rates (Corden, 2002, p. 23). The role of the exchange rate changes from being the policy target to being a part of the transmission mechanism, representing the short-term interest rate determined by the Reserve Bank (Debelle & Plumb, 2006). It has become more difficult for the authorities to manage the currency markets with the removal of restrictions on capital flows.

After the floating of the exchange rate, there was a close relationship among the US dollar effective exchange rate, the Australian and the U.S. short-term and long-term interest differentials (see Figure 2.8). The Australian interest rates were stable in early 1984 and exceeded the US interest rates, resulting in capital inflow at that time and consequently the Australian dollar's appreciation. The Australian dollar was at its peak at around US$0.9319 in the March quarter of 1984, which was the highest point it had attained so far since the floating of the Australian dollar. The upward climb of the US dollar against the major currencies, that is the Deutschmark, Pound Sterling and Japanese Yen, affected the direction of the Australian dollar significantly. Additionally, Australian interest rates declined following the period of tax payment and the long-term interest differential between Australian and the US had become negative in the June quarter of 1984 (Manuell, 1986, p. 135).

Figure 2.8: Direction of the Australia dollar, 1983-2007, quarterly data



Note: **a**. Quarterly data for short-term interest differential and for AUD/USD exchange rates are period averages. Data for Australia are from RBA and for the US from FRB (Federal Reserve Bank). Quarterly data for long-term interest differentials between Australia and the US are from RBA and FRB. Quarterly data for AUD/USD effective exchange rate are period averages from RBA Bulletin F11 Exchange Rates.
b. The definitions are as follows: Short-term interest rates for Australia are 90 day bank accepted bills since 3-month Treasury Bills were discontinued in June 2002, so 90 day bank accepted bills are used as a proxy; short-term interest rates for the US are 3-month Treasury Bills; long-term rates for both nations are 10-year government bond yields.

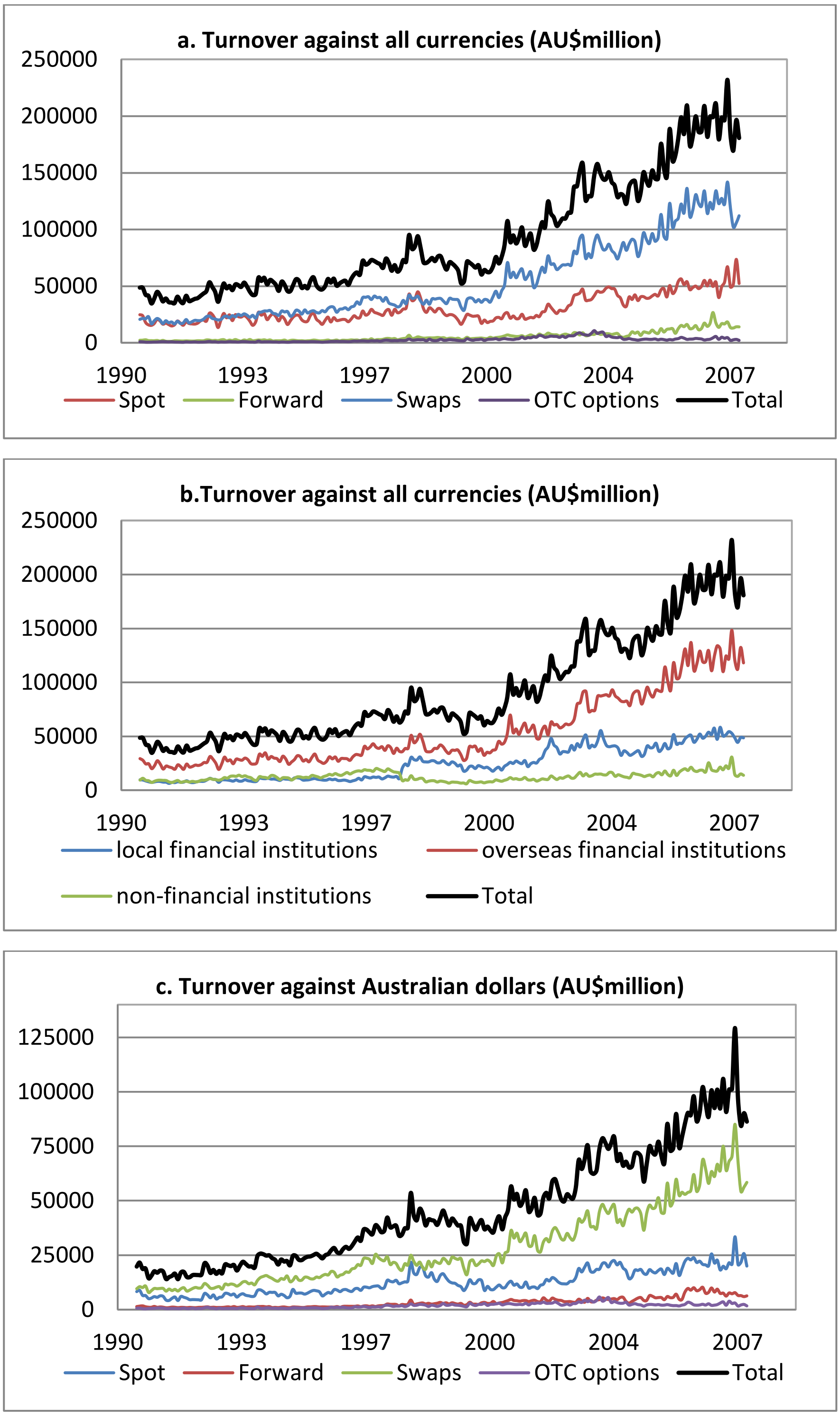
Source: RBA, 2008a & 2008e. Bulletin, Table F01: Interest rates and yields--Money market, bank accepted bills, 90 days; Federal Reserve Bank Statistics Release H.15, RBA Bulletin F11 Exchange Rates.

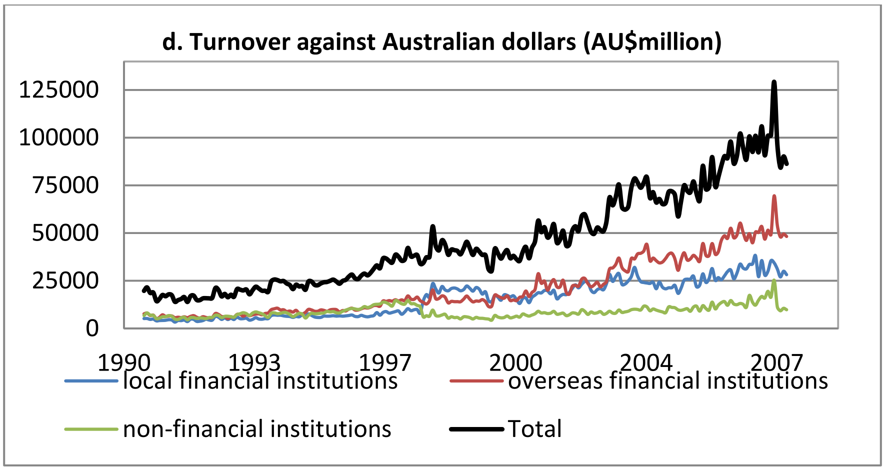
In the money market, the RBA dismantled the restrictions on the length of deposit maturities from commercial banks from August 1984. Therefore, there were dramatically increased demands for funds which led to the increased volatility in domestic short-term interest rates. Figure 2.8 also shows that the movements in interest differentials were smaller whereas the volatility in the AUD/USD exchange rate was larger such as in the year of 1984. This could be explained by the fluctuation of domestic interest rates being passed to the exchange rate due to the floating of the exchange rate.

Given the structure of Australia's economy, the greater exchange rate flexibility is needed since Australia is susceptible to highly volatile terms of trade. In the previous fixed exchange rate regime, a large fall in Australia's terms of trade usually led to a considerable contraction of the economy, but with a floating exchange rate there would be an automatic exchange rate depreciation which would reduce those shrinking effects to some extent (Fraser, 1992). Therefore, exchange rate fluctuations contribute greatly in smoothing the impact of the shocks on the terms of trade. Some research papers, such as Gruen and Wilkinson (1994), and Chen and Rogoff (2002), present the close relationship between the Australian dollar and Australia's terms of trade (Debelle & Plumb, 2006).

The Australian foreign exchange market grew significantly after the floating of the Australian dollar without direct intervention by the RBA in the foreign exchange market. Figure 2.9 shows that both the number of authorised dealers and the market's turnover has increased sharply with a great deal of volatility in the foreign exchange market. The BIS survey in 1989 indicated that "the Australian foreign exchange market was the eighth largest in the world and the Australian dollar was the sixth most heavily traded currency" (Fraser, 1992).

Figure 2.9: Australian foreign exchange market, 1990-2007, monthly data





Source: RBA, 2008f. Bulletin, Table F09: Foreign exchange turnover against all currencies and F10 Foreign exchange turnover against Australian dollars.

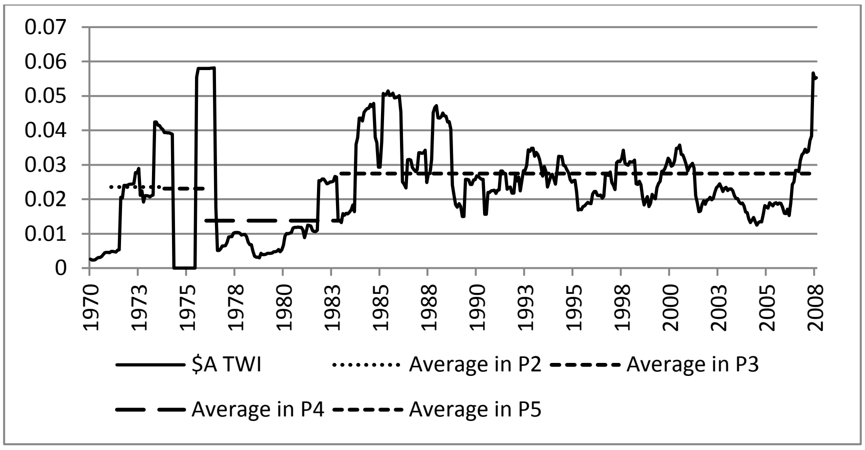
Australia's effective exchange rates after the floating of the Australian dollar in 1983 showed that Australian's international competitiveness had increased (see Figure 2.4). Real effective exchange rates through nominal effective exchange rates being adjusted for CPI between trading partners presents the overall international price and a country's international competitiveness. The sharp depreciation of the real exchange rate in the mid-1980s and early 2000s enhanced Australia's international competitiveness to its highest level for more than two decades.

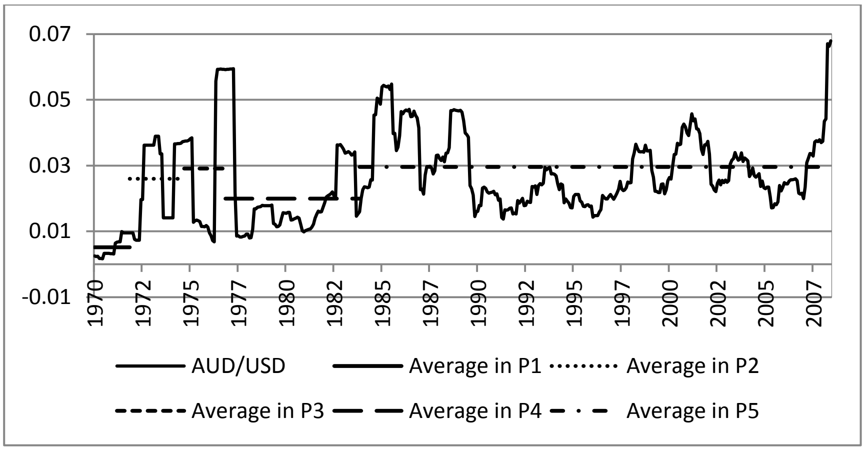
After shifting to the floating exchange rates, Australia was not totally free to implement any fiscal and monetary policies as it still had to take into account the influences of fiscal and monetary policies on output, employment and prices. Thus, Australia tried to implement a positive exchange rate policy which resulted in an appropriate rate for stabilising the economy and achieving balance of payments. For example, with a rise in the nominal wage, real wages increase and employment declines below a desired level. The resulting monetary expansion leads to the depreciation of the exchange rate, an increase in prices and a reduction in real wages. Therefore, through this approach monetary policy and its impact on the exchange rates follow the movements of wages rather than guiding them (Corden, 2002, p. 27).

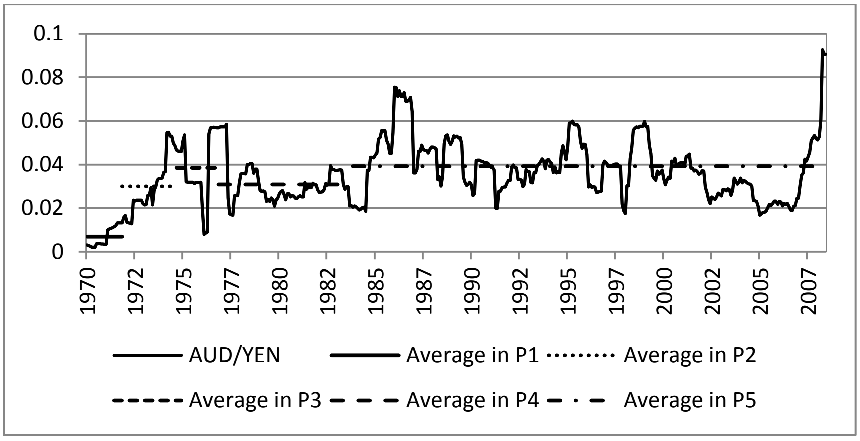
Under the floating exchange rate regime the exchange rate also played an important role in inflation. With the previous fixed-exchange-rate regimes, the Australian economy brought in the inflation rate from the pegged country or group of trading partners. When the exchange rate was floated in 1983, changes in the exchange rate directly affected inflation, but the degree of the impact on the inflation changed over time. The pass-through effect that the changes of exchange rate had on consumer price inflation via the price changes in tradable goods and services becomes more lengthened (Heath, Roberts & Bulman, 2004).

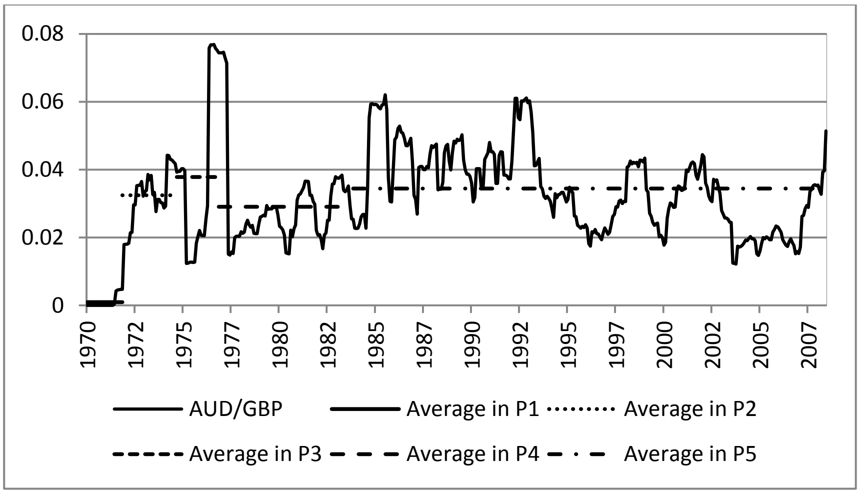
Figure 2.10 depicts the volatility of the Australian dollar during each regime. The calculation is based on the moving standard deviation of the first difference of the logarithm of trade-weighted exchange rate of Australian dollar and the bilateral exchange rate between AUD and USD, YEN and GBP, respectively. The results indicate that the average volatility of the exchange rates has been greater since the Australian dollar floated in December 1983.

Figure 2.10: Australian dollar volatility (moving standard deviation of the first difference of the logarithm of bilateral exchange rate), monthly data





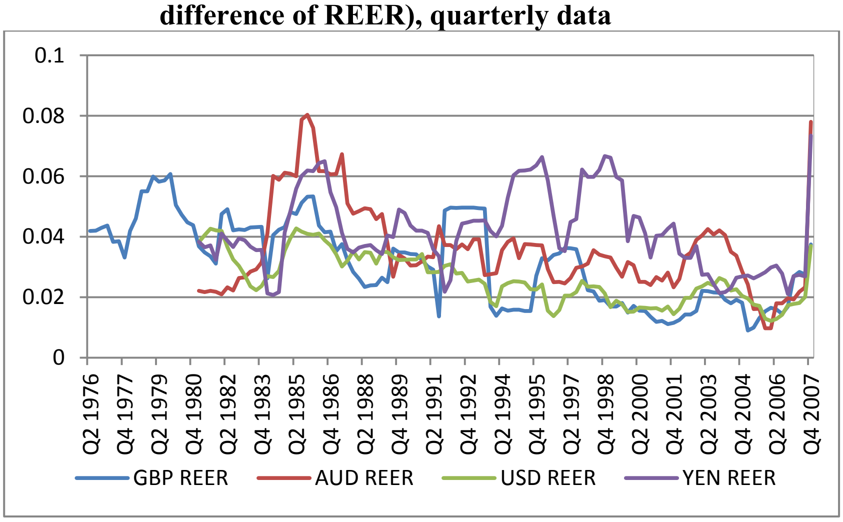




Note: P1: Pegged to GBP, from January 1950 to November 1971.
P2: Pegged to USD, from December 1971 to September 1974.
P3: Pegged to TWI, from October 1974 to November 1976.
P4: Crawling peg to TWI, from December 1976 to November 1983.
P5: Floating regime, from December 1983 to June 2008.

Source: RBA, 2008a. Table F11: Exchange rates, monthly data.

Figure 2.11: Exchange rate volatility (moving standard deviation of the first difference of REER), quarterly data



Source: IMF, 2008, *International Financial Statistics (IFS) database*.

There has been a significant change in both the structure of Australia's capital flows and their proportion to the GDP since the floating of the exchange rate and the abandonment of capital controls. In the previous exchange rate regime, the capital inflows were mainly in the equity instrument. After the floating of the exchange rate, debt-based capital inflows have gradually become the dominant form, with the percentage of the GDP increasing from 6 in 1980 to 52 in 2007. Table 2.6 demonstrates that there have been considerably significant changes in the stock of foreign liabilities and assets in the past three decades. Also the composition of these stocks changed noticeably due to the composition change in capital flows.

Table 2.6: Stock of foreign liabilities and assets (per cent of GDP)

	1980	1983	1995	2007
Total foreign liabilities	30.2	38.7	90.5	153.3
Equity	17.6	16.5	35.4	60.4
Debt	12.6	22.2	55.1	92.9
Total foreign assets	9.5	12.1	38.0	91.9
Equity	2.9	3.5	22.1	51.0
Debt	6.6	8.7	15.9	40.9
Net foreign liabilities	20.7	26.6	52.5	61.4
Equity	14.7	13.0	13.3	9.4
Debt	6.0	13.6	39.2	52.0

Source: ABS, 2008a & 2008b. Australian National Accounts: National income, expenditure and product (Cat. No, 5206.0), Table 30 (GDP, current prices); Balance of payments and international investment position (Cat. No, 5302.0), Tables 2, 3 and 4.

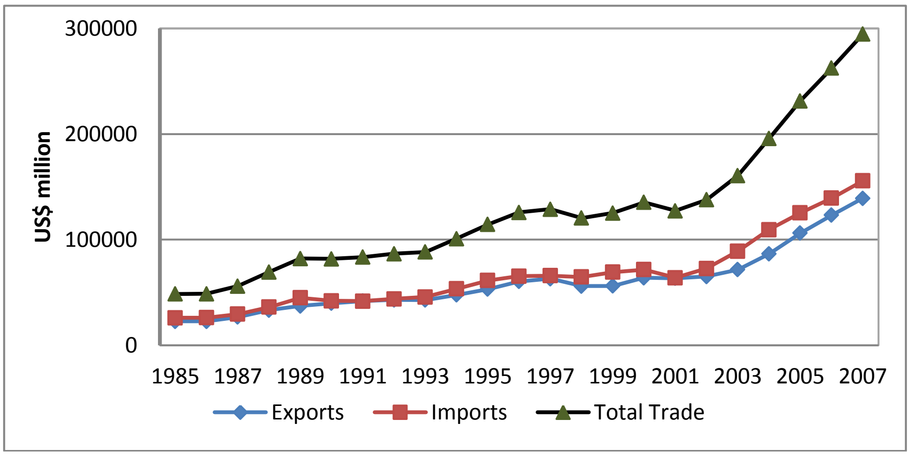
Over the past three decades, Australia's net foreign liabilities, including debt and equity relative to GDP, more than tripled to reach 61.4 per cent at the end of 2007. Australia has used these foreign savings to build up assets in order to save domestic incomes; however, the income increase which generates assets investment does not match the growth in Australian foreign liabilities, so Australia has had to borrow from overseas to support its domestic consumption. Furthermore, this indicates a decrease in Australia's net worth as a percentage of GDP and a weakening balance sheet for Australia proprietary limited company, reflecting the institutional atmosphere in favour of consumption more than savings and debt more than equity. Another major use of the increased foreign liabilities is to support increased "Australian ownership of foreign companies and other foreign assets" (Business Council of Australia, 1990, p. 49).

Because all Australian external liabilities are denominated in Australian dollars while all of its assets are in foreign currency, which is quite similar to the situation in the U.S., the depreciation of the Australian dollar decreases the amount of Australia's net foreign liabilities (Debelle & Plumb, 2006).

2.3 Statistical Analysis of Australia's Merchandise Trade

During the last two decades, Australia's total merchandise trade rose by 507.9 per cent to the value of US$294.8 billion in 2007. Australia exported goods and services valued at US$139.1 billion and imported goods and services worth US$155.7 billion in 2007, up 515 per cent and 501 per cent respectively compared to 1985. The deficit of goods and services imports over exports, at US$16.5 billion in 2007, was the largest during the period. Only in 1991 was there a trade surplus, worth US$0.2 billion. As shown in Figure 2.12, a growing trade deficit has been experienced in Australia in the past eighteen years, with the trend of further broadening.

Figure 2.12: Total trade in goods and services in Australia, 1985-2007



Source: WTO, 2008.

2.3.1 Trends in exports

Table 2.7 shows data on Australia's merchandise exports by commodities, tabulated by three-yearly intervals from 1996 to 2005. Overall, total merchandise exports rose by 66.7 per cent up to AU$126.7 billion in 2005. Primary goods show a larger export increase (78.9 per cent) than manufactured goods (50.4 per cent) during the period considered. The weight of primary goods in the total exports rose from 57.2 per cent in 1996 to 61.4 per cent in 2005. Among the primary goods the top three export commodities are: Mineral fuels, lubricants and related materials; Crude materials; and Food and live animals. These account for 23.1, 20.3 and 15.4 per cent respectively of the total exports in 2005.

Table 2.7: Australia's merchandise exports by commodities (three-yearly intervals), 1996-2005 (AU$million)

Commodity (SITC section)	1996	1999	2002	2005	Change % (1996-2005)
Total	76004	86000	121108	126718	66.7
Primary goods	43499	48449	72628	77830	78.9
Food and live animals	15272	15453	22380	19550	28.0
Beverages and tabacco	648	1238	2360	2934	352.8
Crude materials, inedible, except fuels	14752	17219	22448	25717	74.3
Mineral fuels, lubricants and related materials	12590	14162	25130	29300	132.7
Animal and vegetable oils, fats and waxes	237	377	310	329	38.8
Manufactured goods	32503	37552	48481	48888	50.4
Chemical and related products, n.e.s.	3015	3575	5293	5937	96.9
Manufactured goods classified chiefly by material	9844	10117	13572	12335	25.3
Machinery and transport equipment	9720	10324	14160	12426	27.8
Miscellaneous products	2717	3447	4483	4377	61.1
Commodities and transactions not classified elsewhere in the SITC(b)	7207	10089	10973	13813	91.7

Note: Data are on a fiscal year basis, years ending 30 June.
Source: Compiled from ABS (1998, 2000, 2004, 2006), International Merchandise Trade, Cat. No. 5422.0.

Beverages and tobacco (352.8 per cent) is the sector with the highest percentage change in exports during the period, followed by Mineral fuels, lubricants and related materials (132.7 per cent), then Chemical and related products (96.9 per cent). The other fast growing commodities in the period include Commodities and transactions n.e.s., Crude materials (inedible, except fuels) and Miscellaneous products. All sectors have seen increases in exports to varying degrees.

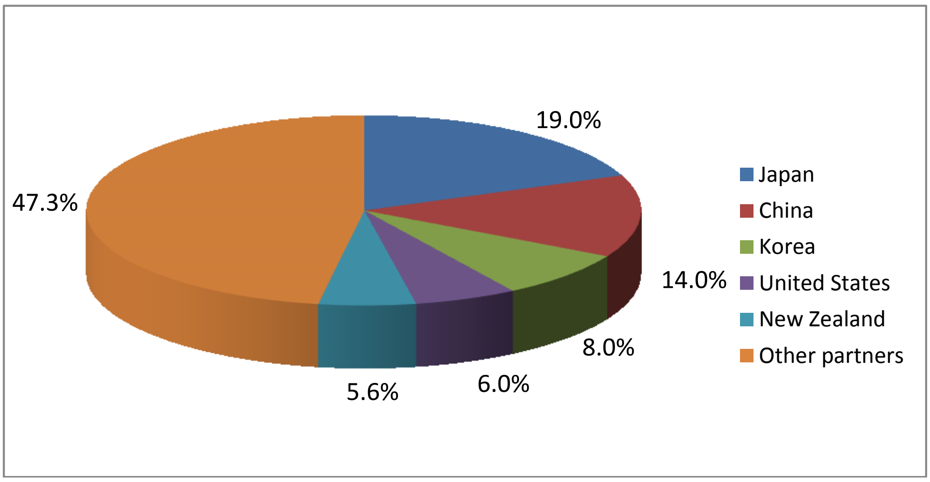
Table 2.8: Australia's top exported commodities in 2007

Code	Description (Export)	Trade Value (US$million)	Percentage (%)
27	Mineral fuels, mineral oils and products of their distillation	31648	22.7
26	Ores, slag and ash	22808	16.4
71	Natural or cultured pearls, precious or semi-precious stones	10222	7.3
99	Commodities not specified according to kind	8449	6.1
28	Inorganic chemicals	5521	4.0
*	Other commodities	60474	43.5

Source: Comtrade database, 2008. Selected classification: HS2002.

Table 2.8 shows Australia's top five exported commodities in 2007 which accounted for more than half (56.5 per cent) of Australian total exports. Australia's export specialisation in primary products is due mainly to the relatively large endowment of resources per worker in Australia (Pomfret, 1995, p. 89).

Figure 2.13: Australia's top export partners in 2007



Source: Compiled from Comtrade database (2008).

Figure 2.13 shows that Australia's top five export destinations in 2007 were (in order) Japan, China, Korea, US and New Zealand. These five countries accounted for more than half (52.7%) of Australia's exports in 2007. Early statistics show that in 2001 (fiscal year), Australia's top five export partners were (in order) Japan, US, Korea, New Zealand and China, together accounting for 49 per cent of Australia's exports. Therefore, since 2000, China has moved from fifth place to second in 2007, while Japan has remained in the number one position.

2.3.2 Trends in imports

Using data for three-yearly intervals Table 2.9 shows how Australian imports by commodities have increased from 1996 to 2005. During the period, total merchandise imports rose by 92.2 per cent up to AU$149.5 billion in 2005. Primary goods (151.5 per cent) have a higher percentage change than manufactured goods (83.9 per cent). The fastest growing sectors include Mineral fuels, lubricants and related materials (up 250.7 per cent); Beverages and tobacco (up 96.2 per cent); and Food and live animals (up 93.3 per cent). All sectors experienced varying degrees of increase in imports.

Table 2.9: Australia's merchandise imports by commodities (three-yearly intervals), 1996-2005 (AU$million)

Commodity (SITC section)	1996	1999	2002	2005	Change % (1996-2005)
Total	77792	97623	119649	149522	92.2
Primary goods	9554	10909	16552	24024	151.5
Food and live animals	2894	3760	4613	5594	93.3
Beverages and tobacco	504	622	864	989	96.2
Crude materials, inedible, except fuels	1576	1611	1756	1947	23.5
Mineral fuels, lubricants and related materials	4311	4620	9030	15118	250.7
Animal and vegetable oils, fats and waxes	269	296	289	376	39.8
Manufactured goods	68238	86715	103097	125498	83.9
Chemical and related products, n.e.s.	8901	11434	14635	17482	96.4
Manufactured goods classified chiefly by material	11040	12859	14819	17725	60.6
Machinery and transport equipment	36459	45425	53654	67058	83.9
Miscellaneous products	11035	14466	17416	20528	86.0
Commodities and transactions not classified elsewhere in the SITC(b)	803	2531	2573	2705	236.9

Note: Data are on a fiscal year basis, years ending 30 June.
Source: Compiled from ABS (1998, 2000, 2004, 2006). International Merchandise Trade, Cat. No. 5422.0.

Although the percentage change of manufactured goods in imports is smaller than primary goods during the period, manufactured goods dominate Australia's total imports, accounting for 83.9 per cent at the beginning and 88.8 per cent at the end of the period. This dominance reflects the nature of Australia's merchandise trade: an exporter of agricultural and resource-based primary goods and importer of manufactured goods from the rest of the world.

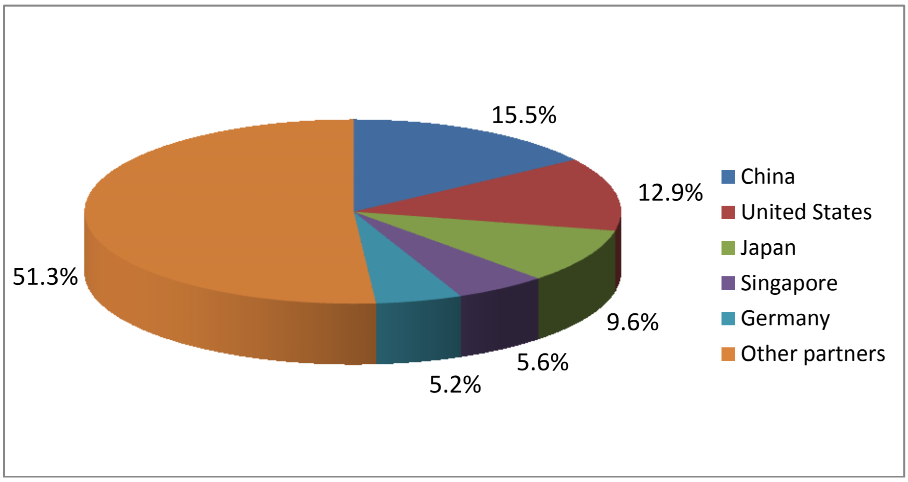
Table 2.10: Australia's top imported commodities in 2007

Code	Description (Import)	Trade Value (US$million)	Percentage (%)
84	Machinery and mechanical appliances; parts thereof	24865	16.0
87	Vehicles other than railway or tramway rolling stock	20631	13.3
27	Mineral fuels, mineral oils and products of their distillation	20178	13.0
85	Electrical machinery and equipment and parts thereof; sound recorders and r	17153	11.0
71	Natural or cultured pearls, precious or semi-precious stones	6547	4.2
*	Other commodities	66284	42.6

Source: Comtrade database, 2008. Selected classification: HS2002.

Table 2.10 shows Australia's top five imported commodities in 2007. Figure 2.14 illustrates that in 2007, among Australia's top import partners, US lost its historical place as Australia's largest import partner with China moving to first place at 15.5 per cent, followed by US, Japan, Singapore and Germany.

Figure 2.14: Australia's top import partners in 2007



Source: Compiled from Comtrade database (2008).

2.3.3 Australia's trade direction

Table 2.11 highlights Australia's two-way trade direction after 1980. Among the single country export markets, Japan remains in the lead, although its relative significance has slowly decreased, similar to the experience of the US. It is obvious that China and ASEAN countries are increasingly important as export destinations for Australia's products. New Zealand has had a relatively stable position on Australia's export market rankings in the past decade.

Table 2.11: Australia's trade direction after 1980 (percentage of total)

	1980	1985	1990	1995	2000	2005
Exports						
UK	5.0	3.1	3.5	3.4	4.3	3.8
USA	10.9	11.6	10.9	6.9	9.8	7.4
ASEAN	7.5	7.5	10.3	15.4	13.2	11.7
Japan	26.9	26.9	26.1	24.3	19.3	19.7
China	4.5	3.6	2.4	4.4	5.1	10.2
Korea	2.1	3.9	5.5	7.9	7.8	7.7
Hong Kong	1.5	2.8	2.7	3.9	3.3	2.1
New Zealand	4.6	5.2	5.3	7.1	6.9	7.2
All others	37.0	35.4	33.3	26.6	30.2	30.1
Imports						
UK	10.2	6.8	6.5	5.9	5.8	4.0
USA	22.1	22.1	24.1	21.5	20.9	14.2
ASEAN	6.2	5.7	5.8	8.6	14.0	16.4
Japan	15.6	22.7	19.2	17.1	12.8	11.5
China	1.2	1.3	2.4	4.9	6.8	13.3
Korea	0.9	1.6	2.4	2.7	3.9	3.3
Hong Kong	2.3	2.3	1.7	1.2	1.2	0.8
New Zealand	3.4	3.8	4.2	4.8	4.0	3.6
All others	38.2	33.7	33.6	33.3	30.6	33.0

Note: ASEAN countries include Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. Data are on a fiscal year basis, years ending 30 June.

Source: Yang and Siriwardana 2007, p. 40, Table 3.6. (ABS, international merchandise trade, Cat. No. 5422.0).

As the source of Australia's imports, China's share has increased remarkably from 1.2 per cent up to 13.3 per cent of Australia's total imports during the period. The group of ASEAN countries has a larger share in 2005 than at the beginning of the period. However, Japan and the US still dominate as the largest sources of Australian imports. This analysis indicates that Australia's trade pattern is experiencing a geographical change, with China and ASEAN countries sharing more of Australia's market which used to be occupied by Japan and the US. This point shows that China as a world powerhouse is gaining more share for its products in Australia's market. On the other hand, the importance of the UK as a major partner of Australia's imports is gradually decreasing as a share of Australia's total imports from 10.2 per cent in 1980 to 4.0 per cent in 2005.

2.4 Concluding Remarks

In summarising Australian exchange rate policy, it is obvious that the rationale behind policy changes on exchange rate regime and the abandonment of capital restrictions was the changing economic and monetary conditions both worldwide and domestically. This chapter documents the historical background of each regime and how each exchange rate regime worked. While discussing the major movements in the Australian dollar's exchange rate, some influences have been particularly highlighted, including Australia's terms of trade, foreign indebtedness, domestic resources boom and interest differentials at both the short and long end (Blundell-Wignall, Fahrer & Heath, 1993).

Trade flows between countries create demand and supply for a currency. The statistical analysis of Australia's merchandise trade shows that Australia's trade pattern is experiencing a geographical change. This could be a critical factor in moving the Australian dollar's exchange rates.

Chapter 3
Trade Theory about Exchange Rate Volatility's Impact on Trade

3.1 Introduction

The relationship between exchange rate volatility and international trade is always under the debate. The impact of exchange rate volatility on trade depends on different assumptions and different measurements of the volatility in different theories.

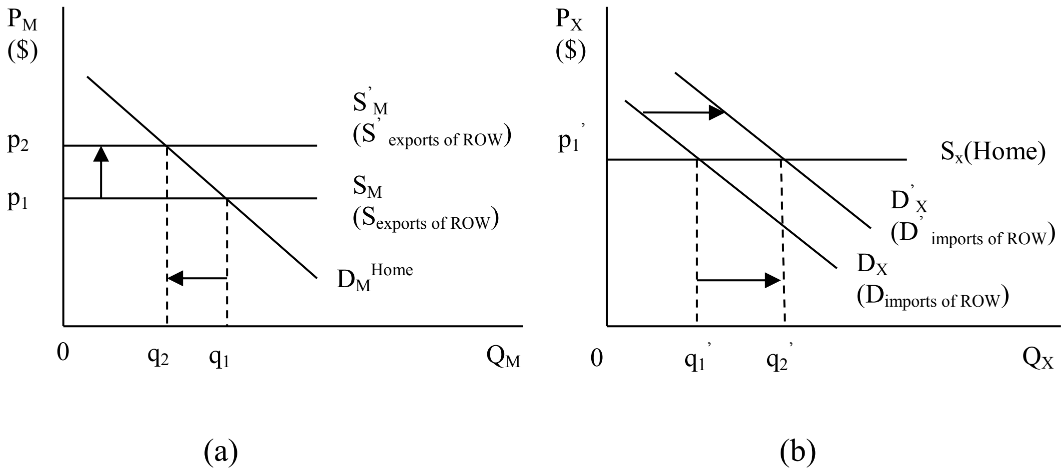
This chapter attempts to provide different theories on the impact of exchange rate volatility on the trade for a country. The chapter is divided into six sections. An introductory overview is followed by section two which overviews standard trade theory. Section three is concerned with the Marshall-Lerner condition. Sections four and five analyse the J-curve phenomenon and the exchange rate pass-through effect together with some relevant empirical studies. Concluding remarks end the chapter in section six.

3.2 Standard Trade Theory Related to Exchange Rate

International trade involves both imports and exports. The export price compared with the price of foreign goods plays an important role in the volume of exports. If there is domestic currency depreciation, it follows that domestic products will become relatively cheaper, resulting in an increase in the export volume. Home country currency depreciation means that there is an increase in the home currency price of the foreign currency (Appleyard et al., 2006, p. 468). Figure 3.1 shows both import and export market effects with the changes in the foreign exchange rate.

In Figure 3.1, the supply curves of both imports and exports in the home country are horizontal, indicating that the supply of exports in both countries is infinitely elastic, a depreciation of the home currency will result in two effects. As shown in panel (a), the import supply curve will shift upward from S_M to S'_M because of the higher domestic price of imports in the home currency. The depreciation effect on the imports value depends on the imports demand elasticity. Prior to the depreciation, the import outlays were p_1q_1, and after the depreciation they are p_2q_2. If import demand is elastic, the depreciation reduces import outlays. If import demand is inelastic, the depreciation leads to a growth in the import outlays value in dollar terms.

Figure 3.1: Market effects of foreign exchange rate change

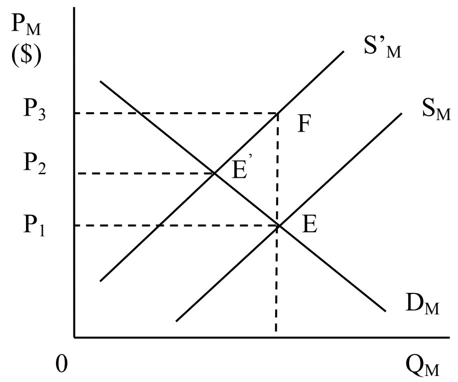


Source: Appleyard et al., 2006, p. 570, Figure 6.

In panel (b), the export demand curve shifts right from D_X to D'_X due to the relatively cheaper home-country exports in the foreign currency price. The export receipts value increases because a larger quantity q'_2 is purchased at a constant-dollar price. Given the two effects displayed in panel (a) and panel (b), therefore, the eventual depreciation impact on the current account balance can be positive or negative depending on the demand elasticity in each country for the other country's goods and services (Appleyard et al., 2006, p. 570).

Alternatively to the infinite elasticity shown in Figure 3.1, Figure 3.2 shows the supply curve sloping upwards to the right, indicating that the foreign supply of traded goods is not infinitely elastic. The home currency's depreciation will shift the supply curve upward from S_M to S'_M: the difference between S_M and S'_M is the same as the exchange rate percentage change by a constant price percentage. As demonstrated in Figure 3.2, the new equilibrium price P_2 reflects a smaller growth in domestic price relative to the original price p_1 in terms of the effect of the currency depreciation EF. Such import price change reflects the elasticities of both demand and supply of the traded goods and is less than the exchange rate percentage change (Appleyard et al., 2006, p. 571).

Figure 3.2: Import market response to changes in the foreign exchange rate when foreign supply is not infinitely elastic



Source: Appleyard et al., 2006, p. 571, Figure 7.

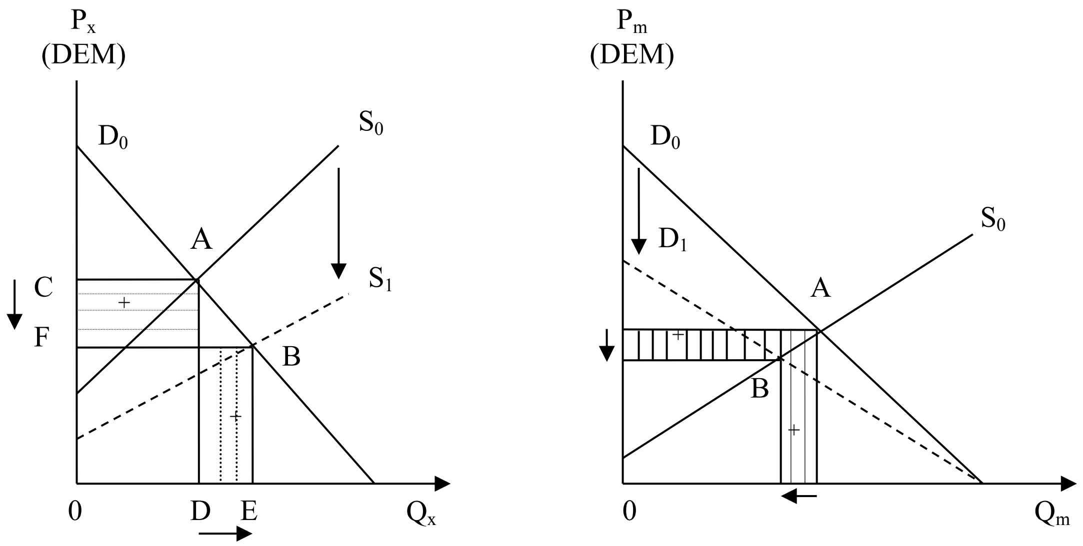
3.3 Marshall-Lerner Condition

The Marshall-Lerner condition indicates whether the exchange market is stable or unstable. The condition verifies that the exchange rate market is stable if the sum of the absolute values of the domestic price elasticity of demand for imports and the price elasticity of demand for domestic exports is greater than 1, shown in the following formula, where X and M represent the total exports and imports values respectively and are stated in domestic currency (Appleyard et al., 2006, p. 571):

$$\frac{X}{M}\left|\eta_{D_x}\right| + \left|\eta_{D_m}\right| > 1 \qquad (3.\ 1)$$

Figure 3.3 illustrates the impact of a 20 per cent improvement in the level of competitiveness on the export and import markets. Both export price P_x and import price P_m are expressed in foreign currency, *in casu* in DM. The two markets are assumed to be in equilibrium at point A before the competitiveness change (Nielsen et al., 1995, p. 180).

Figure 3.3: Export and import markets under 20 per cent depreciation of home currency



(a) Export market (b) Import market

Source: Nielsen et al., 1995, p. 181, Figure 11.2.

In panel (a), the export supply curve shifts vertically downwards by 20 per cent due to a 20 per cent increase in the competitiveness level, and domestic costs are also reduced. The export price declines whereas the volume increases since the foreign demand for exports (in DM) remains the same. Export revenue, illustrated by the area of 0CAD, may change. The effect on export revenue depends on export demand elasticity. If it is numerically greater than one, the export revenue will increase. If it is numerically smaller than one, the export revenue will decline, and if it is equal to one, the revenue remains the same as before (Nielsen et al., 1995, pp. 180-181).

In the import market (see Panel (b)), the supply curve is not affected by the competitiveness change while the foreign cost level remains unchanged with respect to the foreign currency. The demand curve shifts vertically downwards by 20 per cent due to the reduced domestic price resulting from the competitiveness improvement. Thus, if the home country retains the same import volume, the import price will decrease correlatively with the foreign currency. But if we consider that the domestic product will also be increased with the competitiveness improvement, the import volume will also increase and import demand will move to the right. In such a situation, the demand curve will shift downward by less than 20 per cent (Nielsen et al., 1995, p. 181).

As to the import revenue changes in terms of foreign currency, the import expenditure in terms of the foreign currency will decrease since import price in DM and the import volume reduces with the improvement in competitiveness. As a consequence, the trade balance (*X-M*) will improve if export demand elasticity is elastic. Such a condition is too narrow since there is a decrease in the import expenditure at the same time. However, it is likely that the sum of the elasticities of both import and export demand is larger than one. This general condition for exchange market stability is called the Marshall-Lerner condition (Robinson, 1947; Nielsen et al., 1995, p. 181; Appleyard et al., 2006, p. 571):

$$|\eta_{D_x}| + |\eta_{D_m}| > 1 \qquad (3.2)$$

However, in the above condition, supply elasticities are 'presupposed' to be infinitely large and the trade account is in an initial equilibrium. If the initial trade account is in a disequilibrium situation, the condition is as follows (Nielsen et al., 1995, p. 181):

$$|\eta_{D_x}| + \frac{M}{X}|\eta_{D_m}| > 1 \qquad (3.3)$$

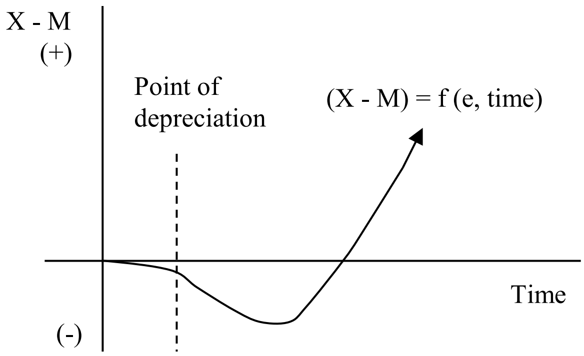
Where, *M* and *X* represent the value of imports and exports, respectively, prior to the competitiveness improvement, denominated by the foreign currency. If *M* and *X* are expressed in the domestic currency, the condition has formula 3.1 above (Nielsen et al., 1995, p. 182; Appleyard et al., 2006, p. 571).

3.4 The J-curve Effect

The previous sections have discussed the standard theory concerning the market effects of foreign exchange rate changes and the Marshall-Lerner condition regarding whether the exchange market is stable or not. Sometimes there are no expected responses from exchange rate changes. In particular, the relative price effect, such as a depreciation causing exports to rise and imports to fall, does not happen frequently, particularly when an exchange rate change has an improper effect on the current account in the short-run due to time lags.

Normally, import and export contracts are negotiated in advance of actual delivery and payment. If import contracts are stated in the exporter's currency, when the importing country depreciates its currency, the value of the imports will actually increase in terms of that currency (Ingram, 1983, p. 214). On the other hand, exports will not be immediately affected by the depreciation. Therefore, the current account balance will be worsened at first because of the rising imports and constant exports. But with the passage of time, the price effects do gradually have an impact on both consumers and producers so trade deficit will begin to narrow. This lagged response of the current account balance to the currency depreciation traces out a locus which resembles the letter J. Thus, it is referred to as the J-curve effect (see Figure 3.4) (Appleyard et al., 2006, p. 578).

Figure 3.4: The J-curve effect



Source: Appleyard et al., 2006, p. 578, Figure 10.

Aside from the timing matter, empirical researches find that the current account imbalances are unusually immovable and resistant to the exchange rate changes. For example, the trade surpluses in Germany and Switzerland continued firmly even when the currencies in those two countries appreciated 30 to 40 per cent, and the US trade deficit persisted even after significant dollar depreciation occurred during certain intervals (Ingram, 1983, p. 214).

There are a number of research papers that test the J-curve effect in reality. Some empirical researches believe the existence of the J-curve phenomenon whereas others do not provide the evidence to support the J-curve effect. Bahmani-Oskooee and Ratha (2004) in their review paper of the J-curve, classify all empirical researches into two groups. The first group uses aggregate trade data to test the J-curve. These include Bahmani-Oskooee (1985), Himarios (1989), Bahmani-Oskooee (1991), Backus et al. (1994), Bahmani-Oskooee and Alse (1994), Demirden and Pastine (1995), Brada et al. (1997) and Gupta-Kapoor and Ramakrishnan (1999). The results from this group are mixed with not much support for the J-curve hypothesis either in the short-run or in the long-run. The second group employs bilateral trade data. These include Rose and Yellen (1989), Marwah and Klein (1996), Bahmani-Oskooee and Brooks (1999) and Bahnami-Oskooee and Goswami (2003). They find that there is no strong support for the J-curve with the long-run effects resulting from the currency depreciation being satisfactory in many cases (Bahmani-Oskooee & Wang, 2006).

There are also some other empirical studies, such as Hacker and Hatemi-J (2003), confirming the existence of the J-curve effect, and providing evidence supporting the J-curve phenomenon in Sweden together with four other small European countries (Backman, 2006). Bahmani-Oskooee et al. (2005) show that domestic consumption, international competitiveness of tradable goods and changes in regards to trade also have an impact on the J-curve effect (Backman, 2006). But Hsing (2005) finds no J-curve effect.

Generally, it seems that the J-curve phenomenon arises from prefixed contracts. However, nowadays most developed countries use foreign currency to state their nominal trade balance, import and export prices. In this situation, existing contracts cannot explain the J-curve effect. On the other hand, the J-curve phenomenon can be demonstrated by the extent of foreign exchange rate pass-through as well as the short-run price elasticities of both import and export demands if the country's trade balance is stated in the foreign exchange rate. The degree of the J-curve is determined by the short-run scale of exchange rate pass-through; the degree becomes higher as the pass-through scale increases (Han & Suh, 1996; Backman, 2006).

3.5 Exchange Rate Pass-Through Effect

Exchange rate pass-through has been a concern of both theoretical and empirical examinations (Parsley, 1993). The Marshall-Lerner condition for market stability indicates that the currency depreciation would decrease current account deficits and the currency appreciation would increase current account deficits as long as the sum of the absolute values of the foreign and domestic elasticities of import demands is larger than one. In such a situation, the exchange rate changes lead to appropriate shifts in expenditures between domestic and foreign goods. With a current account deficit, the home currency depreciation causes foreign goods to become more expensive, which results in decreased consumption of imports and increased consumption of domestic substitutions. Meanwhile, home exports become comparatively cheaper to foreign buyers, thus there is an increase in the export volume.

The above analysis generally assumes that both consumers and producers react immediately and that supply prices remain unchanged although there is a switch in expenditures in both countries (infinitely elastic supply). Meanwhile, it also ignores likely impacts on income, the interest rate and other variables. Moreover, it assumes that the exchange rate changes are passed on in full to the product prices in the buying country. Therefore, for example, a 10 per cent increase in the exchange rate (depreciation of the home currency) causes a 10 per cent decrease in the prices of the domestic products to foreign consumers and a 10 per cent rise in the prices of the foreign goods to domestic consumers. This is called complete exchange rate pass-through (Appleyard et al., 2006, p. 573). However, in reality, exchange rate pass-through is rarely 100 per cent. Empirical studies show that the exchange rate pass-through can have both partial and complete effects.

Krugman (1987) suggests that from the early to mid-1980s, foreign exporters to the US market pass-through only about 60 to 65 per cent of the real appreciation of the US dollar to their US buyers.

Hooper and Mann (1989) test the impact of exchange rate changes on the U.S. import prices for manufactured goods. They find that about 50 to 60 per cent of the nominal exchange rate change is reflected in the manufactured import prices.

Kim (1990) estimates the import-price function in the US through a varying-parameter model. The results indicate that in the short-run, the changes in the non-oil import-price respond to exchange rate changes less than to the changes in foreign-cost since the generalised exchange rate floating in the early 1970s. Meanwhile, the markup has differed largely, falling when the dollar declined and rising when it went up.

Menon (1993) tests the exchange rate pass-through effect on the prices of Australian passenger motor vehicle imports for the 1980s by applying a model associating the import pricing decision to exchange rate changes in order to estimate production costs and competing prices. Menon finds that in the long-run, there is incomplete pass-through of exchange rate changes to import prices.

Athukorala and Menon (1994) examines the relationship between the exchange rate changes and Japanese export pricing performance. The results show that there is a pervading incomplete exchange rate pass-through. Also the estimates that catch only pricing to market performance might over-emphasise the extent of the exchange rate pass-through to the degree that production cost is sensitive to the exchange rate changes.

Lee (1997) finds that Korea's domestic market concentration automatically affects the exchange rate pass-through of individual sectors. The results indicate that there is only partial exchange rate pass-through to Korea's import prices, which suggests that there is a relationship between the imperfect competition and the exchange rate pass-through even in a small economy (i.e. Korea).

Yang (1997) examines exchange rate pass-through in the US manufacturing industries and its cross-sectional variation by employing an adapted Dixit-Stiglitz product differentiation model. The pass-through elasticities estimates show that pass-through is incomplete and differs across industries. There is a positive correlation between the degree of exchange rate pass-through and different proxies for product differentiation, a negative correlation between the degree of pass-through and a proxy for the elasticity of marginal cost.

Campa and Goldberg (2005) investigate twenty-five OECD countries by using cross-countries and time series evidence and find that across the OECD countries, particularly with the manufacturing industries, there exists strong evidence for partial pass-through in the short-run, whereas in the long-run producer-currency pricing is more widespread for many kinds of imported goods. Also they find that higher exchange rate pass-through into import prices is weakly associated with higher inflation and exchange rate volatility.

Dixit (1989) finds that the pass-through of the exchange rate to the prices of domestic goods is about one in the stages where foreign companies enter or exit, and around zero in all other situations.

Parsley (1993) examines the exchange rate pass-through into Japanese exports at both aggregate and disaggregated sectoral levels during the 1980s. The results show that pass-through elasticities vary substantially among sectors with sectoral differences in pass-through consistent with even simple pass-through theories. In particular, aggregate pass-through can differ simply because of the aggregation effects, even with constant pass-through in each industry. This indicates the possibility that aggregation effects of this kind are a factor behind recent findings of a decrease in pass-through in US imports.

Kardasz and Stollery (2001) examine the exchange rate pass-through into the real prices of domestically produced and imported goods in the Canadian manufacturing sectors by pass-through elasticities estimates as well as a cross-sectional analysis of their determinants. They find that the domestic exchange rate pass-through elasticity rises with the impact of the exchange rate on domestic production costs, the export share, the substitution elasticity between imports and domestic goods, and the domestic advertising intensity. Import elasticity rises with the substitution elasticity and the price protection rate, and declines with advertising intensity.

Dwyer et al. (1993) tests exchange rate pass-through into the prices of both imports and manufactured exports and finds that exchange rate pass-through differs heavily with regard to the pass-through speed and its pattern in the short-run. Pass-through to import prices is much quicker than that to the export prices of the manufactured goods. However, there is a complete exchange rate pass-through for both imports and exports in the long-run.

Trade economists have identified some factors which may explain why there is unlikely to be a total 100 per cent complete exchange rate pass-through in reality. For example, the degree of pass-through has been found to have a relationship with the size of the export market economy (Khosla & Teranishi, 1989), the industry concentration level in the target country (Feinberg, 1986, 1989), whether the export market is in an appreciation or a depreciation phase (Kreinin et al., 1987; Marston, 1990) and the percentage of foreign exporters to domestic firms (Dornbusch, 1987; Feinberg, 1986), etc. (Clark et al., 1999).

3.6 Concluding Remarks

In summarising the trade theory about the impact of exchange rate changes on trade, it is important to remember that every theory has some important assumptions. Besides overviewing foreign trade patterns in terms of standard trade theory, the Marshall-Lerner condition, the J-curve phenomenon and the exchange rate pass-through effect, this chapter also classifies some related empirical studies. The relationship between exchange rate changes and import and export levels is explained.

However, the exchange rate is a two-edged sword (Miller & Leptos, 1987, p. 69). While the relatively low home currency exchange rate may stimulate exports, it also makes off-shore activities more expensive with payment in the home currency.

Chapter 4
Review of Empirical Studies of Exchange Rate Volatility's Impact on Trade

4.1 Introduction

There is a large body of literature about the effects of exchange rate volatility on trade flows during the last three decades. Since the IMF (1984) study started the literature survey on this topic, two large reviews were undertaken by McKenzie (1999) and Bahmani-Oskooee and Hegerty (2007). Those surveys in total cover a wide range of literature on the effects of exchange rate volatility on trade flows, testing both the theory and the empirical results up to 2005, and concluding that theoretically there is no consensus on the topic since different results can be obtained with reasonable alternative assumptions and modelling techniques. Since the last review by Bahmani-Oskooee and Hegerty (2007), the literature has almost doubled, and new volatility measures, new estimation methods and new models have been introduced. It is necessary to review the current literature to determine the current views in this field.

The objective of this chapter is to provide an overview of the empirical studies about the exchange rate volatility's impact on trade performance and to describe in detail the measures used to generate exchange rate volatility, the estimation techniques and the estimation results. The chapter has six sections. The introduction is followed by section two which surveys the measures used to generate exchange rate volatility. Section three provides the specifications for trade equations. Section four describes techniques used in empirical studies. Section five is organized according to the aggregate, bilateral and sectoral trade data levels used by the empirical studies. Concluding remarks are in the sixth section at the end of chapter.

4.2 Measures of Exchange Rate Volatility

Todani and Munyama (2005) define exchange rate volatility as a measure that attempts to catch the uncertainty encountered by exporters and importers due to unforeseeable exchange rate fluctuations. In addition to exchange rate volatility, other terms have also been used in the literature with similar meaning, including exchange rate variability, exchange rate uncertainty, exchange rate risk and exchange rate instability (Brodsky, 1984). Since this is an unobservable variable, how to measure it is the most basic task when examining the effects of exchange rate volatility on trade. In the large amount of literature on exchange rate volatility and trade, there is no agreement on a suitable technique for measuring such volatility (Clark et al., 2004). Therefore, various measures have been devised and used to proxy the exchange rate volatility in different studies (see Table 4.1).

The most widely used measures of exchange rate volatility are based on the standard deviation of the first difference of logarithms of the exchange rate (Clark et al., 2004). Some researchers also use variance/deviation of spot exchange around its trend, residuals from ARIMA models, measures based on absolute change of the exchange rate, and measures based on the absolute difference between the previous forward and the current spot rate. A small number of researchers also use coefficient of variation of the exchange rate, long-run exchange rate uncertainty developed by Peree and Steinherr (1989), range of exchange rate, and a measure generated with a linear moment model. Some other measures are scattered in a few papers. However, it seems to be a trend that more and more researchers use some functional forms (ranging from a log function to a square root function, e.g. Kroner and Lastrapes (1993), Solakoglu (2005), to the conditional variance from an ARCH/GARCH process introduced by Engle (1982) and Bollerslev (1986) as volatility measures.

Each measure has its own characteristics. The measure based on the standard deviation of the first difference of logarithms of the exchange rate has the property of being zero in the presence of an exchange rate that follows a constant trend, and it gives a larger weight to extreme observations (consistently with the standard representation of risk-averse firms) (Dell'Ariccia, 1999). Its underlying assumption is that a constant trend would be absolutely anticipated and would not affect uncertainty. The measure based on the standard deviation of the level of the nominal exchange rate depends on the underlying assumption that the exchange rate moves around a constant level. In the presence of a trend this index would probably overestimate exchange rate uncertainty (Dell'Ariccia, 1999).

The measures based on moving average standard deviation catch the movements of exchange rate uncertainty over time. Their main characteristic is their ability to catch the higher constancy of real exchange rate movements in the exchange rate (Klaassen, 2004; Chit et al., 2010). The moving standard deviation of exchange rate changes with equal weights placed on past changes results in substantial serial correlation in the summary measure (Baum et al., 2004). In early studies, the volatility measure is based on the standard deviation of percentage changes in the exchange rate. For example, Lanyi and Suss (1982) define their volatility measure as a standard deviation of monthly percentage changes and argue that this measure gives the most suitable method of removing the trend in the exchange rate changes. Because de-trending the variables is not required by cointegration and error-correction techniques, rather than using the standard deviation of percentage change in the exchange rate, the later studies just use the standard deviation of the real exchange rate itself, for example De Vita and Abbott (2004a), Bahmani-Oskooee and Mitra (2008), Bahmani-Oskooee and Wang (2007), and Bahmani-Oskooee and Kovyryalova (2008).

A key characteristic of the standard deviation measure is that it gives weight to extreme volatility. Since the countries being considered focus on export promotion and their domestic markets cannot absorb the total production, their exports might not be affected by rather small volatility (Chit et al., 2010).

However, the standard deviation method has been reproached for wrongly assuming that the empirical distribution of the exchange rate is normal and for ignoring the distinction between predictable and unpredictable elements in the exchange rate process. Qian and Varangis (1994) argue that the moving standard deviation of past growth rates approach as a measure of volatility may incorrectly specify the stochastic process that generates exchange rate. In addition, as pointed out by Kroner and Lastrapes (1993), the test requires a two-step procedure, first calculating the volatility and then using it in the regression, which may lead to incapable estimators.

The moving standard deviation measure has been questioned on the grounds that it lacks a parametric model for the time-varying variance of exchange rates. Moreover, as assessed by Pagan and Ullah (1988), it is possible for it to suffer from a measurement error problem and, as such, produce biased estimators of the impact of risk on the economic agents' decision making (Boug & Fagereng, 2007).

ARCH models and their extensions name the variance of a variable as a linear function of the expected squares of the lagged value of the error term from an auxiliary regression determining the mean of the variable of interest (Arize et al., 2008). (G)ARCH-type models allow the capturing of non-constant time varying conditional variance, and thus are very useful in describing volatility clustering and certain other characteristics of financial time series, such as excess kurtosis and fat-tailedness (Cheong et al., 2002). Engle (1982) notes the conditional variance is 'of more relevance to economic agents planning their behavior'. Asseery and Peel (1991) state that 'from an optimizing perspective the conditional rather than unconditional second moment seems economically relevant'.

The GARCH model is suitable to capture stylised facts of the log foreign exchange rate process such as the martingale property, volatility clustering and leptokurtosis (Herwartz, 2003). However, the GARCH method has two distinct problems: first, the nonnegativity conditions of the variance may be violated by the estimated model; secondly, the models cannot account for leverage effects, although they can account for volatility clustering and leptokurtosis in the series (Yarmukhamedov, 2007).

After comparing GARCH and EGARCH models, Nelson and Cao (1992) argue that the nonnegativity constraints in the linear GARCH model are too restrictive. However, there are no restrictions on the parameters in the EGARCH model, and it is more efficient than previous measures (Yarmukhamedov, 2007).

Cotter and Bredin (2007) use Asymmetric Power ARCH (APARCH) to estimate exchange rate volatility. The model developed by Ding et al. (1993) advantageously nests many extensions of the GARCH process, including three ARCH specifications (ARCH, Non-linear ARCH and Log-ARCH), two specifications of the GARCH model, and two asymmetric models. It also makes it possible to incorporate leverage effects by letting the autoregressive term of the conditional volatility process be represented as asymmetric absolute residual. Non-linear GARCH models are derived from different power coefficients. Fat tails are allowed by the model by fitting with a conditional student-t distribution. The model also adequately deals with the second moment persistence for the underlying variables (Cotter & Bredin, 2007).

Arize et al. (2008) also employ another volatility measure generated by a linear moment (LM) model proposed by Antle (1983). This model describes the variance (and higher moments) of a variable as a linear (in the parameters) function of the regressors used in an auxiliary regression for the mean of the variable of interest (Arize et al., 2008). As Pagan et al. (1983) point out, "the major difference between the ARCH and LM methodologies lies in the type of alternative set up, with the former allowing the variance to be a function of previous forecast errors and the latter being conditional on past values of the explanatory variables".

Bonroy et al. (2007) point out that measures based on prediction errors from ARIMA or ARCH models have one serious flaw in that they are usually estimated over the whole sample and thus include information that is not available to agents.

The most successful applications utilising the ability of GARCH models to mimic the 'volatility clustering' are generally at high frequency (daily or intra-daily), and a GARCH model fitted to monthly data may find very weak persistence of shocks (Baum et al., 2004). However, the Merton's (1980) approach provides a more typical measure of the perceived volatility, avoiding potential problems such as high persistence of real exchange rate shocks when moving average representations are used, or low correlation in volatility when ARCH/GARCH models are applied to quantify exchange rate volatility (Baum et al., 2004). The advantage of Merton's measure is that it introduces intra-month variation in the exchange rate by using daily exchange rate data as it is generally available (Bonroy et al., 2007).

Some researchers consider the average absolute difference between the previous period forward rate and the current spot to be the best indicator of exchange rate risk. The advantage of this measure is that, under a target zones regime, or under pegged but adjustable exchange rates, it would pick up the effect of the presence of a 'peso problem' or the lack of credibility of the official parity (Dell'Ariccia, 1999).

Another possibility is to use the percentage difference between the maximum and the minimum of the nominal spot rate over t years preceding the observation, plus a measure of exchange rate misalignment. This index emphasises the importance of medium-run uncertainty. It is worth noting that the measures proposed as proxies for risk are backward-looking, the assumption being that firms use past volatility to predict present risk. Then, even if one could restrict the choice to a particular measure, there would still be many options: daily, weekly, or monthly changes (Dell'Ariccia, 1999).

Log range is used by Cotter and Bredin (2007) as another volatility measure. It has been widely used in an ad hoc fashion in the literature and its time series properties are formally examined in Alizadeh et al. (2002). They find that it is an efficient estimator with small measurement error and has further attractive time series properties by being approximately Gaussian (Cotter & Bredin, 2007).

Most of the existing studies use realised exchange rate volatility, measured by the absolute percentage changes in the exchange rate, lagged standard deviations or moving average variance around trend. These measures either have an adaptive expectations assumption that economic agents use only past information in forecasting future exchange rate distributions, or have an endogeneity problem, in the case where centred moving averages are used in spite of the fact that future exchange rate movements are surely affected in part by current trading behaviours. All measures that use realised values of exchange rate volatility suffer various kinds of conceptual and statistical problems (Lanyi & Suss, 1982; Wang & Barrett, 2007).

As discussed above, there is no one measure that is consistently superior to others. However, in deciding which volatility measure is appropriate to the problem at hand, several other issues must be considered, including whether the exchange rate should be real or nominal, and bilateral or effective, whether the data should be high-frequency or low-frequency, whether the time horizon should be short-run or long-run, and whether the perception of variability should be ex-ante or ex-post (Côté, 1994).

4.3 Various Model Specifications

4.3.1 Basic models

There are two primary determinants of export and import demand (Dornbusch, 1988; Hooper & Marquez, 1993), including the foreign income variable, which measures the economic activity and the purchasing power of the trading partner country, and the relative price or the terms of trade variable, which catches the price power on shaping market behaviour. In order to investigate the effect of exchange rate volatility on trade, exchange rate volatility needs to be explicitly taken into account. Therefore, the export and import demand are usually expressed through the partial equilibrium approach as (Siregar & Rajan, 2002):

$$X_t = \beta_{10} + \beta_{11}Y_t^f + \beta_{12}RP_t + \beta_{13}V_t + \varepsilon_{1t}$$
$$M_t = \beta_{20} + \beta_{21}Y_t^d + \beta_{22}RP_t + \beta_{23}V_t + \varepsilon_{2t}$$

where, X_t and M_t denote export and import volume, RP_t is relative price (constructed as the ratio of domestic export price to the foreign export price), Y_t^f and Y_t^d are foreign and domestic income, V_t denotes exchange rate volatility, and ε_{1t} and ε_{2t} are error terms for the two equations respectively.

According to economic theory, exports to a foreign country or imports to a domestic country ought to increase as the real income of the trade partner or domestic economy rises, and vice versa. Thus, $\beta_{11} > 0$ and $\beta_{21} > 0$ is expected. When the terms of trade increase (decrease), the domestic goods will become less (more) competitive than foreign goods, therefore exports will decrease (increase) and imports will increase (decrease). Therefore, $\beta_{12} < 0$ and $\beta_{22} > 0$ is expected. However, the effect of exchange rate volatility on exports and imports is ambiguous. So, β_{13} and β_{23} could either be positive or negative (Siregar & Rajan, 2002). If traders are risk-neutral, exchange rate uncertainty becomes an additional opportunity to increase their profits, resulting in increased overall trade flows. On the contrary, if traders are risk-averse, the risk due to exchange rate uncertainty becomes an additional cost, resulting in depressed overall trade volumes (Pattichis et al., 2004). However, De Grauwe (1988) shows that even within a framework of risk-aversion, the dominance of income effects over substitution effects may boost external trade. Therefore, in the context of such uncertainty, the effect of exchange rate volatility on trade is essentially an empirical issue (Pattichis et al., 2004).

As to the dependent variable, while most researchers use import and export volume, some researchers do use other variables, for example the trade balance (expressed as the difference between real exports and real imports) (e.g. Singh, 2004), and growth rate (e.g. Backman, 2006).

With regard to the independent variables, McKenzie (1999) lists fifteen variables used in the empirical studies. To date the income and relative price are still the two most commonly used variables in addition to exchange rate volatility. In addition, dummy variables are also used. A common one is one that captures exchange rate regime (e.g. Rahmatsyah et al., 2002). More dummy variables are used in gravity models, which will be discussed in the next section. Some researchers (e.g. Cho et al., 2002; Dell'Ariccia, 1999; Larson et al., 2005; Wei, 1996) also construct a measure to account for the 'third country effect' in bilateral trade studies, which takes into account the exchange rate volatility for all other countries, excluding trade between the two countries under analysis. It is expected that the sign of the coefficient for the third effect variable will be positive as found by Wei (1996). However, Dell'Ariccia (1999) finds it to be negative and not significant, and Cho et al. (2002) find that the coefficient is positive and negative for different sectors (Larson et al., 2005).

While logarithmic transformation is used on the variables in most studies, there is no consensus on it. All variables are not logarithmically transformed by Cheong (2004). Exchange rate volatility is not transformed by Baum and Caglayan (2010), Byrne et al. (2008), Rahmatsyah et al. (2002), Serenis et al. (2008) and Siregar and Rajan (2002). Relative price is not transformed by Byrne et al. (2008). Exchange rate is not transformed by Bahmani-Oskooee and Kovyryalova (2008).

4.3.2 Gravity models

While some researchers use the basic trade equations, many adopt the gravity model, which is regarded as one of the most empirically favourable frameworks in international economics (Anderson & van Wincoop, 2003; Klein & Shambaugh, 2006). It has both theoretical foundations and empirical supports (Rose, 2000). Actually, it is a very simple empirical model that displays the size of international trade between countries. The model relates trade between a given pair of countries to characteristics of each of them and the characteristics of their relationship, among which the two most important ones are the economic mass, that is GDP, and the distance between the countries (Clark et al., 2004). In addition, the empirical specifications of the gravity model typically control for other factors which may boost or depress trade, such as land areas, cultural similarity, geographical position, historical links, and preferential trading arrangements, all of which tend to affect the transaction costs relevant for bilateral trade and have been found to be statistically significant determinants of trade in various empirical studies (Clark et al., 2004). The model also typically controls for the level of economic development, which is expected to have a positive effect on trade as more developed countries tend to specialise and trade more (e.g. Frankel & Wei, 1993). Therefore, the gravity model has the following general form:

$$lnT_{ijt} = \sum_{k=1}^{m_1} \beta_{1k} Y_{kijt} + \sum_{k=1}^{m_2} \beta_{2k} Z_{kij} + \sum_{k=1}^{m_3} \beta_{3k} D_{kijt} + \beta_4 V_{ijt} + \varepsilon_{ijt}$$

where, lnT_{ijt} is the natural logarithm of trade between countries i and j in time *t*. While in most studies, either the import or the export from country *i* to country *j* is used for the T_{ijt}, the product of the two trading countries' exports is used for T_{ijt} in some studies (e.g. Baak, 2004); Y_{kijt} represents a set of variables that vary over time, such as the natural logarithm of income of countries *i* and *j* at time *t*; Z_{kij} represents a set of variables that do not vary over time, such as the natural logarithm of the distance between countries *i* and *j*; D_{kijt} is a set of dummy variables, such as the one representing exchange rate regime, which equals 1 for a fixed exchange rate between the two countries at time *t*, and 0 for a flexible exchange rate; V_{ijt} is a measure of volatility of the exchange rate between countries i and j at time t, and lnV_{ijt} is used in some studies; and ε_{ijt} is an error term.

A relatively recent development in the theoretical foundation of the gravity model emphasises the 'remoteness' or 'multilateral resistance' effects proposed by Anderson and van Wincoop (2003), which are catch-all expressions that summarise the effects on a given bilateral trade from differential, possibly unobserved, trade costs between this country pair and all other trading partners. In empirical applications, the multilateral resistance indices can be conveniently proxied by country effects (fixed or time varying) (Clark et al., 2004).

It is quite common that the product of the values of two countries for a variable is used instead of the two values being used separately. That means a common coefficient is estimated for the two countries for the variable instead of one coefficient for each country, that is, $\beta \ln(Y_{it}Y_{jt}) = \beta lnY_{it} + \beta lnY_{jt}$ instead of $\beta_1 lnY_{it} + \beta_2 lnY_{jt}$. Income and population are two such variables. For example, a common parameter is estimated by De Gauwe and Skudelny (2000) and Rose (2000), and separate coefficients are also estimated by De Gauwe and Skudelny (2000). It is not known whether this difference has any effect and how large the effect (if any) on the estimation of the focal parameter (of volatility). However, the common coefficient version is only a special case of the separate coefficients version.

4.3.3 Other variants of models

While most researchers use the relatively standard forms of equations as discussed above, some do use different forms of equations to solve their own problems. Serenis et al. (2008) include time trend in their export demand equation. Klein and Shambaugh (2006) use both exchange rate volatility and exchange rate volatility square in their gravity model. De Gauwe and Skudelny (2000) include the one period-lagged dependent variable (logarithm of export) in their gravity model of bilateral trade flows.

Thorbecke (2008) includes both leading and lagged first difference of the variables as well as a country pair effect and a fixed time effect to model the electronic components exports using the following specification:

$$x_{ij,t} = \beta_0 + \beta_1 fx_{jw,t} + \beta_2 rer_{ij,t} + \beta_3 V_{ij,t} + \sum_{k=-p}^{p} \alpha_{fx,k} \Delta fx_{jw,t+k} + \sum_{k=-p}^{p} \alpha_{rer,k} \Delta rer_{ij,t+k} + \sum_{k=-p}^{p} \alpha_{V,k} \Delta V_{ij,t+k} + \mu_{ij} + \pi_t + \varepsilon_{ij,t}$$

where, $x_{ij,t}$ represents real electronic components exports from East Asian country i to East Asian country j, $fx_{jw,t}$ represents real final electronic goods exports from East Asian country j to the world, $rer_{ij,t}$ is the bilateral real exchange rate between countries i and j, $V_{ij,t}$ is the volatility of the bilateral exchange rate between countries i and j, and μ_{ij} and π_t are country pair and time fixed effects.

Baum and Caglayan (2010) employ the distributed lag structure to study the relationship between trade flows and exchange rate volatility because there may be considerable lags associated with the impact of exchange rate volatility on trade flows. They also take into account the dynamics of the dependent variable arising from the time lags associated with agents' decisions to purchase and the completion of that transaction. Their model is as follows

$$x_t = \alpha + \gamma \sum_{j=1}^{6} \delta^j x_{t-j} + \beta_1 \sum_{j=1}^{6} \delta^j V_{t-j} + \beta_2 \sum_{j=1}^{6} \delta^j \Delta y_{t-j} + \beta_3 \sum_{j=1}^{6} \delta^j r_{t-j} + \varepsilon_t$$

where they introduce the first difference of log real GDP (Δy_t) of the importing country as a control variable in the basic equation. The lag parameter δ is set to a specific value to ensure dynamic stability in that relationship while they estimate a single coefficient associated with each of the variables expressed in distributed lag form: γ, β_1, β_2 and β_3, respectively.

Frey (2005) adopts another flexible model. Since cointegration is rejected by the Johansen test, the common approach to investigating the trade and exchange rate volatility relationship is invalid. The author takes further differences of single time series to render them stationary (dependent on the number of unit roots of the series). Their initial model is as follows:

$$d^n(x_t) = c + \sum_{j=0}^{24} \alpha_j d^m(k_{t-j}) + \sum_{j=0}^{24} \beta_j d^q(i_{t-j}) + \sum_{j=1}^{24} \gamma_j d^o(er_{t-j})$$
$$+ \sum_{j=1}^{6} \lambda_j V_{t-j} + \sum_{j=1}^{24} \delta_j d^p(l_{t-j}) + \sum_{j=1}^{24} \varphi_j d^n(x_{t-j}) + \sum_{j=1}^{24} \mu_j \varepsilon_{t-j}$$

where, *c* is constant; d^i is the difference of the order i (i = *m*, *n*, *o*, p or *q*) depending on the number of unit roots of the underlying time series; x is export quantity; l is labour costs; i is foreign income; *er* is nominal exchange rate; *V* is exchange rate volatility; and ε is error term.

4.4 Estimation and Analysis Methods

4.4.1 Ordinary Least Squares (OLS) and related methods

For a linear model

$$Y = X\beta + \varepsilon$$

where, Y is an $n \times 1$ column vector, X is an $n \times (p+1)$ matrix, β is a $(p+1) \times 1$ vector of parameters, and ε is an $n \times 1$ vector of errors. If taking the variance of ε to be $\sigma^2 I$, where I is the $n \times n$ identity matrix, the estimate $\hat{\beta}$ resulted from the method of least squares (i.e. the so-called ordinary least squares, OLS) is a best linear unbiased estimator (BLUE). If the variance of the error ε is $\sigma^2 \Omega$, where Ω is a known matrix other than the identity matrix, then one estimates β by the method of ‘Generalised least squares’ (GLS) by minimising a different quadratic form in the residuals. The resulting estimate $\hat{\beta}$ is also the BLUE for β. If all of the off-diagonal entries in the matrix Ω are 0, then one normally estimates β by the method of ‘weighted least squares’ (WLS), with weights proportional to the reciprocals of the diagonal entries. If the matrix Ω is not known, but must be estimated, then the parameter β can be estimated by the method of ‘feasible generalised least squares’ (FGLS).

As a basic estimation method, OLS has been the most popular technique used in many studies, especially early studies, by the end of 1990s (McKenzie, 1999). Bahmani-Oskooee and Hegerty (2007) use a section to review the empirical studies using OLS in particular. Though still being used in some studies, it is mainly used as a benchmark for comparison with other estimation methods (e.g. Rose, 2000).

When the null hypothesis that the disturbances are homoskedastic is rejected by some tests, for example the Bartlett statistic, and heteroskedastic errors are expected, FGLS should be applied. Awokuse and Yuan (2006) conduct a poultry meat trade study with a cross-section of countries of various sizes. Bartlett's test rejects the null hypothesis of homoskedastic errors at the 5 per cent significance level. In order to account for cross-sectional heterogeneity, a FGLS estimation technique is applied to the data. The improved statistics, including the substantially lower sum of squared residuals and higher adjusted R^2, indicate the existence of inter-country heterogeneity and justifies the adoption of the FGLS technique.

Many researchers criticise the practice with the two-step procedure, that is, generating the volatility using ARCH-type models and estimating the structural equation in the second stage with the conventional OLS technique by substituting the unobserved volatility with the measured one. However, even though the resulting OLS estimators are consistent, they do not have consistent covariance matrix and, therefore, are inefficient (Pagan, 1984). Given that uncertainty in exchange rates is captured by an ARCH class auxiliary model, there exists an orthogonal condition between structural parameters (including a measured volatility) and error terms, because the risk variable generated by an ARCH class model has a 'strong property', as defined by Pagan and Ullah (1988). Podivinsky et al. (2004) derive OLS-based GMM estimators by exploiting the orthogonality condition, using the Newey and West (1987) method, which adjusts the non-scalar covariance matrix of OLS estimators in the second stage, mainly due to the generated regressor. By applying this approach, Podivinsky et al. (2004) find a statistically significant and negative impact of exchange rate uncertainty on US imports from the UK.

Arize et al. (2008) estimate and test the coefficients of the export demand equation (independent variables include world demand, relative price and volatility) using three alternative approaches: the fully modified ordinary least squares (FMOLS) estimator of Phillips and Hansen (1990), the dynamic ordinary least squares (DOLS) estimator of Stock and Watson (1993) and the instrumental variable estimator of Bewley (1990) and Wickens and Breusch (1988). DOLS is also used by Égert and Morales-Zumaquero (2005) to estimate their export equations.

4.4.2 Instrumental variable (IV) estimation

An instrument is a variable that is not itself in the initial equation of interest, and it is correlated with the endogenous explanatory variables, conditional on the other covariates. Causal relationships can be estimated by using the method of instrumental variables (IVs) when controlled experiments are not feasible. Statistically, IV methods allow consistent estimation when the explanatory variables are correlated with the error terms. Such correlation may occur when the dependent variable causes at least one of the covariates, when some relevant explanatory variables are omitted from the model, or when there is measurement error in the covariates. In this situation, OLS generally produces biased and inconsistent estimates. However, if an instrument is available, consistent estimates may still be obtained.

There is the potential for simultaneity bias because the causal link between exports and exchange rate volatility may be bidirectional. If the endogeneity problem is confirmed, then an IV estimation method will be more appropriate. The Hausman (1978) test can be used to determine if the endogeneity problem is an issue. Larson et al. (2005) uses an instrumental variable procedure to test the simultaneity bias with a Hausman test (Dell'Ariccia, 1999). They adopt the instrument for exchange rate volatility provided by Bittencourt (2004), which is related to the variability of the fundamentals including real money supply and real GDP for each country (Larson et al., 2005). Awokuse and Yuan's (2006) results from the Hausman test indicate that the null hypothesis of no simultaneity bias could not be rejected at the 5 per cent significance level. As a result, their FGLS fixed effect model estimates are efficient and consistent.

Klein and Shambaugh (2006) address the possible endogeneity of exchange rate regimes to trade. They argue that while the use of country year effects and country pair fixed effects control for many factors, there are time-varying bilateral effects and, rather than bilateral trade responding to a change in the exchange rate regime, the exchange rate regime responds to an anticipated change in bilateral trade. They also review the previous studies with IV estimation. They state that previous research on the effects of currency unions on trade reports results obtained with instrumental variables estimates that are consistent with those obtained using OLS, namely that currency unions increase trade and there is only a weak effect of exchange rate volatility on trade.

Frankel and Wei (1993) use the standard deviation of relative money supplies as an instrument for the exchange rate volatility and find a negative and significant effect of exchange rate volatility on trade, but the size of this effect is smaller when using IV than when using OLS. Rose (2000) uses inflation and monetary quantity variables as instruments and the results are consistent with those from OLS. Alesina et al. (2002) use, as an instrument, a dummy indicating whether two countries share a common base country or the probability that two countries share a common base, and find a strong effect of currency unions on trade. Tenreyro (2007) uses the same approach to generating instruments for exchange rate volatility and finds negligible effects of volatility.

Estevadeordal et al. (2003) consider the possibility that membership in the gold standard is more likely to be endogenous than the choice of the exchange rate regime in the modern era. They find that the bilateral trade estimates obtained with OLS are robust to estimation in which membership in the gold standard is instrumented by a function that includes both countries' average distance from all the countries on the gold standard at the time. Klein and Shambaugh (2006) use information about whether neighbouring countries peg and, if so, to whom. They calculate, for a given pair of countries, country i and country j, the percentage of countries in country j's region that are directly pegged with country i, which serves as their instrument. These IV regressions appear to support the core specifications by showing that eliminating endogeneity does not weaken their results.

4.4.3 Seemingly unrelated regression (SUR)

SUR is a technique for analysing a system of multiple equations with cross-equation parameter restrictions and correlated error terms. An economic model may contain multiple equations which appear independent of each other. For example, they are not estimating the same dependent variable, or they have different independent variables, and so on. However, if the equations are using the same data, the errors may be correlated across the equations. SUR is an extension of the linear regression model which allows correlated errors between equations. It uses generalised least squares (GLS) to estimate the parameters. By using the SUR method to estimate the equations jointly, efficiency is improved compared to OLS estimates.

Bouoiyour and Rey (2005) use SUR to find that a rise in volatility reduces the trade flows (imports and exports), and the misalignments also affect the trade flow.

4.4.4 Stationarity and cointegration tests

A unit root tests whether a time series variable is non-stationary using an autoregressive model. The most famous test is the Augmented Dickey-Fuller (ADF) test (Said & Dickey, 1984). Another test is the Phillips-Perron (PP) test. Both these tests use the existence of a unit root as the null hypothesis. Other tests include the Kwiatkowski, Phillips, Schmidt, and Shin test (KPSS) (Kwiatkowski et al., 1992) and Elliot, Rothenberg, and Stock (ERS) point optimal test.

The common practice is first to test each data series for non-stationarity using ADF and Philips-Peron (PP) tests; secondly to difference the data series according to unit root status; thirdly to respecify the model using the differenced data series; and finally to estimate the respecified model using OLS. McKenzie (1998), for example, used this approach.

If all variables are of the same order of integration, for example I(1), usually linear combinations of them will also be I(1). However, if a linear combination of them is I(0), then the variables are cointegrated, which means that an equilibrium linear relationship exists (Doyle, 2001). If some cointegration exists among the variables in the equation, then there are a number of approaches of different complexities to estimate the model. Some main approaches are the Engel and Granger (1987) two-step procedure and the Johansen (1991, 1995) maximum likelihood reduced rank procedure. Both these procedures work well when all variable are I(1) (Todani & Munyama, 2005).

However, some researchers argue that the unit root finding may be spurious because of possible non-linear effects. Some non-linear models are available, including the exponential smooth transition autoregressive model (ESTAR). Grier and Smallwood (2007) consider an ESTAR process as an alternative to unit root for the real exchange rate (RER) series. They test their RER series for non-linearity using the procedure outlined by Teräsvirta (1994) in conjunction with the tests of Kapetanios et al. (2003).

4.4.5 Error correction model (ECM)

The estimated cointegration relationship reveals the factors affecting trade volume in the long-run. However, in the short-run, deviations from this relationship could occur as shocks to any of the relevant variables (Onafowora & Owoye, 2008). According to the Granger representation theorem (Engle & Granger, 1987), when a vector of n I(1) time series X_t is cointegrated with a cointegrating vector α, there exists an error-correction representation (Doyle, 2001):

$$A(L)\Delta X_t = -\gamma\alpha' X_{t-1} + \beta(L)\varepsilon_t$$

where $A(L)$ is a matrix polynomial in the lag operator L with $A(0) = I_n$, γ is a $(n \times 1)$ non-null vector of constants, $\beta(L)$ is a scalar polynomial in L and ε_t is a vector of white noise errors. The ECM shows how the system converges to the long-run equilibrium ($\alpha' X = 0$) implied by the cointegrating equation (Onafowora & Owoye, 2008). In the short-run, any deviation from the long-run equilibrium will impact on changes in X_t, and lead to movement back to equilibrium (Doyle, 2001). The coefficient on the lagged error-correction term represents the response of the dependent variable in each period to departure from equilibrium (Onafowora & Owoye, 2008). When an error-correction term has a statistically significant coefficient and displays the appropriate (i.e. negative) sign, the hypothesis of an equilibrium relationship between the variables in the cointegrating equation is valid (Doyle, 2001). A parsimonious model is usually obtained by following Hendry's (1987) 'general-to-specific' paradigm, which proceeds by eliminating all insignificant lags (Onafowora & Owoye, 2008).

4.4.6 Vector autoregression (VAR)

VAR is an econometric model used to capture the evolution and the interdependencies between multiple variables, thus generalising the univariate AR models. All the variables in a VAR are treated symmetrically by including for each variable an equation explaining its evolution based on its own lags and the lags of all the other variables in the model. It is suggested as a theory-free method to estimate economic relationships. However, because it is a reduced form model, it cannot distinguish between structural hypotheses in general (McKenzie, 1999).

Boug and Fagereng (2007) use a cointegrated VAR approach to study exchange rate volatility and parts of Norwegian exports. This approach is particularly beneficial in the present context as different characteristics of the time series are involved which are often neglected in existing studies, and they can be treated by essentially the same method. They conduct cointegration rank inference by means of (i) a VAR model with all variables involved being non-stationary and (ii) a VAR model with the measure of exchange rate volatility being a stationary regressor. Their findings suggest that a reduced rank VAR—in which exports, relative prices and world market demand represent the modelled variables—explains the data quite well. But they are unable to identify any statistically significant cointegrating relationship among the selected variables when the information set also included a GARCH-based measure of exchange rate volatility, treated as either a stationary or a non-stationary variable in the VAR.

4.4.7 Multivariate-GARCH-M

A multivariate ARCH-M (M-ARCH-M) model generalises the ARCH model to the multivariate environment to allow the conditional variance to affect the mean, which implies that changes in exchange rate volatility (measured as the conditional variance) directly affect the trade volume (Qian & Varangis, 1994). This approach has two advantages: first, the risk resulting from the exchange rate volatility is explicitly modelled and included as a regressor in the trade volume equation, thus avoiding arbitrariness in defining the measure of volatility risk; secondly, possible heteroscedasticity has been taken into full account in the estimation process, thus avoiding the possibility of biased estimates of the test statistics (Qian & Varangis, 1994).

Specifically, the M-ARCH-M model would be (Qian & Varangis, 1994):

$$a_x(L)\Delta x_t = \varphi_x \Delta s_t + b_x(L)\Delta p_t + c_x(L)\Delta y_t + d_x f(h_{t+1}) + \varepsilon_{xt} \quad (1)$$

$$a_p(L)\Delta p_t = \varphi_p \Delta s_t + b_p(L)\Delta x_t + c_p(L)\Delta y_t + d_p f(h_{t+1}) + \varepsilon_{pt} \quad (2)$$

$$\Delta s_t = c_{s0} + \varepsilon_{st} \quad (3)$$

where, L is the lag operator, and $a_x(L)$, $b_x(L)$, $c_x(L)$, $a_p(L)$, $b_p(L)$ and $c_p(L)$ are polynomials in lag operators, thus denoting the coefficient structure of the system of equations; x_t is real exports at time t; p_t is the relative price; s_t is exchange rate; c_{s0} is a constant; y_t is a vector of exogenous variables; ε's are white noise stochastic processes; and $f(h_{t+1})$ is the function of the expected time-varying conditional variance term of the exchange rate for $t+1$.

Define $\varepsilon_t = [\varepsilon_{xt}, \varepsilon_{pt}, \varepsilon_{st}]$. ε_t follows a conditional distribution $\varepsilon_t | \varepsilon_{t-1} \sim N(0, H_t)$. The covariance matrix of the residuals from equations (1), (2) and (3) thus is (Qian & Varangis, 1994):

$$\boldsymbol{H}_t = \begin{bmatrix} \sigma_x^2 & \sigma_{xp} & 0 \\ \sigma_{xp} & \sigma_p^2 & 0 \\ 0 & 0 & h_t \end{bmatrix}$$

$$h_t = \gamma_0 + \gamma_1 \sum_{i=1}^{n} w_i \, \varepsilon_{s\,t-i}^2$$

where, σ's are unconditional variances/covariances from the respective equations. Only the exchange rate specification allows the ARCH effects, where the h_t term is based on time t, and is the weighted sum of past squared error terms; w_i is the weight, which discounts older innovations in a pre-determined consistent manner.

The model is estimated with a two-step iteration method, which is equivalent to the procedure of conditional log-likelihood maximisation (Qian & Varangis, 1994). M-GARCH-M has been used in Kroner and Lastrapes (1993), Grier and Smallwood

(2007), and Wang and Barrett (2007), bivariate GARCH-M in Fang and Miller (2004), and dynamic conditional correlation (DCC) bivariate GARCH-M in Fang et al. (2006).

4.4.8 Poisson pseudo-maximum likelihood-IV (PPML-IV)

Tenreyro (2007) develops a PPML-IV approach to the estimation of gravity models, which simultaneously tackles all four problems commonly occurring in the previous studies, that is, heteroskedasticity and zero-valued trade observations as well as endogeneity and the measurement error of exchange rate variability.

To develop the PPML-IV methodology, the gravity equation is written in its exponential form as:

$T_{ij} = \exp(x_{ij}\beta) + \xi_{ij}$

where, the vector x_{ij} includes (the log of) the countries' GDPs, (the log of) geographical distance, and a set of dummy variables indicating whether the countries share a common border, language and colonial history. x_{ij} also includes the term δ_{ij}, to reflect the impact of exchange rate variability. To account for multilateral resistance, x_{ij} also includes importer- and exporter-specific effects (Tenreyro, 2007).

In the absence of endogeneity, that is, if $E(\xi_{ij}|x)=0$, the PPML estimator is defined by

$$\tilde{\beta} = arg \max_{b} \sum_{i,j}^{n} \{T_{ij}(x_{ij}b) - \exp(x_{ij}b)\}$$

which is equivalent to solving the following set of first-order conditions:

$\sum_{i,j}^{n}[T_{ij} - \exp(x_{ij}\tilde{\beta})x_{ij}] = 0$ (4)

The form makes clear that all that is needed for this estimator to be consistent is for the conditional mean to be correctly specified, that is, $E[T_{ij}|x_{ij}]=\exp(x_{ij}\beta)$. Note that, terminology aside, this is simply a Generalized Method of Moments (GMM) estimator that solves the moment conditions in Eq. (4).

Turning now to the IV estimation, suppose that one or more of the regressors are no longer exogenous, that is, $E(\xi_{ij}|x_{ij})\neq 0$. If z_{ij} is a set of instruments such that $E(\xi_{ij}|z_{ij})=0$, the consistent PPML estimator will solve the following moment conditions:

$\sum_{i,j}^{n}[T_{ij} - \exp(x_{ij}\bar{\beta})]z_{ij} = 0$

Note that this moment (or orthogonality) condition has the same form as that stated in Eq, and the condition E($\xi_{ij}|z_{ij}$)=0 ensures the consistency of the estimator.

It is important to point out that an IV that is appropriate for the equation in levels is not necessarily appropriate for the log specification. Therefore, in the presence of heteroskedasticity and/or zero-valued bilateral exports, the IV approach has to be applied to the multiplicative version of the gravity equation for it to produce a consistent estimator, which makes a strong case for the use of the PPML-IV estimator (Tenreyro, 2007).

4.4.9 Models with poisson lag structure

Klaassen (2004) introduces a new and convenient Poisson lag structure for the distributed lag model for export. It is specified as (Bredin & Cotter, 2007)

$$x_t = \beta_0 + \sum_{l=1}^{\infty} [\beta_{1l} y_{t-l} + \beta_{2l} E_{t-l} r_t + \beta_{3l} V_t]$$

where, real exports (*x*) are dependent on real foreign income (*y*), the expected real foreign exchange level (*r*) and exchange rate volatility (*V*). The model is run using a forecast of both real and nominal exchange rate volatility for time *t* that is unknown to them at time *t-l* to determine if their respective influences vary. With this model the timing impact of exchange rate volatility is allowed to be examined by having a flexible lag structure that uses l lags ranging from the export decision to payment at time *t*.

While the alternative approaches including the geometric and polynomial lag specifications are more restrictive, for example the geometric approach implies that β_l is decreasing as the lag increases, the Poisson lag approach is quite flexible due to the Poisson probability distribution for each underlying variable (Bredin & Cotter, 2007):

$$\beta_{kl} = \beta_k \frac{(\lambda_k - 1)^{l-1}}{(l-1)!} \exp[-(\lambda_k - 1)]$$

for $\lambda_k \geq 1$ and $k = y$, r and V, λ_k is the lag at which the maximum effect occurs. Its important advantage is that the number of parameters to be estimated is minimised, $2m + 1$, where m is the number of independent variables. Since the parameters λ_1, …

λ_m enter into the equation in a non-linear fashion, they are estimated with the simulated annealing optimisation technique (see Goffe et al., 1994). After the parameters have been calculated from the non-linear optimisation technique, the coefficients $\beta_1,\ldots\beta_k$ are estimated using OLS (Bredin & Cotter, 2007).

Baum et al. (2004) and Klaassen (2004) also use the Poisson lag approach. Klaassen (2004) also tests another model with the polynomial lag structure, obtaining a similar result to the Poisson lag approach.

4.4.10 Leamer's extreme bound analysis (EBA)

Solakoglu (2005) investigates the sensitivity of real exports to exchange rate volatility by applying the Extreme Bound Analysis (EBA) to US exports to its five major trading partners. The EBA is proposed by Leamer (1978, 1985) and Leamer and Leonard (1983), and tests the sensitivity of coefficient estimates to alterations in the set of conditioning variables. Solakoglu identifies the family of alternative models and summarises the range of inferences implied by each model. For a broad enough family, if the range of inferences is small enough, the researcher might conclude that inferences from these data are robust. Otherwise, it might be concluded that the inferences are too fragile to be useful (Solakoglu, 2005).

Consider an equation of the form (Solakoglu, 2005):

$$Y_t = X_t\beta + M_t\gamma + Z_t\delta + \varepsilon_t$$

Where, *Y* is the response variable (e.g. trade volume), *X* is a set of variables always included in the regression (free variables), *M* is the focus variable (e.g. exchange rate volatility), and *Z* is a subset of doubtful variables (e.g. lagged variables). The objective of the EBA is to find the upper and lower bounds of the coefficient estimates on the focus variable *M* by varying the subset of doubtful variables *Z* included in the regression. If the distance between the minimum and maximum coefficient estimates is short in comparison to sampling uncertainty, the ambiguity in the model is irrelevant since all models lead to the same inferences. Solakoglu (2005) also discusses other alternatives for the robustness examination.

4.4.11 ARDL bounds testing approach

Pesaran et al. (2001) propose the autoregressive distributed lag (ARDL) bounds testing approach to cointegration, which allows testing for the existence of cointegration irrespective of whether the underlying regressors are I(0), I(1) or mutually cointegrated. The procedure is based on the Wald or F-statistic in a generalised Dickey Fuller type regression used to test the significance of the lagged levels of relevant variables in a conditional unrestricted equilibrium correction model (ECM). Inferences are made by making use of two sets of asymptotic critical values corresponding to two extreme cases, one assuming purely I(0) and the other assuming purely I(1), without the need to know the regressors' underlying order of integration (Todani & Munyama, 2005).

The equation Todani and Munyama (2005) estimated is as follows (Todani & Munyama, 2005)

$$\Delta X_t = \alpha_0 + \alpha_1 t + \prod_1 X_{t-1} + \prod_2 B_{t-1} + \sum_{i=1}^{p-1} \Psi_i \Delta Z_{t-i} + \omega' \Delta B_t + \varepsilon_t \quad (5)$$

where $B_t = [INC_t, RP_t, V_t]'$, $Z_t = [X_t, B_t']'$.

The starting point for this type of model is to determine the lag length. This is done by estimating the conditional model (5) with and without the deterministic trend and the appropriate lag is selected on the basis of a careful analysis of the Akaike Information Criteria (AIC), the Schwarz's Bayesian Information Criteria (SBIC) and the Lagrangean Multiplier (LM) test. With the appropriate lag selected, the next step is to test the existence of a long-run relationship between the variables in the export demand equation. This is tested by conducting an F-test on the significance of lagged levels of variables in the error correction form (4). That is, we test the null hypothesis that all coefficients on lagged levels of variables are all equal to zero against the null that each one is not equal to zero (Todani & Munyama, 2005).

The asymptotic distribution of the F-statistic is non standard irrespective of whether the regressors are I(0), I(1) or a mixture of both. The calculated F-statistic is compared with the critical value tabulated by Pesaran et al. (2001). If the calculated F-statistic is above the upper bound, we proceed to test another null hypothesis that the coefficient associated with the response level variable is 0. If this hypothesis is rejected, then we say there exists a long-run relationship, without needing to know whether the underlying variables are I(0), I(1) or fractionally integrated. If the calculated F-statistic is smaller than the lower bound, we cannot reject the null hypothesis of no cointegration. If the calculated F-statistic is between the critical value bounds, the result is inconclusive. In this case, we may require prior knowledge of the order of integration of the underlying variables. That is, we may have to resort to the standard unit roots techniques (Todani & Munyama, 2005).

Once the existence of a long-run relationship is established, the long run coefficients are then estimated using the ARDL, after which an error correction form is estimated (Todani & Munyama, 2005).

De Vita and Abbott (2004a), Égert and Morales-Zumaquero (2005) and Bahmani-Oskooee and Kovyryalova (2008) also use Pesaran et al.'s (2001) bounds testing approach to cointegration and error-correction modelling to avoid pre-unit-root testing of variables for both export and import equations. They reveal both mixed short-run and long-run effects.

4.4.12 Methods using panel data

One of the advantages of using panel data is that unobservable cross-sectional effects can be accounted for either via fixed effects or random effects specification. If such unobservable effects are omitted and are correlated with the regressors, OLS estimates would be biased (Cho et al., 2002). Fixed effects and random effects estimations are frequently used in empirical studies with panel data. Some authors have claimed (e.g. Clark et al., 2004) that country-specific constant terms help control for remoteness or multilateral resistance effects (Hondroyiannis et al., 2008). Dell'Ariccia (1999) claims that use of both fixed and random effects can help deal with simultaneity problems. Hondroyiannis et al. (2008) also use three other methods, including common fixed coefficients, generalised method of moments (GMM) and random coefficients (RC). The GMM approach, proposed by Hansen (1982), purportedly does not require distributional assumptions such as normality, can allow for heteroskedacity of unknown form, and can correct for the effects of misspecification errors including omission of variables (Hondroyiannis et al., 2008). Random coefficient (RC) estimation, by correcting for factors that cause spurious relationships (e.g. the effects of omitted variables, unknown functional forms, and measurement errors), can find the most-reasonable approximations to the 'true' values of the identifiable coefficients of the 'true', but unknown, model (Hondroyiannis et al., 2008).

In their panel data analysis, Byrne et al. (2008) use fixed effects, random effects and IV estimation, Md-Yusuf (2008) uses OLS and fixed effects estimation, and Solakoglu et al. (2008) use OLS, GLS, fixed effects and random effects estimation, the Lagrange Multiplier (LM) test and the Hausman test.

Thorbecke (2008) uses panel dynamic ordinary least squares (DOLS) estimation. This involves regressing the dependent variable on a constant, independent variables, and leads and lags of their first differences. The presence of lags and leads of the first differences of the independent variables corrects for endogeneity and serial correlation problems. DOLS estimators and t-statistics have better small sample properties and provide better approximations to the normal distribution than estimators and t-statistics obtained using panel OLS or panel fully modified OLS methods (Kao & Chiang, 2000).

Cho et al. (2002) use fixed effects, random effects and IV estimation with panel data and a gravity model to study the relationship between exchange rate volatility and agricultural trade. Third country effects are also considered. They conclude that compared to other sectors, agricultural trade is more adversely affected by medium to long-run uncertainty in real exchange rates.

Chit et al. (2010) use fixed effects and random effects estimation, panel unit root and cointegration tests including the IPS test (Im, Pesaran & Shin, 2003) and the Hadri LM test (Hadri, 2000) with panel data and a generalised gravity model to study the relationship between exchange rate volatility and exports. They conclude that the impact of bilateral exchange rate volatility on bilateral exports is negative and statistically significant in both fixed-effect and random-effect estimations.

Égert and Morales-Zumaquero (2005) use a panel unit root test (Im-Pesaran-Shin test) and the cointegration tests worked out by Pedroni (1999). Out of the seven panel cointegration statistics developed by Pedroni (1999), they choose those which not only permit heterogeneity in the slope coefficients and the constant term but also allow for heterogeneous autoregressive coefficients in the residuals. These are the nonparametric PP, rho statistics and an ADF-based t-statistic. The coefficients are estimated using fixed effect OLS.

Awokuse and Yuan (2006) use the Levin, Lin and Chu (LLC) test (Levin et al., 2002) and Im, Pesaran and Shin (IPS) test (Im et al., 2003) to determine whether the data series under study contain unit roots. Both tests have the null hypothesis of non-stationarity, a rejection of the null hypothesis suggests that the data series are stationary.

4.4.13 Other models and methods

Non-linear models

Herwartz (2003) uses bilateral models formalising the monthly growth of US imports and exports to investigate the potential of non-linear relationships linking exchange rate uncertainty and trade growth. Parametric linear and non-linear models as well as semiparametric time series models are evaluated in terms of fitting and ex ante forecasting. The overall impact of exchange rate variations on trade growth is found to be weak. Empirical results support the view that the relationship of interest might be non-linear.

Bonroy et al. (2007) investigate the relationship between exchange rate volatility and Quebec pork exports to the US and Japan using linear and non-linear estimation methods, including SUR, Tsay's (1998) bivariate threshold model and Hamilton's (2001) non-linear model. The results support the hypothesis that the relationship between exports and volatility is non-monotonic.

Two direction model

Broda and Romalis (2003) develop a model of international trade in which international trade depresses real exchange rate volatility and exchange rate volatility impacts trade in products differently according to their degree of differentiation. In particular, commodities are less affected by exchange rate volatility than more highly differentiated products. These insights allow them to simultaneously identify both channels of causation, thereby structurally addressing one of the main shortcomings of the existing empirical literature on the effects of exchange rate volatility on trade—the failure to correct for reverse causality. Using disaggregate trade data for a large number of countries for the period 1970-1997 they find strong results supporting the prediction that trade dampens exchange rate volatility. They find that once the reverse-causality problem is addressed, the large effects of exchange rate volatility on trade found in some previous literature are greatly reduced.

Various methods used in gravity models

Rose (2000) uses OLS as the benchmark method and further checks its sensitivity to different estimation techniques. Trade flows are censored in that they must be greater than zero to appear in the sample. A related concern is undue importance of trifling trade observations since the sample includes many small countries. Both problems are handled by first setting (the log of) small trade values (defined as those <$50k) to zero, and second using Tobit. Tobit is an appropriate estimator for gravity equations. A different way of addressing the issue of unimportant observations is to use weighted least squares, in which the product of real GDPs (i.e. $\ln(Y_iY_j)$) is used as the weights.

Another concern is non-randomly missing observations (since many country-pairs do not engage in any trade at all). Heckit can be used to solve this problem. Random effects, maximum likelihood, and a generalised linear Gaussian model estimator are used. Both quantile (median) and robust (iterative Huber/biweight) regression results, which take potential outliers into greater account, are tabulated. A comprehensive set of country-specific fixed effects are also added. The estimates of focal parameters do not vary much despite the use of this econometric artillery; they remain correctly signed and economically and statistically significant (Rose, 2000).

Generalised impulse response function

To investigate the impact of exchange rate volatility on the disaggregated exports of UK using sectoral data on manufacturing exports, Cheong et al. (2002) use VAR models and apply generalised impulse response functions proposed by Pesaran and Shin (1998), which measure the time profiles of the effects of shocks at a given point in time on the future values of variables in the dynamic system. Their results indicate that for the four major categories, exchange rate volatility negatively affects export trade.

4.5 Empirical Studies According to Three Data Levels

4.5.1 Empirical studies with aggregate data

Siregar and Rajan (2002) study the impact of exchange rate volatility on Indonesia's trade performance using quarterly data from the 1980s to 1997. Their independent variables include real GDP, terms of trade and real exchange rate volatility, which is proxied by moving standard deviation of the change of real exchange rate in logarithm and the conditional variance of a GARCH model for the real exchange rate in logarithm. Cointegration relationships are found for all the equations. They find negative and significant effect of real effective exchange rate volatility on both imports and exports.

Bouoiyour and Rey (2005) study the behaviour of the real effective exchange rate (REER) of the dirham against the European currencies (the EU15) over the period 1960 to 2000 using annual data. They measure the volatility using standard deviation, and the misalignments as the difference between the actual REER and the equilibrium REER from a model. They choose to estimate the simultaneous-equation model by the SUR method, where the misalignment is treated as an instrumental variable. They conclude that a rise in the volatility of the dirham reduces the trade flows (both exports and imports) and misalignments also affect the trade flows.

Égert and Morales-Zumaquero (2005) analyse the direct impact of exchange rate volatility on the export performance of ten Central and Eastern European transition economies as well as its indirect impact via changes in exchange rate regimes using panel data, where the volatility is proxied with standard deviation. Three panel cointegration statistics are used and the coefficients are estimated using fixed effect OLS. For the equations in first differences, all (lagged) volatility measures are mostly insignificant. But results for the CEEC-8 (excluding Russia and Ukraine) indicate that the direct volatility measures are statistically significant with a negative sign, and the results are fairly robust over the time period investigated.

Kasman and Kasman (2005) investigate the impact of real exchange rate volatility on Turkey's exports to its most important trading partners using quarterly data. Cointegration and error correction modelling approaches are employed, and exchange rate volatility is proxied by moving standard deviation of the logarithm of the real effective exchange rate. Their results indicate that exchange rate volatility has a significant positive effect on export volume in the long-run.

Hondroyiannis et al. (2008) examine the relationship between exchange rate volatility and aggregate export volumes for twelve industrial countries. Their model also includes real export earnings of oil-producing economies as a determinant of industrial-country export volumes. Five estimation techniques, including a generalised method of moments (GMM) and random coefficient (RC) estimation, are employed on panel data using three measures of volatility (including absolute percentage change in the exchange rate, moving standard deviation and GARCH derived). They find no evidence of a negative and significant impact of volatility on real exports, regardless of which of these measures of volatility is used.

Todani and Munyama (2005) examine whether exchange rate volatility has affected the South Africa's exports flows to the rest of the world. They take foreign income, relative price and exchange rate volatility as export determinants. Their volatility measures are calculated as the moving standard deviation of the exchange rate growth and the conditional variance of a GARCH model. ARDL bounds testing procedures developed by Pesaran et al. (2001) is employed on quarterly data for the period 1984 to 2004. They find long-run relationships among the variables when three of the four volatility measures are used. They find that the coefficients on volatility are consistently positive but not significant (at least at the 5 per cent level). The results suggest that, depending on the measure of volatility used, either no statistically significant relationship exists between South African exports flows and exchange rate volatility, or when a significant relationship exists, it is positive. No evidence of a long-run gold and services exports demand relationship are found. These results are, however, not robust as they show a great amount of sensitivity to different definitions of variables used.

Grier and Smallwood (2007) evaluate the questions of how foreign income uncertainty and real exchange rate (RER) uncertainty impact international trade for a sample of nine developed and nine developing countries. They adopt a GARCH-M approach. Their export growth equation includes lagged export growth, foreign income growth and RER growth, as well as lagged volatility of real exchange rate and foreign income. They model the conditional variance of exports as a potential asymmetric GARCH process. Since they find cointegration for the US, they also include an error correction term in the US export equation. They conclude that RER uncertainty has a negative and significant impact on export growth for six of the nine less developed countries, and it has an insignificant effect for a majority of the developed countries. However, foreign income uncertainty has a more pervasive significant (and frequently larger) influence on trade than does RER uncertainty.

Schnabl (2007) scrutinise the impact of exchange rate stability on export growth for a sample of forty-one mostly small open economies at the EMU (European Monetary Union) periphery. Exchange rate volatility is proxied by four measures including arithmetic average and standard deviation of per cent exchange rate changes and their combination as well as yearly exchange rate change. Panel estimations including GLS and GMM reveal a robust negative relationship between exchange rate volatility and export growth.

Serenis et al. (2008) examine the impact of exchange rate volatility on the exports of fourteen EU countries. In addition to relative price, GDP and exchange rate volatility, their model also includes a time trend, three seasonal dummies, and several dummies for the possible effects that movement to a fixed exchange rate system has produced.

Given the absence of cointegration, they adopt a model in first difference. However, they could not find any significant overall effects. Their results also suggest that the change of exchange rate regime has not produced any significant effect for the level of exports.

Singh (2004) analyses the effect of exchange rate volatility on the balance of trade in India, which is defined as the difference between real exports and real imports. The independent variables include domestic and foreign real income, real exchange rate and its volatility, which is the conditional variance in a GARCH model. He employs cointegration estimation error correction model and finds that exchange rate volatility does not play any significant role in affecting the balance of trade in India.

Solakoglu et al. (2008) investigate the relationship between real exports and exchange rate volatility using panel data analysis at firm level. Their independent variables include the importing country's GDP, relative price, the bilateral exchange rate and its volatility, which is proxied by the standard deviation of the monthly bilateral exchange rate in a particular year. They use GLS, fixed effects and random effects estimations. Their results indicate that there is no negative or positive relationship between volatility and real exports, and firm size and level of international activity do not influence the size and significance of the volatility effect on exports; but there is some evidence that firms use import revenue to lower their exchange rate exposure. Table 4.2 provides the main features of twenty-one empirical studies of the effects of exchange rate volatility on trade by using aggregate trade data.

4.5.2 Empirical studies with bilateral data

Rose (2000) uses a gravity model to assess the separate effects of exchange rate volatility and currency unions on international trade with a panel data set including bilateral observations for five years spanning 1970 through 1990 for 186 countries. Five exchange rate volatility measures and various estimation methods are employed including OLS, GLS, fixed effects and IV-estimation and so on. He finds a large positive effect of currency unions on international trade, and a small negative effect of exchange rate volatility, even after controlling for a number of features, including the endogenous nature of the exchange rate regime.

Siregar and Rajan (2002) study the impact of exchange rate volatility on Indonesia's trade flows to Japan using quarterly bilateral data from the 1980s to 1997. Using similar modelling methodology, they find that a cointegration equation exists in both export and import regressions. Their results indicate that exchange rate volatility significantly and negatively impacts both Indonesia's imports from and exports to Japan.

Rahmatsyah et al. (2002) investigate the effect of exchange rate volatility on Thailand's imports from and exports to Japan and US from 1970 to 1997. They use similar export and import equations to Siregar and Rajan (2002), and cointegration and autoregressive distributed lags model are also employed. They conclude that the rise in exchange rate volatility had adverse consequences on both exports and imports of Thailand with the Japanese market, and the imports of Thailand from the US.

Clark et al. (2004) conduct a comprehensive study to investigate the impact of exchange rate volatility on trade using a gravity model with panel data. They explore a range of different exchange rate volatility measures: short-run (one-year period) and long-run (five-year period), real and nominal, official IFS-based and parallel market-based, and conditional (GARCH-derived) and unconditional (the standard deviation of the first difference of logarithms of the exchange rate). Because a large number of countries are included in their dataset, they also test if the impact of exchange rate volatility differs across country groupings (industrial and developing countries). They explore various model specifications with country and time fixed effects, country pair and time fixed effects, and time-varying country effects. In order to control for potential endogeneity bias, they use two instrumental variable (IV) approaches: (i) that proposed by Frankel and Wei (1993), whereby the volatility in the relative quantity of money is an instrumental variable for exchange rate volatility, and (ii) that proposed by Tenreyro (2007) which relates exchange rate volatility to the incidence and the propensity of countries to share a common anchor. They conclude that a negative relationship between exchange rate volatility and trade is borne out by some of the empirical evidence in this study. However, such a negative relationship is not robust to reasonable perturbations of the specification linking bilateral trade to its determinants. Overall, if exchange rate volatility has a negative effect on trade, this effect would appear to be fairly small and is by no means a robust, universal finding.

In addition to aggregate exports analyses, Égert and Morales-Zumaquero (2005) also analysed bilateral exports using time series data. The export equations are estimated using the dynamic ordinary least squares (DOLS) approach suggested by Stock and Watson (1993) and the autoregressive distributed lag (ARDL) approach proposed by Pesaran et al. (2001). To check these results, OLS estimations are carried out for variables in year-on-year changes ($dx = lnx_t - lnx_{t-12}$) that turn out to be stationary in levels. The results range from one end of the spectrum to the other. For some countries, such as Slovenia and Russia, there is little evidence of a negative relationship between foreign exchange rate volatility and exports. The evidence for Romania is weak. Croatia, the Czech Republic, Hungary and Poland are located at the other end of the spectrum; for these countries, the estimation results provide some evidence of the adverse effect of foreign exchange rate volatility on exports.

Herwartz (2003) investigates the potential of non-linear relationships linking exchange rate uncertainty and US trade growth using monthly bilateral imports and exports data among the Group of Seven. Parametric linear and nonlinear as well as semiparametric time series models are evaluated in terms of fitting and ex ante forecasting. He finds that the overall impact of exchange rate volatility on trade growth is weak. In periods of large exchange rate variations, trade growth forecasts gain from conditioning on volatility. His results support the view that the relationship between exchange rate volatility and trade might be non-linear and heterogeneous across countries and imports vs. exports.

Tenreyro (2007) points out four estimation problems in previous studies of the impact of nominal exchange rate variability (and more generally, of exchange rate regimes) on trade that cast doubt on previous answers in the context of gravity models. She develops an approach, PPML-IV (Poisson pseudo-maximum likelihood-instrumental variable estimator), to address all four problems. The trade equation is an unlog-linearised gravity model with the two trading countries' GDP, the distance between the two countries, some dummies and exchange rate volatility, which is measured by the standard deviation of the logarithm of the monthly bilateral exchange rate and also instrumented by the propensity to anchor the currency. She analyses a broad sample of countries using annual data from 1970 to 1997 with PPML-IV, PML and OLS. Even though she addresses all four problems with her PPML-IV, she still could not find any significant effect on trade—a result that is robust on the choice of instruments.

Agoli (2004) investigates the effect of exchange rate uncertainty on Albania's trade volumes with its three main trading partners, Italy, Greece and Germany, using quarterly data from 1993 to 2003. The volatility is proxied with standard deviation and the GARCH model approach. Both common models and gravity models are considered for the import and export equations. Both time series approach and panel data approach, and both short-run and long-run relationship are examined. The results show that there is evidence that exchange rate volatility has a deteriorating effect on trade volume, but its magnitude, significance and direction is a function of other factors considered.

Baak (2004) investigates the impact of exchange rate volatility on exports among fourteen Asia Pacific countries using annual data for the period from 1980 to 2002. Two forms of gravity models are employed, either using the exports from one country to another or the product of the exports between the two trading countries as the dependent variable. The volatility is proxied by the standard deviation of the logarithm of monthly real exchange rate within a year. OLS, fixed effects and random effects estimations are used. The results reveal a significant negative impact of exchange rate volatility on the volume of exports. In addition, various tests using the data for sub-sample periods indicate that the negative impact had been weakened since 1989 and surged again from 1997.

Baum et al. (2004) investigate empirically the impact of exchange rate volatility on real international trade flows using a thirteen-country data set of monthly bilateral real exports for 1980-1998. One-month-ahead exchange rate volatility from the intra-monthly variations in the exchange rate is calculated to better quantify this latent variable. Their model uses a flexible Poisson lag specification to allow the data to determine the appropriate dynamic specification of the time form of explanatory variables' impacts. They also introduce a new variable, foreign income uncertainty, to address potential omitted-variable bias in similar studies and investigate if the impact of exchange rate uncertainty fades or intensifies as uncertainty in foreign income levels varies. They find that the effect of exchange rate volatility on trade flows is non-linear, depending on its interaction with the importing country's volatility of economic activity, and that it varies considerably over the set of country pairs considered.

Fang and Miller (2004) examine the relationship between exchange rate depreciation and exports of Singapore to US by using monthly data over the period of 1979-2002. They employ a bivariate GARCH-M modelling technique that simultaneously estimates time varying exchange rate risk. Their results show that the effect of exchange rate depreciation on exports is positive but insignificant, but exchange rate risk significantly impedes exports, and the exchange rate risk effect dominates the depreciation effect in magnitude, leading to a negative net effect of exchange rate changes on export revenue.

Klaassen (2004) analyses why it is so difficult to find an effect of exchange rate risk on trade from time series analysis. He uses data on monthly bilateral aggregate US exports to the other G7 countries from 1978 to 1996. He makes two methodological contributions to the trade literature. First, he improves on currently used risk measures (moving variance and GARCH conditional measures) by using daily exchange rates to construct more accurate monthly volatilities and then using AR(2) forecasts of these monthly volatilities to compute multi-month-ahead risk. Second, he introduces a new Poisson lag structure for the distributed lag model, which enhances the dynamic specification of the model. The results show that export decisions are mostly affected by the probability distribution of the about one-year-ahead rate. The riskiness of the exchange rate at such a long horizon appears fairly constant. This explains why it is so difficult to discover the true effect of exchange rate risk on trade from the time series data that are typically available.

Solakoglu (2005) investigates the sensitivity of real exports to exchange rate volatility by applying Leamer's EBA to US exports to five major trading partners using monthly data from 1974 to 1996. Various volatility measures, ranging from ad hoc measures to a nonparametric one, are used. The main conclusion is that the relationship between real exports and exchange rate volatility is not robust across measures of volatility used and across countries.

Both exchange rate depreciation and variability affect exports. While depreciation raises exports, the associated exchange rate risk could offset that positive effect. Fang et al. (2006) use a dynamic conditional correlation bivariate GARCH-M model to investigate the net effect for eight Asian countries with monthly bilateral export data from US between 1979 and 2003. Time-varying correlation and exchange rate risk are simultaneously estimated in this model. Their results show that depreciation encourages exports for most countries, but its contribution to export growth is weak. Exchange risk contributes to export growth in two countries, leading to positive net effects; it generates a negative effect for six countries, resulting in a negative net effect in four countries and a zero net effect in the other two countries.

Klein and Shambaugh (2006) test whether trade is promoted by a fixed exchange rate. They employ a gravity model with independent variables: income, distance, exchange rate volatility and some dummies including one representing whether there is a fixed exchange rate between two countries. They use a large panel dataset with 181 countries over the period 1973-1999. The results from several estimation methods, including OLS and different fixed effects and IV estimations, show a large, significant effect of a fixed exchange rate on bilateral trade between a base country and a country that pegs to it, and a small impact of exchange rate volatility over the various specifications.

Baak et al. (2007) investigate the impact of exchange rate volatility on export volumes of four East Asian countries to the US and Japan using quarterly data from 1981 to 2004. The standard deviation of the logarithm of monthly real exchange rate within a year is used as the volatility measure. A cointegration and error correct model are also employed. The results indicate that except for the case of Hong Kong's exports to Japan, exchange rate volatility has negative impacts on exports either in the short-run or in the long-run, or both.

Baum and Caglayan (2010) investigate the impact of exchange rate volatility on both the volume and variability of exports, considering a broad set of countries' bilateral real trade flows over the period 1980 to 1998. The volatility of exchange rate and the volatility of trade volume are generated using a bivariate GARCH system for the real exchange rate and the volume of trade flow data. The dynamics of the mean and the variance of trade flows are modelled with a distributed lag structure. Their results show that the impact of exchange rate uncertainty on trade flows is indeterminate and exchange rate volatility has a consistent positive and significant effect on the volatility of bilateral trade flows.

Bredin and Cotter (2007) analyse the impact of exchange rate and foreign income volatility on Irish real exports to UK and US using monthly data from 1979 to 2002. Their volatility measures include squared, absolute range and GARCH-based estimates. They take account of the time lag between the trade decision and the actual trade or payments taking place by using a flexible Poisson lag approach. They find a positive effect of exchange rate volatility, a negative effect of income volatility, and a positive effect of the interaction between the two volatilities. This indicates an indirect effect of foreign exchange and income volatility on the import function.

Lin (2007) gives an explanation for the common empirical finding in the literature that exchange rate uncertainty has a small or insignificant impact on export volume. When export volume is decomposed into the extensive and intensive margins, panel regressions with gravity models reveal that exchange rate uncertainty has a negative effect on the extensive margin and a positive effect on the intensive margin, both of which are statistically significant. However, these two opposing effects cancel each other out when combined, producing an insignificant effect on overall export volume.

Chit et al. (2010) examine the impact of bilateral real exchange rate volatility on real exports of five emerging East Asian countries among themselves as well as to thirteen industrialised countries using quarterly data from 1982 to 2006. Three measures of exchange rate volatility are used, including the standard deviation of the first difference of the log real exchange rate, the moving average standard deviation of the quarterly log of bilateral real exchange rate, and the conditional volatilities of the exchange rates estimated using a GARCH model. The long-run export demand is modelled with a generalised gravity model. Various test and estimation methods are employed, including panel unit root and cointegration tests, fixed effects, random effects, GMM, and G2SLS estimations. The results indicate that exchange rate volatility has a negative impact on the exports of emerging East Asian countries. These results are robust across different estimation techniques and do not depend on the variable chosen to proxy exchange rate uncertainty.

Choudhry (2008) investigates the influence of exchange rate volatility on the real imports of the UK from Canada, Japan and New Zealand using quarterly data from 1980 to 2003. Conditional variance of the first difference of the logarithm of the exchange rate is used to proxy volatility, which is estimated with a GARCH model. The Johansen multivariate cointegration method and the constrained error correction (general-to-specific) method are applied to study the relationship between real imports and its determinants. Results indicate a significant effect of the exchange rate volatility on real imports. These exchange rate volatility effects are mostly positive.

Onafowora and Owoye (2008) examine the impact of exchange rate volatility on Nigeria's exports to its most important trading partner–the US–using quarterly data from 1980 to 2001. Empirical tests, using cointegration and vector error correction (VECM) framework, indicate the presence of a unique cointegrating vector linking the independent variables in the long-run. They find that increases in the volatility of the real exchange rate raise uncertainty about profits to be made which exert significant negative effects on exports both in the short and long-run.

Cheong et al. (2004) investigate the effect of exchange rate volatility on US imports from UK using monthly data from 1974 to 2003. Exchange rate volatility is proxied by the conditional variance of a GARCH model. An OLS-based GMM estimator is derived and used for the estimation of the model coefficients. By applying this new two-step approach, they find a statistically significant, negative impact of exchange rate uncertainty on US imports from the UK. Table 4.3 provides the main features of thirty empirical studies of the effects of exchange rate volatility on trade by using bilateral trade data.

4.5.3 Empirical studies with sectoral data

Because there may be differences in the impact of exchange rate volatility across sectors, recent studies have often used sectoral trade data and sought economic justifications for differences across industry (Byrne, 2008).

Cheong et al. (2002) investigate the impact of exchange rate uncertainty on the disaggregated exports of the UK using monthly data from 1976 to 2000 on its four major manufacturing categories. A GARCH-derived measure is used to proxy the volatility. They use a VAR model and apply impulse response functions. The results indicate that for the major manufacturing categories analysed, exchange rate uncertainty depresses international trade.

To further evaluate the role of exchange rate volatility on Indonesia's imports, Siregar and Rajan (2002) sub-divided Indonesia's imports into its two main components: intermediate and capital imports. Using similar modelling methodology, they find that a cointegration equation exists in import regressions. They also find significant and negative effects of real exchange rate volatility on both Indonesia's capital and intermediate imports from Japan.

Broda and Romalis (2003) develop a model of international trade in which international trade depresses real exchange rate volatility and exchange rate volatility impacts trade in products differently according to their degree of differentiation. Using disaggregate annual export data for a large number of countries for the period 1970-1997 and OLS and GMM methods, they find that trade dampens exchange rate volatility, and once the reverse-causality problem is addressed, the large effects of exchange rate volatility on trade found in some previous literature are greatly reduced.

Yuan and Awokuse (2003) evaluate the effects of exchange rate volatility on US poultry exports to forty-nine countries from 1976 to 2000 using the gravity model on panel data. Three volatility measures are used, including the absolute percentage change of the exchange rate, the variances of the spot exchange rate around its trend, and the moving average of the standard deviation of the exchange rate. Both OLS and fixed effects estimation are employed. They find that exchange rate volatility has a negative effect on the US poultry export but is only statistically significant for the model in which the variance of spot exchange rate is used as the measurements.

In their comprehensive study, in addition to aggregate trade analysis, Clark et al. (2004) also examine how the exchange rate volatility effect depends on the type of product traded—differentiated or homogeneous, which allows them to test if the effect of exchange rate volatility varies in direction and magnitude across different types of goods. They consider a system of two equations separately for trade in differentiated products and in homogenous products, which are estimated by the SUR technique. This specification allows the parameters on the same variables to be different for different types of trade, while the error terms for a given country pair are correlated in the two equations. When time and country fixed effects are included, the coefficients on exchange rate volatility are negative in both equations, but the volatility effect is statistically significant only in the equation on trade in differentiated products. When time-varying country fixed effects are included, the coefficients on exchange rate volatility are not statistically different from zero for trade both in differentiated and in homogenous products.

Pattichis et al. (2004) investigate the impact of exchange rate uncertainty on the disaggregated imports of the UK using data from fifteen major manufacturing categories from 1974 to 2000. The conditional standard deviation from a GARCH model is used to proxy the exchange rate volatility. Results from cointegration and ECM suggest that exchange rate uncertainty has a consistent effect on UK trade. It is shown that for all of the fifteen categories analysed, exchange rate volatility has a negative impact on import trade. This impact is, however, statistically insignificant in many cases.

In addition to aggregate exports and bilateral exports analyses, Égert and Morales-Zumaquero (2005) also analyse sectoral exports using the same methodology as aggregate exports. They find that exchange rate volatility hampers manufacturing exports, and exports of the chemicals sector are, in fact, also influenced by exchange rate volatility. Although the effect is mostly positive for the cointegration relationships, including the dummy variables, the effect switches sign when data in first differences are used, that is, higher exchange rate volatility appears to dampen export growth in chemicals and manufacturing. These results seem to be most robust for manufactured goods classed by materials and for machinery and transport equipment.

In terms of aggregate level export analysis, Todani and Munyama (2005) also examine whether exchange rate volatility has affected South Africa's disaggregated export flows to the rest of the world. Three categories are considered: services, gold and goods. They adopt a similar methodology as for aggregated trade. They only find long-run relationships for goods exports with two of the four volatility measures. They find that the coefficients on volatility are also positive but not significant (at least at the 5 per cent level).

Herwartz and Weber (2005) analyse the impact of exchange uncertainty on sectoral categories of multilateral exports and imports for fifteen industrialised economies using monthly data from 1981 to 1998. They particularly provide a comparison of linear and non-linear models in sample-fitting and ex-ante forecasting. The results from semiparametric estimates indicate a locally significant relationship between exchange uncertainty and trade. In terms of average ranks of absolute forecast errors, non-linear models outperform both a common linear model and some specification building on the assumption that exchange uncertainty and trade growth are uncorrelated. Their results support the view that the relationship between the two variables might be non-linear and it is heterogeneous across countries, economic sectors and when contrasting imports vs exports.

Awokuse and Yuan (2006) examine the relationship between exchange rate volatility and US poultry exports to its forty-nine importing nations using annual data for over two subperiods: 1976 to 1985 and 1986 to 2000. Three volatility measures are used, including the absolute percentage change in exchange rate levels, the moving average of the standard deviation of the growth rate of the nominal exchange rate, and the variance of the 'spot' exchange rate around its trend. Panel unit root tests, fixed effects and IV estimation are employed. Their results indicate that there is a positive relationship between exchange rate uncertainty and US poultry exports, but the choice of volatility measure matters.

Bonroy et al. (2007) investigate the relationship between exchange rate volatility and Quebec pork exports to the US and Japan using monthly data from 1992 to 2003. They use both linear and non-linear model estimation. SUR is used for the linear model estimation. In searching for potential non-linear volatility effects on exports, they use Tsay's threshold model and Hamilton's flexible estimation approach. The results support the hypothesis that the relationship between exports and volatility is non-monotonic.

Larson et al. (2005) estimate the trade flow patterns of Brazil in the Mercosur, and how trade flows respond to changes in exchange rates and other trade determinants including exchange rate volatility, which is estimated with moving standard deviation and a GARCH model. A sectoral gravity model is estimated with fixed effects method. Results show that the reduction in exchange rate volatility can increase bilateral trade. Trade among agribusiness firms can increase due to exchange rate stability as well as from tariff reductions and economic growth.

Boug and Fagereng (2007) examine the causal link between exchange rate volatility and machinery and equipment exports from Norway to its main trading partners using quarterly data from 1985 to 2005. Volatility is measured by the conditional variance from a GARCH model. Cointegration estimation and a VAR model are employed. Although the volatility measure is treated as either a stationary or a non-stationary variable in the VAR, they are not able to find any evidence suggesting that export performance has been significantly affected by exchange rate uncertainty.

May (2007) investigates the effect of real exchange rate volatility on Thai production and export of five key agricultural commodities using monthly data from 1981 to 2006. Volatility is measured as the moving average standard deviation of the daily real exchange rate, the residual of an ARMA process of the monthly real exchange rate, the residual of an ARIMA process of the daily real exchange rate, and the conditional variance of the GARCH process of the monthly real exchange rate. Except for volatility, the independent variables also include real exchange rate and the industrial production for each of its major trading partners. The results from the OLS estimation show that the effect of real exchange rate volatility on the volume of exports is consistently negative and often statistically significant.

Wang and Barrett (2007) examine the effect of exchange rate volatility on Taiwan's exports to the US from 1989 to 1998 using sectoral level monthly data. They employ an expectation-based multivariate GARCH-M estimator with corrections for leptokurtic errors and a conditional heavy-tailed multivariate student-t distribution. They find that real exchange rate risk has insignificant effects in most sectors, although agricultural trade volumes appear highly responsive to real exchange rate volatility.

Bahmani and Kovyryalova (2008) investigate the impact of exchange rate uncertainty on trade flows between US and UK using annual data over the 1971-2003 period for 177 commodities traded. They employ a bounds testing approach for cointegration and error correction modelling to avoid pre-unit-root testing of the variables in the system, an approach introduced by Pesaran et al. (2001), in which the variables in the system can be either I(0) or I(1). The results show that the real bilateral exchange rate volatility has a short-run significant effect on imports of 109 and exports of 99 industries. In most cases, such effects are negative. In the long-run the number of significant cases is somewhat reduced. Furthermore, the affected industries do not seem to have any specific commodity attribute.

Byrne et al. (2008) consider the impact of exchange rate volatility on the volume of bilateral US trade (both exports and imports) using data for twenty-two industries and six countries from 1989 to 2001. Relative price, domestic output for the industry in consideration and the exchange rate volatility, which is proxied by the standard deviation of monthly exchange rate changes, are taken as the determinants of the trade demand. Results from various estimations, including fixed effects, random effects and IV estimations, indicate that exchange rate volatility has a robust and significantly negative effect across sectors, although it is strongest for exports of differentiated goods.

Hayakawa and Kimura (2008) explore the relationship between exchange rate volatility and international trade between sixty countries, though focusing on East Asia, using annual data from 1992 to 2005. A gravity model is employed and estimated with OLS. They find that intra-East Asian trade is discouraged by exchange rate volatility more seriously than trade in other regions, and this negative effect of volatility is mainly induced by the unanticipated volatility and has an even greater impact than that of tariffs.

Thorbecke (2008) investigates how exchange rate volatility affects electronic components exports within East Asia using panel annual data from 1985 to 2005. Panel unit root test, cointegration and dynamic OLS (DOLS) are employed. The model involves regressing exports on constant, real final electronic goods exports, bilateral real exchange rate and its volatility, and leads and lags of their first differences. The results present evidence that exchange rate volatility decreases the flow of electronic components within those countries.

Md-Yusuf (2008) investigate the impact of exchange rate variability on the value of the bilateral exports of Malaysia's five major export categories using monthly data over two time periods: floating (1990:1-1998:8) and fixed (1998:9-2002:12) exchange rate regimes. The volatility is proxied by the moving standard deviation of the growth rate of exchange rate and the conditional variance from a GARCH model. OLS and fixed effects estimations are employed. The results show that exchange rate variability is statistically significant in the majority of the categories.

Table 4.4 provides the main features of twenty-three empirical studies of the effects of exchange rate volatility on trade by using sectoral trade data.

4.6 Concluding Remarks

This chapter reviews the various measures for exchange rate volatility, various models and estimation methods used in exchange rate volatility—trade relationship analysis, as well as the empirical studies on the effect of exchange rate volatility on trade flows at three data levels, aggregate, bilateral and sectoral. Some trends are found in this specific field.

First, there are some new volatility measures and more volatility measures being used. It is very common that more than one measure is employed in the same study in order to check the robustness of the results given to the measures used. Among the measures reviewed, moving standard deviation and conditional variance from

ARCH/GARCH models are the two most commonly used measures, each of which is used in more than fifty studies reviewed. They are followed by the within-period standard deviation, which is applied in more than thirty studies reviewed. Next comes a group of four types of measures, including those based on absolute/squared/percentage change of the exchange rate or its change, those based on the absolute/squared/percentage difference between the previous forward and the current spot rate, variance/standard deviation of the spot exchange rate around its trend which is predicted from some models, and residuals (or their moving standard deviation) from ARMA/ARIMA models, which appear in around thirty studies in total. All the other measures are sparsely scattered in individual studies.

While the most popular measures are relatively old, some new measures are still being introduced into the field. Solakoglu (2005) introduces the conditional variance calculated from an autoregressive model or recursive variance estimation or nonparametric estimation. Cotter and Bredin (2007) introduce the aggregated absolute/squared exchange rate change for any month with some daily intervals. Hayakawa and Kimura (2008) introduce unanticipated exchange volatility as the absolute residual of a regression model, which takes the within-period standard deviation of the bilateral exchange rate as the dependent variable and the five-period-ahead country risk for each of the two countries as the independent variables. A new instrument variable is also introduced by Tenreyro (2007), which is the probability that two countries peg their currencies to the same anchor. It is expected that more new measures will emerge in the future.

Secondly, there are some new test and estimation methods being introduced. Many studies adopt the newer techniques based on panel data, including panel unit root tests and cointegration estimations, and fixed effects and random effects estimations, in order to take advantage of using panel data account for the unobservable cross-sectional effects. Instrumental variable estimation is also frequently applied by researchers to account for the simultaneity problem. Peseran et al.'s (2001) bounds testing approach for cointegration has been used in several studies. Its advantage is that both stationary and unstationary variables can be incorporated in the analysis, and this will be acknowledged by more and more researchers. In addition, semi-parametric and nonparametric estimations as well as non-linear models (e.g. Poisson lag structure) have been used in some studies. It is also expected that the new methods will be used by more and more researchers and more methods will emerge.

In addition, there are more studies using disaggregated data. The number of studies at each of the three data levels (from aggregate, bilateral to sectoral) is 17, 16 and 3 in McKenzie's (1999) review; 34, 25 and 16 in Bahmani-Oskooee and Hegerty's (2007) review; and 21, 30 and 23 in this review. It is obvious that both the proportion of studies using disaggregated data (i.e. at both bilateral and sectoral level) and that at the sectoral level have increased steadily during the last three decades.

Though a large number of studies are reviewed in this chapter, it is still difficult to give a general definitive conclusion on whether there is any effect of exchange rate volatility on international trade because the results among the studies are inconsistent. Maybe a meta-analysis approach can help solve this problem in the case of Coric and Pugh (2008). However, when applying this approach, while following the objective selection of the published studies, some studies, especially the old ones, must be excluded from further analysis because of their obvious statistical problems.

Table 4.1: Various volatility measures

Code	Measure	Applications
V1	Measures based on absolute/squared/percentage change of the exchange rate or its change	Awokuse and Yuan (2006), Bailey et al. (1986, 1987), Hondroyiannis et al. (2008), Rose (2000), Schnabl (2007), Solakoglu (2005), Thursby and Thursby (1985), Yuan and Awokuse (2003)
V2	Measures based on the absolute/squared /percentage difference between the previous forward and the current spot rate	Cushman (1988), Dell'ariccia (1999), Doyle (2001), Hooper and Kohlhagen (1978)
V3	Variance/standard deviation of the spot exchange rate around its trend which is predicted from some models, e.g. $lne_t = \emptyset_0 + \emptyset_1 t + \emptyset_2 t^2 + \varepsilon_t$	Arize and Ghosh (1994), Awokuse and Yuan (2006), Broda and Romalis (2003), De Grauwe (1987), Grobar (1993),Thursby and Thursby (1987), Yuan and Awokuse (2003)
V4	Residuals or moving standard deviation of the residuals from ARMA/ARIMA model	Arize and Shwiff (1998), Asseery and Peel (1991), Grobar (1993), May (2007), McIvor (1995), Sauer and Bohara (2001), Abrams (1980), Akhtar and Hilton (1984),
V5	Within-period standard deviation (and variants) of the exchange rate (or its change or percentage change or their logarithms) $\left[\frac{1}{m}\sum_{i=1}^{m}(x_i - \bar{x})^2\right]^{1/2}$	Baak (2004, 2007), Bahmani-Oskooe (1996, 2002), Bahmani-Oskooee and Kovyryalova (2008), Bouoiyour and Rey (2005), Brodsky (1984), Byrne et al. (2008), Chit et al. (2010), Cho et al. (2002), Clark et al. (2004), Cushman (1986), De Grauwe and Skudelny (2000), Dell'ariccia (1999), De Vita and Abbott (2004a), Égert and Morales Zumaquero (2005), Frankel and Wei (1993), Gotur (1985), Hayakawa and Kimura (2008), Hooper and Kohlhagen (1978), Kenen and Rodrick (1986), Kumar and Dhawan (1991),

		Larson et al. (2005), Lin (2007), Medhora (1990), Pozo (1992), Rose (2000), Schnabl (2007), Solakoglu (2005), Solakoglu et al. (2008), Stavárek (2007), Tenreyro (2007), Vergil (2002)
V6	Moving standard deviation (and variants) of the exchange rate (or percentage change or their logarithms) $\left[\frac{1}{m}\sum_{i=1}^{m}(x_{t-i+1}-x_{t-i})^2\right]^{1/2}$ or $\left[\frac{1}{m}\sum_{i=1}^{m}(x_{t+i-1}-x_{t+i-2})^2\right]^{1/2}$ Note: It's difficult to identify which formula is used in some papers.	Agolli (2004), Akhtar and Spence-Hilton (1984), Aristotelous (2001, 2002), Arize (1995, 1996, 1997, 1998), Arize and Ghosh (1994), Arize et al. (2000, 2003), Awokuse and Yuan (2006), Bahmani-Oskooee (1996, 2002), Bahmani-Oskooee and Ltaifa (1992), Bahmani-Oskooee and Payesteh (1993), Bailey et al. (1987), Caballero and Corbo (1989), Caporale and Doroodian (1994), Baum et al. (2004), Bini-Smaghi (1991), Bleaney (1992), Bonroy et al. (2007), Bredin et al. (2003), Caballero and Corbo (1989), Caporale and Doroodian (1994), Chan and Wong (1985), Chit et al. (2010), Cho et al. (2002), Chou (2000), Chowdhury (1993), Corbo and Caballero (1989), Cushman (1983, 1986, 1988), Daly (1998), De Grauwe and De Bellefroid (1987), De Vita and Abbott (2004a, 2004b), Doğanlar (2002), Égert and Morales-Zumaquero (2005), Fountas and Aristotelous (1999), Giorgioni and Thompson (2002), Gotur (1985), Grobar (1993), Hassan and Tufte (1998), Hondroyiannis et al. (2008), Hurley and Santos (2001), Kasman and Kasman (2005), Kenen and Rodrik (1986), Klaassen (2004), Klein (1990), Koray and Lastrapes (1989), Kumar and Dhawan (1991), Lastrapes and Koray (1990), May (2007), Péridy (2003), Poon et al. (2005), Pozo (1992), Rahmatsyah et al. (2002), Rapp and Reddy (2000), Sauer and Bohara (2001), Serenis et al. (2008), Siregar and Rajan (2002), Stavárek (2007), Stokman (1995), Tenreyro (2007), Thursby and Thursby (1985), Todani and Munyama (2005), Usman and Savvides (1994), Vergil (2002), Yuan and Awokuse (2003)

V7	Coefficient of variation of the exchange rate	Bénassy-Quéré and Lahrèche-Révil (2003), Medhora (1990), Thorbecke (2008)
V8	Range: Difference or percentage difference between the maximum and the minimum of the exchange rate (or its change or percentage change or their logarithms) in the respective previous period of time $max\{x_{t-i+1}\|i = 1,2, \dots, m\} - \min\{x_{t-i+1}\|\mathrm{i} = 1,2, \dots, m\}$	Cotter and Bredin (2007), Dell'arccia (1999), Stavárek (2007)
V9	Conditional variances calculated from ARCH/GARCH and their extensions (including Asymmetric Power ARCH, Threshold GARCH, EGARCH, GARCH-M, Multivariate GARCH-M, Dynamic Conditional Correlation Bivariate GARCH-M, etc.)	Agolli (2004), Arize and Ghosh (1994), Arize and Malindretos (1998), Arize et al. (2008), Baum and Caglayan (2010), Benita and Lauterbach (2007), Boug and Fagereng (2007), Caporale and Doroodian (1994), Cheong (2004), Cheong et al. (2002), Cheong et al. (2004), Chit et al. (2010), Chou (2000), Choudhry (2005, 2008), Clark et al. (2004), Cotter and Bredin (2007), Cushman (1983), De Vita and Abbott (2004a), Doroodian (1999), Doyle (2001), Eleanor (2001), Fang and Miller (2004), Fang et al. (2006), Frey (2005), Grier and Smallwood (2007), Grobar (1993), Herwartz (2003), Herwartz and Weber (2005), Holly (1995), Hondroyiannis et al. (2008), Klaassen (2004), Kroner and Lastrapes (1993), Lee (1999), May (2007), Mckenzie (1998), Mckenzie and Brooks (1997), Onafowora and Owoye (2008), Pattichis (2003), Pattichis et al. (2004), Péridy (2003), Pozo (1992), Qian and Varangis (1994), Rahmatsyah et al. (2002), Sauer and Bohara (2001), Siregar and Rajan (2002), Solakoglu (2005), Sukar and Hassan (2001), Todani and Munyama (2005), Wang and Barrett (2007), Yarmukhamedov (2007)
V10	Conditional variance calculated from an autoregressive model or recursive variance estimation or nonparametric estimation	Solakoglu (2005)

V11	Long run exchange rate uncertainty, measured as: $V_t = \frac{maxX_{t-k}^t - minX_{t-k}^t}{minX_{t-k}^t} + \left[1 + \frac{\lvert X_t - X_t^p \rvert}{X^p}\right]^2$ where X_t is the nominal exchange rate at time t, $maxX_{t-k}^t$ and $minX_{t-k}^t$ refer to maximum and minimum values of the nominal exchange rate over a given time interval of size k up to time t, and X_t^p is the 'equilibrium' exchange rate	Cho et al. (2002), Larson et al. (2005), Peree and Steinherr (1989)
V12	A real exchange rate volatility measure combining a nominal exchange rate risk and a price risk, where the former is defined as the difference between the spot rate and the forward rate recorded some period earlier, and the latter is defined as the difference between predicted inflation rate and actual inflation rate	Maskus (1986)
V13	Expected and unexpected volatility generated with stochastic coefficients model	Pickard (2003)
V14	A measure generated with a linear moment model	Arize (1995, 1997), Arize et al. (2008)
V15	Aggregated absolute exchange rate changes (and variants) for any month *t* with *m* daily intervals	Cotter and Bredin (2007)

	$\lvert r_t \rvert^n = \sum_{j=1}^{m} \lvert r_{m,t+j/m} \rvert^n$ $r_{m,t} = p_t - p_{t-1/m}$	
V16	Aggregated squared exchange rate changes (and variants) for any month t with m daily intervals $[r_t^2]^n = \sum_{j=1}^{m} [r_{m,t+j/m}^2]^n$	Cotter and Bredin (2007)
V17	Gini's mean difference (a non-parametric measure)	Medhora (1990), Rana (1981)
V18	Instrument: standard deviation of the relative money supply	Frankel and Wei (1993)
V19	Instrument measured as the probability that two countries peg their currencies to the same anchor	Tenreyro (2007)
V20	Instrument explained by openness, terms of trade disturbances, real productivity shocks, domestic monetary disturbances, and domestic inflation disturbances	Savvides (1992)
V21	Dummies for fixed or floating periods	Aristotelous (2001), Brada and Mendez (1988), Égert and Morales-Zumaquero (2005)
V22	Unanticipated exchange volatility as the absolute residual of the following equation $V_{5\,ij} = \alpha_0 + \alpha_1 lnRisk_{i\,t-5} + \alpha_2 lnRisk_{j\,t-5} + \varepsilon_{ij}$ where, i and j denote two countries, V_5 is the fifth volatility measure in this table, Risk is country risk	Hayakawa and Kimura (2008)
V23	AR risk: one-month-ahead risk predicted from AR(2) for the sum of squared daily real exchange rate changes over all days in the month	Klaassen (2004)
V24	Scale measure of variability	Medhora (1990)

Table 4.2 Empirical studies of the effects of exchange rate volatility at aggregate level

Author	Data	Dependent variable	Exchange rate	Volatility measure	Other explanatory variables	Countries	Method	Effects
Arize et al. (2003)	1973-98/Q	X	R, N	V6	Foreign GDP, relative price	10 LDCs	Cointegration estimation	27/30 ng (27/27 sg), 3/30 ps (3/3 sg)
Arize et al. (2008)	1973-2004/Q	X	R	V9, V14	Real 'world' income, relative price	8 Latin American countries	Cointegration estimation (FMLS, DLS, IVE), ECM	24/24 ng sg
Bahmani-Oskooee (2002)	1959-1989/Y	M, X	R		Real exchange rate, real domestic GDP, world income index	Iran	VAR, cointegration estimation	4/6 ng (3/4 sg), 2/6 ps (0/2 sg)
Bouoiyour and Rey (2005)	1960-2000/Q	(X-M)/GDP, X/GDP, M/GDP	R	V6	Misalignment	Morocco	SUR	4/9 ng (1/4 sg), 5/9 ps (0/5 sg)
Clark et al. (2004)	1975-2000/5Y	Real value of bilateral trade	R, N	V5, V9	Product of real GDP of a pair of trading countries, product of real GDP per capita of a pair of trading countries, distance and some dummies	A large number of countries	Gravity model, panel data estimation, fixed effect	43/54 ng, 11/54 ps
Égert and Morales -Zumaquero (2005)	1990-2003/Y, 1993-2004/M	X	R, N	V5, V6, V21	Domestic income, foreign income, relative price, exchange rate, foreign direct investment	10 central and eastern European countries	Cointegration estimation, panel data estimation, fixed effect, DOLS, ARDL	Mixed effect
Frey (2005)	1972-1997/M	X	N	V9	Relative price, labour cost, foreign income, nominal exchange rate	Germany, Canada, France, UK, US	Cointegration estimation	4/5 ng (3/4 sg), 1/5 ps (0/1 sg)
Grier and Smallwood (2007)	1973-2003/M	X	R	V9	Lagged export, foreign income, real exchange rate, volatility of foreign income	9 developed countries, 9 developing countries	Asysmetric GARCH-M, ECM	6/9 ng sg for developing countries, insignificant for most developed countries

Hassan and Tufte (1998)	1977-1992/M	X	R	V5	World trade volume, export price	Bangladesh	Cointegration method	ng
Hondroyiannis et al. (2008)	1977-2003/Q	X	R	V1, V6, V9	Industrial trading partners' real GDP, relative price, real export earnings of oil-exporting countries	12 industrial countries	Panel data estimation, common-fixed-coefficient estimation, fixed effect, random effect, GMM, random-coefficient estimation	Most ng, all ns
Kasman and Kasman (2005)	1982-2001/Q	X	R, N	V6	Real foreign income, relative price	Turkey	Cointegration estimation, VAR, ECM	3/3 ps sg for long-run effect, 1/3 ps sg, 2/3 ng ns
Péridy (2003)	1975-2000/Y	X	N	V6, V9	Export price, nominal exchange rate, GDP, number of varieties	G7 countries	Panel data estimation, fixed effect, LSDV, IV, GMM, SUR-WLS	53/88 ng (51/53 sg), 35/88 ps (25/35 sg)
Poon et al. (2005)	1973-2002/Q	X	R, E	V6	Real world income, real effective exchange rate, terms of trade	Indonesia, Japan, South Korea, Singapore, Thailand	VAR, ECM	7/10 ng sg, 3/10 ps sg
Qian & Varangis (1994)	1973-1990/M	X	N	V9	Exchange rate, domestic labor cost, real foreign income, foreign price level	Australia, Canada, Japan, the Netherlands, Sweden, the United Kingdom	M-GARCG-M	5/12 ng ns, 7/12 ps (3/7 sg)
Schnabl (2007)	1994-2005/Y	Yearly real growth rates	????	V1, V5	Yearly per cent changes of exports, interest rate, yearly CPI inflation, dummies for crisis and inflation targeting regimes	41 EMU periphery countries	GLS, GMM, fixed effect, dynamic panel estimation model	105/132 ng (75/105 sg), 27/132 ps (12/27 sg)
Serenis (2008)	1973-2004/???	X	R	V5	Relative price, domestic GDP, time trend, and 6 dummies	14 EU member countries	Cointegration estimation	ns
Singh (2004)	1975-1996/Q	lnX-lnM	R, E	V9	Domestic income, foreign income, exchange rate	India	Cointegration estimation, VAR, ECM, ML	3/3 ng ns
Siregar and Rajan (2002)	1980-1997/Q	X,M	R	V6,V9	Real world GDP, real domestic GDP, relative price	Indonesia	Cointegration estimation	3/4 ng (1/3 sg), 1/4 ps ns

Solakoglu et al. (2008)	2001-2003/Y	X	???	V5	GDP, relative price, bilateral exchange rates	Turkey (143 firms)	Panel data estimation, fixed effect, random effect, OLS, GLS	ns
Todani and Munyama (2005)	1984-2004/Q	X	R, N	V6, V9	Relative price, income in trading partners	South Africa	Cointegration estimation, ARDL, ECM, VAR	2/9 ng (1/2 sg), 6/9 ps (3/6 sg)
Yarmukhamedov (2007)	1993-2006/M	X,M	R, E	V9	Real effective exchange rate, industrial production index, relative price, income level	Sweden	OLS	ns

Table 4.3: Empirical studies of the effects of exchange rate volatility at bilateral level

Author	Data	Dependent variable	Exchange rate	Volatility measure	Other explanatory variables	Countries	Method	Results
Agolli (2004)	1993-2003/Q	M/X	R/N	V6/V9	Gross domestic product, relative price, etc.	Albania, Germany, Greece, Italy	OLS, cointegration test, unit root test, VECM	3/6 ng (2/3 sg), 3/6 ps (3/3 sg)
Aristotelous (2001)	1889-1999/Y	X	R	V6	Real income, real income per capita, relative price, exchange-rate regime dummy and war dummy	UK, US	Cointegration test, unit root test	2/2 ng (0/2 sg)
Baak(2004)	1980-2002/Y	X	R	V5	GDP, distance, depreciation rate, dummies for border share, language and membership	14 Asia Pacific countries	Gravity model, OLS, fixed effects, random effects	24/24 ng (20/24 sg)
Baak et al. (2007)	1981-2004/Q	X	R	V5	Real GDP, real bilateral exchange rate	Hong Kong, Singapore, South Korea, Thailand, Japan, USA	Cointegration test, unit root test, ECM	6/8 ng sg, 2/8 ps (1/2 sg)
Baum et al. (2004)	1980-1998/M	X	R	V6	Foreign income, volatility of foreign income	13 countries	Nonlinear least squares estimation	54/149 ng (8/54 sg), 95/149 ps (29/95 sg)
Baum and Caglayan (2010)	1980-1998/M	X	R	V9	GDP, real exchange rate	13 countries	Bivariate GARCH	95/156 ng (8/95 sg), 59/156 (11/59 sg)
Bonroy et al. (2007)	1992-2003/M	X	R	V6	Export price	Quebec of Canada, US, Japan	SUR, Hamilton's flexible nonlinear estimation	Non-monotonic relation
Cheong et al. (2004)	1974-2003/M	M	R	V9	Real income, real exchange rate	US, UK	VAR, ECM	ng sg
Chit et al. (2010)	1982-2006/Q	X	R	V5, V6, V9	Home country GAP, importing country GDP, relative price, distance, common border and membership	China, Indonesia, Malaysia, Philippines, Thailand, 13	Panel data estimation, fixed effect, random effect, cointegration test,	12/12 ng sg

						industrialized countries	GMM-IV, G2SLS-IV	
Cho et al. (2002)	1974-1995/Y	Gross bilateral trade (M+X)	R	V5, V11	Product of a pair of trading countries' GDP, product of a pair of trading countries' population, distance, and dummies for language, border and membership	10 developed countries	Panel data estimation (fixed effect, random effects)	4/6 ng (3/4 sg), 2/6 ps (0/6 sg)
Choudhry (2008)	1980-2003/Q	M	R, N	V9	Real income, relative import price	UK, Canada, Japan, New Zealand	Multivariate cointegration method, constrained ECM	1/4 ng (0/1 sg), 3/4 ps (3/3 sg)
Clark et al. (2004)	1975-2000/5Y	Real value of bilateral total trade	R, N	V5, V9	Product of real GDP of a pair of trading countries, product of real GDP per capita of a pair of trading countries, distance and some dummies	A large number of countries	Gravity mo del, panel data estimation, fixed effect	43/54 ng, 11/54 ps
Cotter and Bredin (2007)	1979-2002/M	X	R	V8, V9, V15, V16	Real foreign income, real exchange rate, real income volatility and the interaction term	Ireland, US, UK	OLS, Possion lag approach	32/32 ps sg
De Grauwe and Skudelny (2000)	1962-1995/Y	X	N	V5	Lagged export, two trading countries' GDP and population, real exchange rate, distance, and some dummies for membership, adjacency and language	EMU countries	Gravity model, panel data estimation, fixed effec	50/64 ng (28/50 sg), 14/64 ps (3/14 sg)
Dell'ariccia (1999)	1975-1994/Y	Gross bilateral trade (M+X)		V2, V5, V8	Product of a pair of trading countries' GDP, product of a pair of trading countries' population, distance, and dummies for language, border and membership	15 EU countries, Switzerland	Gravity model, OLS, 2SGLS, random effects, fixed effects, IVE	27/27 ng sg
Doyle (2001)	1979-1992	X	R, N	V2, V9	Partner's industrial production, real exchange rate	Ireland, UK	Cointegration estimation, ECM, VAR	No long-run estimation, 1/3 ng sg and 2/3 ps sg for short-run
Fang and Miller (2004)	1997-2002/M	X	R	V9	Real foreign income, real exchange rate	Singapore	Bivariate GARCH-M	ng sg
	1997-	X	R	V9	Real foreign income, real exchange rate	8 Asian countries	DCC Bivariate GARCH-M	9/14 ng (8/9 sg),

Fang et al. (2006)	2003/M							5/14 ps (5/5 sg)
Herwartz (2003)	1971-2000/M	X, M	N	V9	Domestic and foreign industrial production index and consumer price index	US, Canada, Germany, UK, France, Italy, Japan	VECM, semiparametric technique	weak effect
Klaassen (2004)	1978-1996/M	X	R	V6, V9, V23	Foreign industrial production, real exchange rate	US and the G7 countries	Poisson lag structure model	ns
Klein and Shambaugh (2006)	1973-1999/Y	Bilateral trade	N???	V5	Product of a pair of trading countries' income, distance, and dummies for exchange rate regime and currency union	181 countries	Gravity model, fixed effect, random effect	For volatility, 23/23 ng (21/23 sg); for volatility square, 2/23 ng ns, 20/23 ps sg
Lin (2007)	1973-2000/Y	Extensive margin of exports, intensive margin of exports, share of world exports	N???	V5	Real GDP per capita of exporter relative to real GDP per capita of all countries who export to the importer, exporter's population relative to population of all countries who export to the importer, distance between two trading countries, dummyies for land border, language, free trade agreement, pairs currently in colonial relationship, pairs ever in colonial relationship	148 countries	Gravity model, panel data estimation, fixed effect	9/15 ng (5/9 sg), 6/15 ps (5/6 sg)
Onafowora and Owoye (2008)	1980-2001/Q	X	R	V9	Real foreign income, real exchange rate, a dummy for liberalization and economic reform policies	Nigeria, US	Cointegration estimation, VECM	ng sg for both long-run and short-run
Qian & Varangis (1994)	1973-1990/M	X	N	V9	Exchange rate, domestic labor cost, real foreign income, foreign price level	Australia, Canada, Japan, the Netherlands, Sweden, the United Kingdom	M-GARCG-M	2/4 ng (1/2 sg), 2/4 ps (1/2 sg)
Rahmatsyah et al. (2002)	1970-1997/Q	X,M	R,N	V6,V9	Real foreign GDP, real domestic GDP, relative price, exchange rate regime dummy	Thailand, US, Japan	Cointegration estimation, ARDL	12/16 ng sg, 3/16 ps sg
Rose (2000)	1970-1990/5Ys	X+M	N	V1, V5	Product of two trading countries' real GDP, product of two trading countries's real GDP per capita, distance between two trading countries, several	186 countries	Gravity model, OLS, WLS, Tobit, Heckit, panel data estimation, fixed effect, random effect, MLE,	48/53 ng (47/48 sg), 5/53 ps (2/5 sg)

					dummies for land border share, common official language, same regional trade agreement, colony and same currency		generalized linear Gaussian model estimator, quantile and robust regression, IVE	
Siregar and Rajan (2002)	1980-1997/Q	X,M	R	V6,V9	Real foreign GDP, real domestic GDP, relative price	Indonesia	Cointegration estimation	4/4 ng sg
Solakoglu (2005)	1974-1996/M	X	N???	V1, V5, V9, V10	Lagged real export, real exchange rate, relative price, foreign income level	US, France, Japan, Germany, UK, Canada	OLS ???	Mixed
Tenreyro (2007)	1970-1997/Y	X	N	V5, V19	Product of two trading countries GDP, distance between two trading countries, probability of common anchor, dummies for continuity, common-language, colonial-tie and free-trade agreement	87 countries	Gravity model, OLS, pseudo-maximum likelihood (PML), Poission PML, IVE, PPML-IVE	ns
Vergil (2002)	1990-2000/M	X	R	V3,V5	Importing country's industrial production index, real bilateral exchange rate	Turkey, France, Germany, Italy, US	Cointegration estimation, ECM,VAR	7/8 ng (4/7 sg), 1/8 ps ns

Table 4.4: Empirical studies of the effects of exchange rate volatility at sectoral level

Author	Data	Dependent variable	Exchange rate	Volatility measure	Other explanatory variables	Countries	Method	Results
Awokuse and Yuan (2006)	1976-2000/Y	X	R	V1, V3, V6	Importing country's income, unit export price, exchange rate level, trade openness	49 countries	Panel data estimation (fixed effect), FGLS, IVE	1/6 ng sg, 5/6 ps (3/5 sg)
Bahmani-Oskooee and Kovyryalova (2008)	1971-2003/Y	M, X	R	V5	Real GDP, real bilateral exchange rate	US, UK	Cointegration estimation, bounds test, ECM, ARDL	208/354 ng (115/208 sg), 146/354 ps (33/146 sg)
Boug and Fagereng (2007)	1985-2005/Q	X	R,N	V9	Relative price, trade-weighted imports, several dummies	Norway	Cointegrated VAR	undeterminant
Broda and Romalis (2003)	1970-1997/Y	Differentiated product trade	R	V3	Total trade, export price level	Large number of countries	OLS, GMM	6/8 ng (5/6 sg), 2/8 ps sg
Cheong et al. (2002)	1976-2000/M	X	EN	V9	Trade-weighted average of consumer price index of major export partners, trade-weighted average of industrial production index of major trading countries	UK and its 13 major export partners	VAR	ng
Cho et al. (2002)	1974-1995/Y	Gross bilateral trade (M+X)	R	V5, V11	Product of a pair of trading countries' GDP, product of a pair of trading countries' population, distance, and dummies for language, borderand membership	10 developed countries	Panel data estimation (fixed effect, random effects)	19/24 ng (9/19 sg), 5/24 ps (1/5 sg)
Clark et al. (2004)	1975-2000/5Y	M	R, N	V5, V9	Product of real GDP of a pair of trading countries, product of real GDP per capita of a pair of trading countries, distance and some dummies	A large number of countries	Gravity model, panel data estimation, fixed effect, SUR	3/4 ng, 1/4 ps
Doyle (2001)	1979-1992	X	R, N	V2, V9	Partner's industrial production, real exchange rate	Ireland, UK	Cointegration estimation, ECM, VAR	No long-run estimation, more positive than negative

								for short-run
Égert and Morales -Zumaquero (2005)	1990-2003/Y, 1993-2004/M	X	R, N	V5, V6, V21	Domestic income, foreign income, relative price, exchange rate, foreign direct investment	10 central and eastern European countries	Cointegration estimation, panel data estimation, fixed effect, DOLS, ARDL	20/32 ng (13/20 sg), 12/32 ps (3/12 sg)
Hayakawa and Kimura (2008)	1992-2005/M	X	R	V5, V22	Product of a pair of trading countries' GDP, distance, and dummies for language and contingency		Gravity model, OLS	46/52 ng (38/46 sg), 6/52 ps (4/6 sg)
Herwartz and Weber (2005)	1981-1998/M	X, M	R	V9	Domestic industrial production, weighted average of the industrial production in partner countries, real effective foreign exchange rate	15 industrialized countries	Cointegration estimation, VAR, VECM	Weak effect
Larson et al. (2005)	1989-2002/Y	Gross bilateral trade (M+X)	R	V5, V11	Product of two trading countries' GDP, product of two trading countries' population, distance between two trading countries, mean of tariffs within the product category between two trading countries, third country real exchange rate volatility for all countries other than the two trading countries	Argentina, Brazil, Paraguay, Uruguay	Gravity model, fixed effects, random effects, IVE	10/12 ng sg, 2/12 ps ns
Maskus (1986)	1974-1984/Q	X, M, X+M	R	V12	Real GNP in the importing country, real sectoral capacity utilization in the importing country, real unit labor costs in the exporting country, real exchange rate		US, Japan, UK, Germany, Canada	58/64 ng (26/58 sg)
May (2007)	1981-2006/M	X	R	V4, V6, V9	Real exchange rate, industrial production of major Thai trading partners	Thailand, US, Japan, Hong Kong, Euro Area	OLS	22/24 ng (10/22 sg), 2/2 ps ns
Md-Yusuf (2008)	1990-2002/M	X	R, N	V6, V9	Foreign income, relative price,	Malaysia, US, Japan,	Panel data (Fixed effect),	

					exchange rate	Singapore, UK, South Korea	OLS	
Pattichis et al. (2004)	1974-2000/M	M	N	V9	Relative price, income level of importing country	UK	Cointegration estimation, ECM	18/28 ng (4/18 sg), 10/18 ps (6/10 sg)
Péridy (2003)	1975-2000/Y	X	N	V6, V9	Export price, nominal exchange rate, GDP, number of varieties	G-7 countries	Panel data estimation, fixed effect, LSDV, IV, GMM, SUR-WLS	305/336 ng (272/305 sg), 31/336 ps (20/31 sg)
Pickard (2003)	1996-2002/M	M	R	V9	Relative price, average world price, real exchange rate	US, Canada, Mexico	Stochastic coefficient model	Most ns
Siregar and Rajan (2002)	1980-1997/Q	X,M	R	V6,V9	Real world GDP, real domestic GDP, relative price	Indonesia	Cointegration estimation	4/4 ng (3/4 sg)
Thorbecke (2008)	1985-2005/Y	X	R	V7	Real final electronic goods exports from the East Asian country to the world, bilateral real exchange rate, country pair and time fixed effects	5 ASEAN countries, and China, Japan, South Korea, Taiwan	Cointegration estimation, panel data estimation, fixed effect, DOLS	16/16 ng sg
Wang and Barrett (2007)	1989-1998/M	X	R	V9	Industrial production, real exchange rate, lagged export volume, a seasonality dummy	Taiwan, US	Multivariate GARCH-M, full information maximum likelihood	5/9 ng (2/5 sg), 4/9 ps ns
Yuan and Awokuse (2003)	1976-2000/Y	X	R	V1,V3,V6	Per capita income, unit export price,	US and its trading partners	Panel data estimation, fixed effect, OLS	4/6 ng (3/4 sg), 2/6 ps ns
Byrne et al. (2008)	1989-2001/Y	X,M	???	V5	sectoral value added in domestic industry, relative price, misalignment term, oil price volatility	US	Panel data estimation, SUR, fixed effects, random effects, IVE	30/30 ng (20/30 sg)

Chapter 5
Model, Variables and Data Specifications

5.1 Introduction

This study employs standard export and import demand equations including export and import as dependent variables, and independent variables including national and foreign income, relative price term and measures of exchange rate volatility.

This chapter has six sections. The introduction is followed by section two, which specifies the model, variables, data sources and preparation at aggregate trade data level. Unit root test methods and the bounds test approach for cointegration are introduced in detail as the main techniques for the analysis of this study. The model, variables and data series used at sectoral level are presented in section three. The model, variables and data series for the analysis at bilateral trade data level are presented in section four. Measures of exchange rate volatility, that is Moving Standard Deviation (MSD), and the conditional variance from the Generalized Autoregressive Conditional Hetroscedasticity (GARCH) models are presented in section five. Concluding remarks end the chapter in section six.

5.2 Unit Root and the Methods of Unit Root Test

Unit root

Suppose a stochastic process $\{y_t, t = 1, \cdots, \infty\}$ can be written as an autoregressive process of order p:

$$y_t = \sum_{i=1}^{p} a_i y_{t-i} + \varepsilon_t \quad (5.1)$$

Here, $\{\varepsilon_t, t = 0, \cdots, \infty\}$ is a serially uncorrelated, mean zero stochastic process with constant variance σ^2. If the characteristic equation:

$$m^p - a_1 m^{p-1} - a_2 m^{p-2} - \cdots - a_{p-1} m - a_p = 0 \quad (5.2)$$

has a unit root (i.e. $m = 1$), then the stochastic process is integrated of order one, denoted as $\mathrm{I}(1)$. If it has r unit roots, then the stochastic process is integrated of order r, denoted as $\mathrm{I}(r)$.

In time series models in econometrics, a unit root is a feature of processes that evolve through time and can cause problems in statistical inference if it is not adequately dealt with (Harris & Sollis, 2003, pp. 26-29).

Unit root test

For an AR (1) process:

$$y_t = ay_{t-1} + x_t'\delta + \varepsilon_t \qquad (5.3)$$

with optional exogenous regressors x_t (a constant or a constant and trend), two parameters a and δ, and a white noise ε_t, if $|a| \geq 1$, y is nonstationary; otherwise, it is (trend-) stationary. Thus, the hypothesis that y is (trend-) stationarity can be tested by evaluating whether the absolute value of a is strictly less than one (Anon, 2007).

Many unit root test methods generally test the null hypothesis H_N: $a = 1$ against the one-sided alternative H_A: $a < 1$. For some methods, the null is tested against a point alternative. However, the KPSS method tests the null $\mathrm{H_N}$: $a < 1$ against the alternative H_A: $a = 1$ (Anon, 2007).

Standard Dickey-Fuller test

The standard DF test is based on the following equation:

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \varepsilon_t \qquad (5.4)$$

where, $\alpha = a - 1$. The null and alternative hypotheses are

H_0: $\alpha = 0$

H_1: $\alpha < 0$ (5.5)

They can be evaluated using the t-ratio for α:

$$t_\alpha = \hat{\alpha}/se(\hat{\alpha}) \qquad (5.6)$$

where, $\hat{\alpha}$ is the estimate of α, and $se(\hat{\alpha})$ is the coefficient standard error (Anon, 2007; Nagstrup, 2012). However, under the null hypothesis of a unit root, this statistic (equation 5.8) does not follow the conventional student's *t*-distribution, and simulated critical values and *p*-values can be used for the test (Dickey & Fuller, 1979; MacKinnon, 1991, 1996).

Augmented Dickey-Fuller test

The Augmented Dickey-Fuller (ADF) test is based on the following equation:

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \sum_{j=1}^{p} \beta_j \Delta y_{t-j} + \nu_t \qquad (5.7)$$

This augmented specification is then used to test the hypotheses (equation 5.5) using the *t*-ratio (equation 5.6) (Anon, 2007).

Now we face two practical issues in performing an ADF test, that is, selecting the lag length (the number of lagged difference terms), and whether to include exogenous variables in the regression, which could consist of a constant, a constant and a linear time trend, or neither. In this study, the automatic lag length selection using a Akaike Information Criterion (AIC) and a maximum lag length of twelve are employed.

Dickey-Fuller Test with GLS detrending (DFGLS)

Generally, the power of the ADF and PP tests is very low against I(0) alternatives that are close to being I(1). For maximum power against very persistent alternatives, Dickey-Fuller Test with GLS detrending (DFGLS), proposed by Elliot, Rothenberg and Stock (1996) (hereafter ERS) should be used (Zivot & Wang, 2006).

The DFGLS test is constructed as follows (Anon, 2007). Define a quasi-difference of y_t :

$$y_t^{(d)}(a) = \begin{cases} y_t & if\ t = 1 \\ y_t - a y_{t-1} & if\ t > 1 \end{cases} \qquad (5.8)$$

It depends on the value a representing the specific point alternative against which we wish to test the null.

$x_t^{(d)}(a)$ can be defined in the same way.

Next, an OLS regression is carried out using the quasi-differenced data $y_t^{(d)}(a)$ and $x_t^{(d)}(a)$:

$$y_t^{(d)}(a) = [x_t^{(d)}(a)]'\delta(a) + \eta_t \quad (5.9)$$

which results in the estimates $\hat{\delta}(a)$.

A value of *a* is still needed. ERS recommend use $a = \bar{a}$, where

$$\bar{a} = \begin{cases} 1 - 7/T & \text{if} \quad x_t = \{1\} \\ 1 - 13.5/T & \text{if} \quad x_t = \{1, t\} \end{cases} \quad (5.10)$$

The *GLS detrended data,* y_t^d can be defined using the estimates associated with the $\bar{a}$:

$$y_t^d \equiv y_t - x_t' \hat{\delta}(\bar{a}) \quad (5.11)$$

Then the DFGLS test is based on the following equation:

$$\Delta y_t^d = \alpha \, y_{t-1}^d + \sum_{j=1}^{p} \beta_j \Delta y_{t-j}^d + v_t \quad (5.12)$$

It can be noted that the x_t are not included in the DFGLS test equation because the y_t^d are detrended. As with the ADF test, the *t*-ratio for $\hat{\alpha}$ from this test equation and simulated critical values should be used for the test (Anon, 2007).

Phillips-Perron test

Phillips-Perron (PP) propose an alternative method for unit root test, which makes a non-parametric correction to the *t*-ratio for $\hat{\alpha}$. This method is based on the following statistic (Anon, 2007):

$$\tilde{t}_\alpha = t_\alpha \left(\frac{\hat{\gamma}_0}{\hat{f}_0} \right)^{1/2} - \frac{T(\hat{f}_0 - \hat{\gamma}_0)[se(\hat{\alpha})]}{2\hat{f}_0^{1/2} s} \quad (5.13)$$

where, $\hat{\alpha}$ is the estimate, and t_α is the *t*-ratio of α , $se(\hat{\alpha})$ is coefficient standard error, and s is the standard error of the test regression. In addition, $\hat{\gamma}_0$ (= $(T - k)s^2 / T$, where *k* is the number of regressors) is a consistent estimate of the error variance in equation (5.4), and $\hat{f}_0$ is an estimator of the residual spectrum at frequency zero, which can be estimated based on kernel-based sum-of-covariances, or on autoregressive spectral density estimation (Anon, 2007).

KPSS Test

For unit root tests, like the ADF and PP tests, the null hypothesis is that y_t is I(1). For stationarity tests, like the KPSS test developed by Kwiatkowski, Phillips, Schmidt and Shin (1992), the null hypothesis is that y_t is I(0). The test statistic for KPSS test is based on the residuals from the following regression:

$$y_t = x_t'\delta + u_t$$

where, x_t are exogenous variables. The test statistic is given by

$$LM = \left(T^{-2} \sum_{t=1}^{T} \hat{S}_t^2 \right) / \hat{f}_0 \qquad (5.14)$$

where, $\hat{S}_t = \sum_{j=1}^{t} \hat{u}_j$, $\hat{u}_t$ is the residual of a regression of y_t on x_t , and $\hat{f}_0$ is an estimator of the residual spectrum at frequency zero (Anon, 2007). Again, the simulated critical values must be used for the test (Zivot & Wang, 2006).

Elliot, Rothenberg and Stock point optimal (ERS) test

ERS test is constructed as follows. Quasi-difference y_t and x_t in the same way as before (equation 5.8), and get $y_t^{(d)}(a)$ on $x_t^{(d)}(a)$ that depend on the value a representing the specific point alternative against which we wish to test the null $a = 1$.

Next, for any value of a , define $SSR(a)$ as the sum of squared residuals from a least squares regression of $y_t^{(d)}(a)$ on $x_t^{(d)}(a)$ (equation 5.9). The ERS (feasible) point optimal test statistic for the null that $a = 1$ against the alternative that $a = \bar{a}$ ($\bar{a} = 1 - \bar{c} / T$ and $\bar{c} < 0$) is then defined as

$$P_T = [SSR(\bar{a}) - \bar{a}SSR(1)] / \hat{f}_0 \qquad (5.15)$$

where, $\hat{f}_0$ is an estimator of the residual spectrum at frequency zero (Anon, 2007). ERS derive the asymptotic distribution of P_T for $x_t = 1$ and $x_t = \{1, t\}$ and provide asymptotic and finite sample critical values of the test (Zivot & Wang, 2006; Nagstrup, 2012).

Ng and Perron (NP) tests

Perron and Ng's (1996) PP tests are modified by Ng and Perron (2001) using the GLS detrending procedure of ERS (equation 5.11). These efficient versions of tests can have much higher power than the PP tests especially when a is close to unity. They are defined as (Anon, 2007):

$$MZ_\alpha^d = [T^{-1}(y_T^d)^2 - \hat{f}_0]/(2\kappa) \tag{5.16}$$

$$MSB^d = (\kappa / \hat{f}_0)^{1/2} \tag{5.17}$$

$$MZ_t^d = MZ_\alpha^d \times MSB^d \tag{5.18}$$

$$MP_T^d = \begin{cases} [\bar{c}^2\kappa - \bar{c}T^{-1}(y_T^d)^2]/\hat{f}_0 & if \ \ x_t = \{1\} \\ [\bar{c}^2\kappa + (1-\bar{c})T^{-1}(y_T^d)^2]/\hat{f}_0 & if \ x_t = \{1, t\} \end{cases} \tag{5.19}$$

Where, $\hat{f}_0$ is an estimator of the residual spectrum at frequency zero,

$\kappa = \sum_{t=1}^{T}(y_{t-1}^d)^2 / T^2$ and

$$\bar{c} = \begin{cases} -7 \ \ if \ \ x_t = \{1\} \\ -13.5 \ if \ \ x_t = \{1, t\} \end{cases} \tag{5.20}$$

NG and Perron derive the asymptotic distributions of these statistics under the local alternative $a = 1 - \bar{c}/T$ for $x_t = \{1\}$ and $x_t = \{1, t\}$.

5.3 Model, Variables and Data at Aggregate Trade Level

5.3.1 Standard export and import demand equations

In this study, the export and import demand equations at the aggregate level are specified as:

$$lnX_t = \beta_{10} + \beta_{11} lnY_t^f + \beta_{12} lnRP_t + \beta_{13} V_t + \varepsilon_{1t} \quad (5.21)$$

$$lnM_t = \beta_{20} + \beta_{21} lnY_t^d + \beta_{22} lnRP_t + \beta_{23} V_t + \varepsilon_{2t} \quad (5.22)$$

where, X_t denotes export volume from Australian to the rest of the world, and M_t denotes import volume to Australia from the rest of the world, RP_t is Australia's terms of trade, representing the ratio of the price of Australia's exports to its imports, also called relative price, Y_t^f is foreign income and Y_t^d is domestic income and are indicators of potential demand for the export and import, V_t denotes Australia's exchange rate volatility (for which logarithmic transformation is not necessary since it is derived from logarithm-transformed exchange rate.), ε_{1t} is the error term for the export equation and ε_{2t} is the error term for the import equation. These equations are commonly used in empirical studies for the long-run relationship between exchange rate volatility and export and import trade flows (Asseery & Peel, 1991; Chowdhury, 1993; Arize, 1995, 1997; Kasman & Kasman, 2005; Todani & Munyama, 2005).

Economic theory suggests that the income of trading partner is a major determinant of a country's trade performance. If foreign income increases, the demand for Australia's exports will also increase, so it is expected that β_{11} is positive. If relative price increases, the demand for Australia's exports will decrease, so it is expected that β_{12} is negative. If Australia's domestic income increases, the demand for imports will also increase, so it is expected that β_{21} is positive. If relative price increases, Australia's demand for imports will also increase, so it is expected that β_{22} is positive. However, the effect of exchange rate volatility on export and import demand cannot be determined a priori, and the sign of β_{13} and β_{23} is theoretically ambiguous (Siregar & Rajan, 2002; Kasman & Kasman, 2005; Todani & Munyama, 2005), and this is the focus of the empirical study.

The stationarity for each variable is tested with Augmented Dicky Fuller (ADF) tests (Dicky & Fuller, 1979). The test equation includes both an intercept and a linear trend. The null hypothesis of the test is that the series is non-stationary. The maximum length of lag required for serial correlation correction in the auxiliary regressions is selected on the basis of the Akaike Information Criterion (AIC). The Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test (Kwiatkowski et al., 1992) and Ng and Perron (2001) unit root test are also conducted. The latter one has been shown to have good size and power (Poon et al., 2005).

5.3.2 ARDL bounds testing approach

In this study, some of variables in the equations of (5.21) and (5.22), are I(1) and some are I(0). Pesaran and Shin (1995a, 1995b) argue that as long as both I(1) and I(0) series co-exist in a model, conventional cointegration tests, such as the two-stage residual-based method by Engle and Granger (1987) and maximum likelihood approximation by Johansen (1988, 1991, 1994), might bias the results of the long-run equilibrium interactions among variables. Therefore, Pesaran et al. (2001) propose the ARDL bounds testing procedure for cointegration and apply the bounds test to examine the long-run equilibrium relationship among variables which might consist of differing orders. The ARDL bounds test approach has been widely applied in various studies in recent years (Nieh & Wang, 2005).

Thus, this relatively new technique of the ARDL bounds test is employed in this study since our variables could be I(1) or I(0). An unrestricted ECM of the ARDL model for equation (5.21) can be formulated as:

$$\Delta lnX_t = c_0 + \sum_{k=1}^{n_1} c_{1k}\,\Delta lnX_{t-k} + \sum_{k=0}^{n_2} c_{2k}\Delta lnY_{t-k}^{f} + \sum_{k=0}^{n_3} c_{3k}\Delta lnRP_{t-k} + \sum_{k=0}^{n_4} c_{4k} lnV_{t-k} + \delta_0 lnX_{t-1} + \delta_1 lnY_{t-1}^{f} + \delta_2 lnRP_{t-1} + \delta_3 lnV_{t-1} + u_t \quad (5.23)$$

where, u_t is serially uncorrelated disturbance. Equation (5.23) is a standard autoregressive distributed lag (ARDL) model with the addition of lagged level variables in order to empirically analyse the long-run relationships and dynamic interactions among the variables of this study. It is also called unrestricted error correction model (UECM). Fosu and Magnus (2006) present three reasons for adopting the ARDL bounds testing procedure. Firstly, the bounds testing procedure is simple. Compared to other multivariate cointegration techniques, such as Johansen and Juselius (1990), it allows the cointegration relationship to be estimated by OLS once the lag order of the model is identified. Secondly, unlike other techniques such as the Johansen approach, the bounds testing procedure does not require the pre-testing of the variables included in the model for unit roots. It is applicable irrespective of whether the regressors in the model are purely I(0), purely I(1) or mutually cointegrated. Thirdly, the test is relatively more efficient in small or finite sample data sizes as is the case in their study.

The bounds testing procedure is the following: the first step in the ARDL bounds testing approach is to estimate equation (5.23) by OLS in order to test for the existence of a long-run relationship among the variables by conducting an F-test (Wald-test) for the joint significance of the coefficients of the lagged levels of the variables, i.e. $H_N: \delta_0 = \delta_1 = \delta_2 = \delta_3 = 0$ against the alternative $H_A: \delta_0 \neq 0$, $\delta_1 \neq 0$, $\delta_2 \neq 0$, $\delta_3 \neq 0$. We denote the test which normalises on X by F_X ($X \mid Y$, RP, V). Two asymptotic critical values bounds provide a test for cointegration when the independent variables are I(d) (where $0 \leq d \leq 1$): a lower value assumes the regressors are I(0) and an upper value assumes purely I(1) regressors.

If the F-statistic falls below the lower critical value, we fail to reject the null hypothesis and conclude that there is no cointegration relationship among the variables. If the F-statistic falls between the lower and upper critical values, then the result is inconclusive (Fosu & Magnus, 2006; Nieh & Wang, 2005). If the F-statistic of the ARDL bounds testing is higher than the upper critical value, the null hypothesis of no long-run relationship (H_N) is rejected. In this case we need to further test H_N': $\delta_0 = 0$ using t-statistic and the bounds critical values provided by Pesaran et al. (2001). Only when H_N' is rejected, we can confirm the existence of a long-run equilibrium relationship among variables irrespective of the orders of integration for the time series.

Once cointegration is established, the long-run effects of the dependent variables on exports are inferred by the estimates of $\delta_1,\ \delta_2,\ and\ \delta_3$ that are normalised by δ_0, i.e. the long-run coefficients for the three variables lnGDPW, lnRP and V are $-\delta_1/\delta_0$, $-\delta_2/\delta_0$ and $-\delta_3/\delta_0$ respectively. The short-run effects are inferred by the sign and size of $c_{2k},\ c_{3k}, and\ c_{4k}$ (Bahmani-Oskooee & Kovyryalova, 2008). When the long-run coefficients are obtained, a restricted error correction model (RECM) is estimated, which has the same structure as the UECM except the lagged error term that replaces the original linear combination of the lagged level variables in (5.23). If the lagged error term in the ECM is statistically significant and negative, the existence of the long-run equilibrium relationship among the variables is further confirmed.

Since the bounds test is based on the assumption that the disturbance u_t is serially uncorrelated (Pesaran et al. 2001), it is important to select appropriately the lag length n_i (i = 1, 2, 3, 4) in equation (5.23). Throughout this study, the maximum lag length is set to 12. Then the Akaike's Information Criterion (AIC) is used to select the lag length. The smaller the AIC, the better the model. During this process the residual serial correlation is also checked with the Lagrange Multiplier (LM) statistics. If the residuals are serially correlated when the lag length corresponding to the smallest AIC used, the lag length corresponding to the second smallest AIC is considered and the residual serial correlation is tested. This procedure continues until the lag length is found which produces serially uncorrelated residuals. For equation (5.23) we consider three variants: (1) no deterministic terms are included, i.e. $c_0 = c_1 = 0$; (2) only intercept term is included, i.e. $c_1 = 0$; (3) both deterministic terms (intercept and time trend) are included. The three variants may select different lag lengths, which variant and lag length are used for the further analysis depends on their AICs. The variant with its selected lag length that produces the smallest AIC among the three variants is finally chosen.

We also investigate both the long-run and short-run effects of Australia's exchange rate volatility on its imports flow. The unrestricted ECM of the ARDL model for equation (5.22) can be formulated as:

$$\Delta lnM_t = d_0 + \sum_{k=1}^{m_1} d_{1k}\, \Delta lnM_{t-k} + \sum_{k=0}^{m_2} d_{2k} \Delta lnY_{t-k}^d + \sum_{k=0}^{m_3} d_{3k} \Delta lnRP_{t-k}$$
$$+ \sum_{k=0}^{m_4} d_{4k} lnV_{t-k} + \lambda_0 lnM_{t-1} + \lambda_1 lnY_{t-1}^d + \lambda_2 lnRP_{t-1} + \lambda_3 lnV_{t-1} + u_t \quad (5.24)$$

where, u_t is serially uncorrelated disturbance. In (5.24), the null hypothesis of no cointegration is: H_N: $\lambda_0 = \lambda_1 = \lambda_2 = \lambda_3 = 0$ against the alternative H_A: $\lambda_0 \neq 0, \lambda_1 \neq 0, \lambda_2 \neq 0, \lambda_3 \neq 0$, by means of an F-test with the bounds critical values provided. Again, if the null hypothesis H_N is rejected, another null hypothesis H'_N needs to be tested. Only when H'_N is rejected, we can confirm the existence of a level relationship among the variables. Once again estimates of $d_{2k}, d_{3k,}$ and d_{4k} indicate the short-run effects, and estimates of $\lambda_1, \lambda_2, and\ \lambda_3$ that are normalised on λ_0, the long-run effects (Bahmani-Oskooee & Kovyryalova, 2008). The lag length m_i (i = 1, 2, 3, 4) is selected in the same way as that for the export equation.

5.3.3 Derivation of variables and data description

At the aggregate data level, export and import equations (5.21) and (5.22) consist of nine variables and nine data series in total: Australia's aggregate exports volume (*EXPORT*, X_t) and aggregate imports volume (*IMPORT*, M_t), Australia's GDP volume as a proxy of domestic income (*GDPAU*, Y_t^d), foreign income (*GDPW*, Y_t^f) which is constructed by taking the trade-weighted average of the GDP volume series of Australia's eight most important trading partners (trade of both exports and imports share is calculated according to each of the trading partners' total trade with Australia) i.e. US, UK, Germany, Japan, China, New Zealand, Singapore and South Korea, terms of trade serving as relative price (*RP*), and four exchange rate volatilities (V_t) generated from real effective exchange rate (REER) and nominal effective exchange rate (NEER) through GARCH and MSD methods, respectively, i.e. *CV_N*, *CV_R*, *MSD_N* and *MSD_R*.

The data on Australia's exports volume (quarterly from 1980Q1 to 2008Q3), imports volume (quarterly from 1980Q1 to 2008Q3), GDP volume (quarterly from 1980Q1 to 2008Q3, Year 2000=100), REER (quarterly from 1980Q1 to 2008Q4) and NEER (quarterly from 1980Q1 to 2008Q4) are collected from International Financial Statistics (IFS) of the International Monetary Fund (IMF). Trade weights are calculated according to the exports and imports values, and annual data from 1980 to 2008 from the Comtrade database (United Nations Statistics Division). Australia's terms of trade data series is sourced from Table 4, in the *Bulletin* of the Reserve Bank of Australia, with quarterly data from 1980Q1 to 2008Q4. The GDP volume data series of Australia's eight most important trading partners considered at the aggregate data level are collected from the IFS of the International Monetary Fund (IMF), with quarterly data from 1980Q1 to 2008Q4. The trade-weighted GDP volume serves as a proxy of foreign income (Y_t^f) in the export equation (5.1).

There are seven data series used in the econometric estimation of export demand equation (5.21): Australia's exports (*EXPORT*), foreign income (*GDPW*), relative price (*RP*), real exchange rate volatility derived from the GARCH method (*CV_R*), nominal exchange rate volatility derived from the GARCH method (*CV_N*), real exchange rate volatility derived from the moving standard deviation method (*MSD_R*) and nominal exchange rate volatility derived from the moving standard deviation method (*MSD_N*).

Meanwhile, there are seven data series, which are used in the econometric estimation of import demand equation (5.22): Australia's imports (*IMPORT*), Australia's domestic income (*GDPAU*), relative price (*RP*), real exchange rate volatility derived from the GARCH method (*CV_R*), nominal exchange rate volatility derived from the GARCH method (*CV_N*), real exchange rate volatility derived from the moving standard deviation method (*MSD_R*), and nominal exchange rate volatility derived from the moving standard deviation method (*MSD_N*).

5.4 Model, Variables and Data at Sectoral Trade Level

5.4.1 Model at sectoral trade data level

In this study, the export and import demand equations at the sectoral level are similar to those at aggregate level, which are specified as:

$$lnX_{it} = \beta_{30} + \beta_{31} lnY_t^f + \beta_{32} lnRP_t + \beta_{33} V_t + \varepsilon_{3t} \quad (5.25)$$

$$lnM_{it} = \beta_{40} + \beta_{41} lnY_t^d + \beta_{42} lnRP_t + \beta_{43} V_t + \varepsilon_{4t} \quad (5.26)$$

where, X_{it} denotes export volume for sector i from Australia to the rest of the world, and M_{it} denotes sector i's import volume to Australia from the rest of the world, RP_t is relative price, Y_t^f is foreign income and and Y_t^d is domestic income, V_t denotes exchange rate volatility, ε_{3t} is the error term for sector i's export equation, and ε_{4t} is the error term for sector i's import equation. If foreign income increases, the demand for Australian sector i's exports will also increase, so it is expected that β_{31} is positive. If relative price increases, the demand for Australian sector i's exports will decrease, so it is expected that β_{32} is negative. If Australia's domestic income increases, the demand for sector i's imports will also increase, so it is expected that β_{41} is positive. If relative price increases, Australia's demand for sector i's imports will also increase, so it is expected that β_{42} is positive. But the effect of exchange rate volatility on sector i's export and import demand cannot be determined, and the sign of β_{33} and β_{43} is theoretically inconclusive.

Engle and Granger (1987) indicate that the error correction model is a useful if the variables are non-stationary but cointegrated. The unrestricted ECM of the ARDL model for equation (5.25) can be formulated as:

$$\Delta lnX_{it} = c_0 + \sum_{k=1}^{n_1} c_{5k} \Delta lnX_{it-k} + \sum_{k=0}^{n_2} c_{6k} \Delta lnY_{t-k}^f + \sum_{k=0}^{n_3} c_{7k} \Delta lnRP_{t-k}$$
$$+ \sum_{k=0}^{n_4} c_{8k} lnV_{t-k} + \delta_4 lnX_{it-1} + \delta_5 lnY_{t-1}^f + \delta_6 lnRP_{t-1} + \delta_7 lnV_{t-1} + u_t \quad (5.27)$$

where, u_t is serially uncorrelated disturbance. Equation (5.27) is a standard autoregressive distributed lag (ARDL) model for Australian sector i's exports with the addition of lagged level variables. In equation (5.27), the null hypothesis of no cointegration is: H_N: $\delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$ against the alternative H_A: $\delta_4 \neq 0$, $\delta_5 \neq 0$, $\delta_6 \neq 0$, $\delta_7 \neq 0$, by means of an F-test with new critical values. If the null hypothesis H_N is rejected, another null hypothesis H_N' needs to be tested. Only when H_N' is rejected, we can confirm the existence of a level relationship among the variables. Once again estimates of $c_{6k}, c_{7k}, and\ c_{8k}$ indicate the short-run effects and estimates of $\delta_5, \delta_6 and\ \delta_7$ that are normalised on δ_4, the long-run effects.

Also Australian sector i's import flow is investigated with both the long-run and short-run effects, then in accordance with Pesaran et al.'s (2001) specification, the unrestricted ECM of the ARDL model for sector i's import equation (5.26) can be formulated as:

$$\Delta lnM_{it} = d_0 + \sum_{k=1}^{m_1} d_{5k}\,\Delta lnM_{it-k} + \sum_{k=0}^{m_2} d_{6k}\Delta lnY_{t-k}^{d} + \sum_{k=0}^{m_3} d_{7k}\Delta lnRP_{t-k}$$
$$+ \sum_{k=0}^{m_4} d_{8k} lnV_{t-k} + \lambda_4 lnM_{it-1} + \lambda_5 lnY_{t-1}^{f} + \lambda_6 lnRP_{t-1} + \lambda_7 lnV_{t-1} + u_t \quad (5.28)$$

where, u_t is serially uncorrelated disturbance. Equation (5.28) is a standard autoregressive distributed lag (ARDL) model for Australian sector i's imports with the addition of lagged level variables. In equation (5.28), the null hypothesis of no cointegration is: H_N: $\lambda_4 = \lambda_5 = \lambda_6 = \lambda_7 = 0$ against the alternative H_A: $\lambda_4 \neq 0$, $\lambda_5 \neq 0$, $\lambda_6 \neq 0$, $\lambda_7 \neq 0$, by means of an F-test with new critical values. If the null hypothesis H_N is rejected, another null hypothesis H_N' needs to be tested. Only when H_N' is rejected, we can confirm the existence of a level relationship among the variables. Once again estimates of $d_{6k}, d_{7k},$ and d_{8k} indicate the short-run effects and estimates of λ_5, λ_6 and λ_7 that are normalised on λ_4, the long-run effects.

The detailed statistical analyses for equations (5.27) and (5.28) are the same as those for equations (5.23) and (5.24) in section 5.3.2, which will not be described here again.

5.4.2 Derivation of variables and data description

For analysis at the sectoral data level, we sub-divide Australia's exports into its three main groups according to the definition of the Australia Bereau of Statistics (ABS): Manufactures, Resources and Rural Goods. Australia's imports are also sub-divided into their three main components: Capital, Consumption and Intermediate Goods. Therefore, there are three sectors in the export demand equation (5.25) and another three sectors in the import demand equation (5.26). In total, there are thirteen variables and thirteen data series included in the sector's export and import equations (5.25) and (5.26): Australian manufactures sector's export value (MAN, X_{it}), the resources sector's export value (RES, X_{it}), the rural goods sector's export value (RUR, X_{it}), the capital sector's import value (CAP, M_{it}), the consumption sector's import value (CSM, M_{it}), the intermediate goods sector's import value ($INTMD$, M_{it}), Australia's domestic income ($GDPAU$, Y_t^d), foreign income ($GDPW$, Y_t^f), relative price (RP_t) and four variables V_t (*CV_N*, *CV_R*, *MSD_N*, *MSD_R*) generated from GARCH and MSD methods.

Quarterly export and import trade data series in value terms of the Australia dollar for those six commodity groupings are collected from the Reserve Bank of Australia (RBA) over the period 1985Q3 to 2009Q1. In export equation (5.25), X_{it} denotes three export sectors, Manufactures (*MAN*), Resources (*RES*) and Rural Goods (RUR). In import equation (5.26), M_{it} denotes three import sectors, Capital (*CAP*), Consumption (*CSM*) and Intermediate Goods (*INTMD*). The other seven data series and sources represented by another seven variables in both equation (5.25) and (5.26) are the same as those included in equations (5.21) and (5.22): $GDPW$ (Y_t^f), $GDPAU$ (Y_t^d), *RP* (RP_t), *CV_N* (V_t), *CV_R* (V_t), *MSD_N* (V_t), *MSD_R* (V_t).

5.5 Model, Variables and Data at Bilateral Trade Level

Clark et al. (2004) suggest that it is essential to consider the effect generated from other trade determinants so that the particular impact of exchange rate volatility on trade flows can be examined. In this section, we move away from Australia's aggregate trade and sectoral trade, and explore trade based on bilateral trade and bilateral exchange rate data that permit the identification of the distinct contribution of exchange rate volatility to Australia's trade performance. Seven countries, China, Japan, New Zealand, South Korea, Singapore, US and UK, are chosen as Australia's seven major trading partners and the bilateral data series collected for those seven countries are applied to the models by using the error correction model and ARDL bounds testing approach. The common models are presented below and their specified form according to Pesaran et al. (2001) will be estimated by changing a specific country's trade data, etc.

5.5.1 Model at bilateral trade data level

The following standard trade equations will be used as the basic bilateral trade models for exports from Australia to one of its seven trading partners and imports from one of its seven trading partners, respectively. For example the equations for China are:

$$lnX_{bt} = \beta_{50} + \beta_{51} lnY_t^f + \beta_{52} lnRP_t + \beta_{53} V_t + \varepsilon_{5t} \qquad (5.29)$$

$$lnM_{bt} = \beta_{60} + \beta_{61} lnY_t^d + \beta_{62} lnRP_t + \beta_{63} V_t + \varepsilon_{6t} \qquad (5.30)$$

where, X_{bt} denotes bilateral export volume from Australian to China, and M_{bt} denotes bilateral import volume to Australian from China. Y_t^f denotes Chinese income and Y_t^d is Australia's domestic income and both are indicators of potential demand for the export and import. RP_t^f denotes the relative price between Australia and one of its seven major trading partners. Due to data limitations, there will be two ways to construct the relative price for different trading partners, and this will be presented in the section on derivation of variables (see section 5.5.2). V_{bt} denotes the volatility of the bilateral exchange rate between Australia and China, ε_{5t} is the error term for the bilateral export equation (5.29), and ε_{6t} is the error term for the bilateral import equation (5.30).

In equation (5.29), if the income of Australia's trading partner increases, the demand for Australia's exports will also increase, so it is expected that β_{51} is positive. If relative price increases, the demand for Australia's exports will decrease, so it is expected that β_{52} is negative. If Australia's domestic income increases, the demand for sector i's imports will also increase, so it is expected that β_{61} is positive. If relative price increases, Australia's demand for sector i's imports will also increase, so it is expected that β_{62} is positive. But the effect of exchange rate volatility on sector i's export and import demand cannot be determined, and the sign of β_{53} and β_{63} is theoretically inconclusive.

According to Engle and Granger (1987), the Error Correction model is a useful if the variables are non-stationary but cointegrated. The unrestricted ECM of the ARDL model for equation (5.29) can be formulated as:

$$\Delta lnX_{bt} = c_0 + \sum_{k=1}^{n_1} c_{9k}\, \Delta lnX_{bt-k} + \sum_{k=0}^{n_2} c_{10k} \Delta lnY_{t-k}^{f} + \sum_{k=0}^{n_3} c_{11k} \Delta lnRP_{t-k}^{f}$$
$$+ \sum_{k=0}^{n_4} c_{12k} lnV_{bt-k} + ð_0 lnX_{bt-1} + ð_1 lnY_{t-1}^{f} + ð_2 lnRP_{t-1}^{f} + ð_3 lnV_{bt-1} + u_t \quad (5.31)$$

where, u_t is serially uncorrelated disturbance. Equation (5.31) is a standard autoregressive distributed lag (ARDL) model for Australia's bilateral exports with the addition of lagged level variables. In equation (5.31), the null hypothesis of no cointegration is: H_N:$ð_0 = ð_1 = ð_2 = ð_3 = 0$ against the alternative H_A: $ð_0 \neq 0$, $ð_1 \neq 0$, $ð_2 \neq 0$, $ð_3 \neq 0$, by means of an *F*-test with new critical values. If the null hypothesis H_N is rejected, another null hypothesis H_N' needs to be tested. Only when H_N' is rejected, we can confirm the existence of a level relationship among the variables. Once again, estimates of $c_{10k}, c_{11k}, and\, c_{12k}$ indicate the short-run effects and estimates of $ð_1, ð_2,$ and $ð_3$ that are normalised on $ð_0$, the long-run effects.

Also Australia's bilateral import flow is investigated with both the long-run and short-run effects. The unrestricted ECM of the ARDL model for the bilateral import equation (5.30) can be formulated as:

$$\Delta lnM_{bt} = d_0 + \sum_{k=1}^{m_1} d_{9k}\, \Delta lnM_{bt-k} + \sum_{k=0}^{m_2} d_{10k} \Delta lnY_{t-k}^{d} + \sum_{k=0}^{m_3} d_{11k} \Delta lnRP_{t-k}$$
$$+ \sum_{k=0}^{m_4} d_{12k} lnV_{bt-k} + ø_0 lnM_{bt-1} + ø_1 lnY_{t-1}^{f} + ø_2 lnRP_{t-1}^{f} + ø_3 lnV_{t-1} + u_t \quad (5.32)$$

where, u_t is serially uncorrelated disturbance. Equation (5.32) is a standard autoregressive distributed lag (ARDL) model for Australia's bilateral imports with the addition of lagged level variables. In equation (5.32), the null hypothesis of no cointegration is: H_N: $ø_0 = ø_1 = ø_2 = ø_3 = 0$ against the alternative H_A: $ø_0 \neq 0$, $ø_1 \neq 0$, $ø_2 \neq 0$, $ø_3 \neq 0$, by means of an *F*-test with new critical values. If the null hypothesis H_N is rejected, another null hypothesis H_N' needs to be tested. Only when H_N' is rejected, we can confirm the existence of a level relationship among the variables. Once again estimates of $d_{10k}, d_{11k}, and\, d_{12k}$ indicate the short-run effects and estimates of $ø_1, ø_2, and\ ø_3$ that are normalised on $ø_0$, the long-run effects.

The detailed statistical analyses for equations (5.31) and (5.32) are the same as those for equations (5.23) and (5.24) in section 5.3.2, which will not be described here again.

Cointegration and error correction models are used to obtain the estimates of the cointegrating relations and the short-run dynamics, respectively. The sensitivity of exports and imports to exchange rate volatility are investigated by applying the bounds test analysis to Australia's seven major trading partners. Two volatility measures, GARCH and MSD, are used to investigate whether results depend upon the measure chosen.

5.5.2 Derivation of variables

At the bilateral data level, Australia's seven major trading partners are taken into account in the analysis. Therefore, there are seven pairs of export and import equations from (5.29) and (5.30), consisting of sixty-four data series in total. The US is used as an example to explain how equations (5.29) and (5.30) work.

In bilateral trade export and import equations (5.29) and (5.30), X_{bt} denotes Australia's exports to the US, M_{bt} denotes Australia's imports from the US, Y_t^f denotes U.S. income, Y_t^d denotes Australia's income, RP_t denotes the relative price of the ratio of US's export price to Australia's export price (see equation (5.33) for the formula of the calculation), and V_{bt} denotes exchange rate volatility generated from the nominal Australia-US bilateral exchange rate through GARCH and MSD methods, so there are two volatility measures at bilateral level analysis for each country.

As for the US, the relative price variable (RP_t) of all the other five major trading partners, excluding China, that is, Japan, New Zealand, South Korea, Singapore and UK, is constructed by the following formula:

$$RP_t = \text{Ln}(ER_{bt} \times \frac{PX_f}{PX_{au}}) \qquad (5.33)$$

where, ER_{bt} denotes the bilateral exchange rate between Australia and its trading partner, PX_f denotes the trading partner's export price index, and PX_{au} denotes Australia's export price index.

In the case of China, given the limitation of the data availability of the Chinese export price in the period of consideration of this study, RP_t^{cn} is constructed by the formula below (Larson et al., 2005):

$$RP_t^{cn} = \text{Ln}(ER_{bt} \times \frac{CPI_{cn}}{CPI_{au}}) \quad (5.34)$$

where, ER_{bt} denotes the bilateral exchange rate between Australia and China, CPI_{cn} denotes the Chinese consumer price index and CPI_{au} denotes the Australian consumer price index.

5.5.3 Data description

For the analysis at the bilateral data level, there are seven pairs of export and import equations and sixty-four data series included. The data series used in bilateral export equation (5.29) is described as the following: bilateral export values (X_{bt}) between Australia and its seven major trading partners are collected from ABS monthly data in A$millions, spanning January 1988 to December 2008, then converted to quarterly data. Annual bilateral export values between 1981 and 1987 are collected from *Year Book of Australia* (1985, 1988), and converted to quarterly data via the Otani-Riechel Smoothing Technique (Chit, 2008), so the seven bilateral export data series span 1981Q1 to 2008Q4.

For foreign income, denoted as GDP volume (Y_t^f), quarterly data are collected for eight countries from 1980Q1 to 2008Q4 from the IMF. Relative price as a proxy of terms of trade is calculated using the formula of equation (5.33) for six country pairs including Australia, US, UK, Japan, New Zealand, Singapore and South Korea. Data on the export price index (PX_{au} & PX_f) are collected from the IFS database for the period 1980Q1 to 2008Q4. For China, CPI data is used to calculate the relative price with Australia via the formula of equation (5.34). Yearly CPI data for China are collected from the *Chinese Statistical Year Book* for the years 1977 to 2008, and then converted to quarterly data by using the Otani-Riechel Smoothing Technique. CPI data for Australia is collected from the IFS, spanning 1980Q1 to 2008Q4. Monthly exchange rates from December 1983 to December 2008 between Australia and its seven major trading partners are collected from the Reserve Bank of Australia (Table F11), then converted to quarterly data by the Otani-Riechel Smoothing Technique.

Data used in the bilateral import equation (5.30) are described as the following: bilateral import values (M_{bt}) between Australia and its seven major trading partners are collected from ABS monthly data in A$millions, from January 1988 to December 2008, and converted to quarterly data. Annual bilateral imports values between 1981 and 1987 for those seven country pairs are collected from the *Year Book of Australia* (1985, 1988), and converted to quarterly data via the Otani-Riechel Smoothing Technique. For foreign income (Y_t^f), denoted as GDP volume, quarterly data are collected for eight countries for 1980Q1 to 2008Q4 from the IMF. Relative price as a proxy of terms of trade is calculated using the formula of equation (5.33) for six country pairs including Australia, US, UK, Japan, New Zealand, Singapore and South Korea. Data on the export price index are collected from the IFS database. In terms of relative price between Australia and China, the data series here in the bilateral import equation is the same as the one in the bilateral export equation above. Once again, the data series of the bilateral exchange rate between Australia and its seven major trading partners is the same as the one in the bilateral export equation.

The empirical models specified at the bilateral trade level consist of sixty-four data series. Since the data were collected from a wide range of sources for the eight countries, including Australia, over twenty-seven years, some data points were not available or missing for various reasons, for example, the relative price for China is calculated (equation 5.34) from the CPI since the data series of the export price index is not available for China, whereas relative prices for the other six countries are calculated from the export price index sourced from the IMF database. Analysis on bilateral data level employs the standard trade model as analysis on both aggregate data and sectoral data.

5.6 Exchange Rate Volatility Measures

5.6.1 MSD measure

Exchange rate volatility intends to capture the uncertainty faced by the exporters due to the unpredictable exchange rate risk (Todani & Munyama, 2005). Though there are many measures to proxy it, the two most commonly used are the moving standard deviation model and the conditional variance from a GARCH model. Both of these models will be used in this study.

The first is the moving standard deviation of the first difference of the logarithm of both nominal and real exchange rate, which is defined as

$$Vs_t = \left[\frac{1}{m}\sum_{i=1}^{m}(lnER_{t+i-1} - lnER_{t+i-2})^2\right]^{1/2} \qquad (5.35)$$

where, *ER* is the monthly real or nominal exchange rate, *m* is the order of moving average, which will be set to 6 months. The resulted volatility series is transformed to quarterly data to be used in the following analysis. This measure has been used in many studies, for example, Siregar and Rajan (2002), Poon et al. (2005), Kasman and Kasman (2005), and Hondroyiannis et al. (2008).

5.6.2 GARCH measure

The second measure is the conditional variance from the generalized autoregressive conditional hetroscedasticity (GARCH) model, proposed by Bollerslev (1986). It is assumed that exporters form the expectations of the exchange rate series following an ARMA(m,n) process, with conditional variance (*CV*) specified as a GARCH(p,q) process, which are specified as in the following equations (5.36), (5.37) and (5.38):

$$A_m(L)\Delta lnER_t = \gamma_0 + B_n(L)\varepsilon_t \qquad (5.36)$$

$$\varepsilon_t|\Omega_{t-1} \sim N(0, h_t^2) \qquad (5.37)$$

$$h_t^2 = \alpha_0 + \sum_{j=1}^{p}\alpha_j\varepsilon_{t-j}^2 + \sum_{k=1}^{q}\beta_k h_{t-k}^2 \qquad (5.38)$$

where, h_t^2 is the conditional variance of the error term ε_t. The resulted volatility series (CV) is transformed to quarterly data to be used in the following analysis. A similar approach has been used in Cheong et al. (2002), Pattichis et al. (2004), Todani and Munyama (2005), and Wang and Barrett (2002).

5.7 Concluding Remarks

The main objective of this chapter is to establish models for three trade data levels in Australia, aggregate trade data, sectoral trade data and bilateral trade data, to test the impact of the exchange rate volatility on Australia's trade performance. The models for both import and export aspects of Australia's trade are presented in this chapter, as well as the estimation techniques used for the three data levels. The error correction model and ARDL bounds testing approach are applied to test the cointegration among variables at different trade data levels. Four measures of the exchange rate volatility are used at both aggregate and sectoral data level and two used at the bilateral data level. Derivations of variables, data sources and preparation of the three data levels are documented in detail.

Chapter 6

Empirical Results at the Aggregate Trade Data Level

6.1 Introduction

The purpose of this chapter is to examine whether exchange rate volatility affects Australia's trade flow and presents the empirical results at the aggregate trade data level. Unit root test results for nine variables are presented in section two. Results for Australia's aggregated exports are shown in section three. The fourth section displays the results for Australia's aggregated imports. Concluding remarks end the chapter in section five.

6.2 Unit Root Test Results

There are a number of statistical procedures available in the literature for testing unit roots in time series data. In this study six methods, that is, Dickey and Fuller (1981, ADF), Phillips and Perron (1988, PP), Elliott, Rothenberg and Stock (1996, DFGLS, the GLS-detrended Dickey-Fuller), Elliott, Rothenberg and Stock (1996, ERS), Kwiatkowski et al. (1992, KPSS) and Ng and Perron (2001, NP), are used to fully analyse the stationarity of each of the nine variables included in the export and import equations, which include *export*, *import*, *gdpw*, *gdpau*, *rp*, *CV_N*, *CV_R*, *MSD_N*, *MSD_R*.

The results are shown in Table 6.1. Two volatility measures (*MSD_N* and *MSD_R*) derived from the MSD method are detected as I(0), and foreign income (*gdpw*) is detected as I(1), which is consistent among all the six test methods. For all the other variables, the results are inconsistent among the six test methods. *export* is tested as I(0) by PP and NP, and as I(1) by ADF and KPSS, but it seems that its first difference still has unit root as detected by the two ERS methods. *import* is found to be as I(0) by ERS, PP, KPSS and NP, and as I(1) by ADF and ERSPO. It seems that the first difference of *gdpau* still has unit root as detected by NP, but it is detected as I(1) by the other five methods. *rp* is detected as I(0) by ADF, ERS and KPSS, and as I(1) by PP and ERSPO, but its first difference still has unit root as

Table 6.1: Results of various unit root tests

Test methods						
Variables	ADF	ERS	PP	KPSS	ERSPO	NP
export						
Level	-2.9069 (4)	-2.5218 (4)	-3.9153** (6)	0.1368* (6)	168.6440 (4)	-3.7625*** (4)
Difference	-4.2201*** (3)	-2.4135 (7)	-15.4881***(10)	0.1390 (28)	8.7228 (3)	-0.9358 (4)
import						
Level	-3.0763 (6)	-3.0484* (6)	-4.0944***(5)	0.0690 (6)	540.6449 (6)	-2.2998** (6)
Difference	-5.0229***(5)	-3.7334***(5)	-25.6916***(90)	0.5000**(90)	1.8352***(5)	-0.8088 (12)
gdpau						
Level	-2.2298 (2)	-2.2800 (1)	9.9827 (4)	0.1632** (7)	1458.84 (1)	-2.0569 (2)
Difference	-7.3054***(0)	-5.3234***(4)	-7.2977***(2)	0.0827 (3)	2.7473***(4)	-4.6538***(1)
gdpw						
Level	5.5748 (1)	-1.0559 (1)	5.7733 (2)	0.1570** (7)	528.1897 (1)	-0.9016 (1)
Difference	-12.2347***(0)	-11.9725***(0)	-12.2586***(0.6)	0.2590 (2)	4.8017**(0)	-2.7361***(0)
rp						
Level	-1.6847***(2)	-1.3677***(2)	-1.2486 (5)	0.2307 (7)	25.2374 (2)	-1.2594 (2)
Difference	-3.7065***(1)	-4.0663 (1)	-6.5445***(4)	0.0573 (5)	1.5305***(1)	-3.2113** (1)
CV_N						
Level	-8.23*** (0)	-3.2921***(5)	-8.1837***(1)	0.1108 (0)	5.2190** (0)	-3.5566***(0)
Difference	-4.9169***(11)	-3.0041***(6)	-37.7629***(42)	0.2572 (14)	14297.49 (12)	0.2139 (6)
CV_R						
Level	7.9671*** (12)	-6.1491***(0)	-7.9099***(2)	0.1112 (0)	5.4349** (0)	3.4880***(0)
Difference	-5.0402***(11)	-4.9266***(11)	-35.4029***(39)	0.2744 (13)	6040.87 (11)	0.6219 (11)
MSD_N						
Level	-4.1841***(5)	-3.6020** (5)	-4.3285***(10)	0.0611 (2)	0.6530***(5)	-2.7657***(2)
Difference	-8.5007***(3)	-8.5071***(3)	-11.1415***(90)	0.4064* (57)	0.8941***(3)	-2.7264***(3)
MSD_R						
Level	-6.5525***(1)	-4.9620***(1)	-4.3683***(9)	0.0629 (3)	0.7695***(1)	-4.1428***(1)
Difference	-8.6014***(3)	-8.4285***(3)	-11.0748***(51)	0.3335 (38)	1.0608***(3)	-2.8579***(3)

Notes:

1. The test statistic of NP is MZ_t.
2. The numbers in the parenthesis after test statistic value is the selected bandwidth for PP and KPSS and the number of selected lags for the other test methods.
3. The maximum lag is set at 12, and the optimal lag was selected using AIC.
4. For PP and KPSS, the Bartlett Kernel method is used for spectral estimation, and the Newey-West Bandwidth method is used for bandwidth selection.
5. For spectral estimation, the AR spectral OLS method is used for ERSPO, and the AR GLS-detrended method is used for NP.
6. Use the smallest AIC in the regression result to decide whether to include intercept or trend or none of them.

detected by NP. *CV_N* and *CV_R* are detected as I(0) by ERS, PP and NP, and as I(1) by ADF and KPSS, but they still have unit roots as detected by ERSPO. From these tests, it can reasonably be assumed that the integration order for all the variables is no more than 1.

6.3 Estimation Results for Export Equation

6.3.1 Bounds test for cointegration

Since all the variables involved in the export equation are integrated in the order of no greater than 1, we can proceed to test the cointegration among the variables using the bounds test approach developed by Pesaran et al. (2001). The lag lengths selected for the UECMs corresponding to the four export equations using *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the exchange rate volatility measures are all 4. The results for these UECMs are shown in Table 6.2, and their corresponding bounds test statistic F is 6.1272, 5.9531, 1.4005 and 1.4430 respectively. The first two with GARCH-derived volatilities are above the upper critical bound value (4.84) at the 1 per cent significance level, and the latter two with MSD-derived volatilities are far below the lower critical bound value (2.72) at the 10 per cent significance level. For the first two, the *t*-statistic values are -3.3646 and -3.4004, which are all beyond the bound critical value -3.33 at the 5 per cent significance level. This indicates that when exchange rate volatility is derived by the GARCH method, there is a long-run equilibrium relationship between Australia's aggregated export and its determinants, that is, cointegration exists among the four variables (Australia's domestic income, foreign income, relative price and volatility of exchange rate *CV_N* or *CV_R*); whereas exchange rate volatility is derived from moving standard deviation, there is no long-run equilibrium relationship between Australia's aggregated export and its determinants, that is, cointegration does not exist among the four variables (Australia's domestic income, foreign income, relative price and volatility of exchange rate *MSD_N* or *MSD_R*).

It can be seen from the first two columns in Table 6.2 that exchange rate volatility is significant at the 1 per cent level and foreign income (*gdpw*) is significant at the 10 per cent level, but relative price (*rp*) is not significant. Table 6.3 provides long-run multipliers for the export equations with GARCH-derived volatilities, and both the estimated coefficients for foreign income (*gdpw*) and relative price (*rp*) have the expected signs, that is, positive and negative respectively. The empirical estimates strongly indicate that exchange rate variability has a positive effect on Australia's aggregate exports trade flows.

6.3.2 Restricted error correction model

On the condition that there exist cointegrations among the variables for the export equations with GARCH-derived volatilities, we go on to estimate a restricted ECM for each of them. The results are shown in Table 6.4. The literature suggests that the coefficient of the lagged error correction term should be negative and statistically significant in order to further confirm the existence of a long-run relationship (Bathalomew & Kargbo, 2009). As shown in Table 6.4, the *EC* terms in the two equations are significant at the 1 per cent level and the corresponding coefficients are negative. This confirms the existence of cointegration among the four variables for each of the two export equations. The coefficients imply that the system converges back to its long-run equilibrium quickly after previous quarter's shock.

Since there is no cointegration among the four variables for each of the two export equations with *MSD_N* and *MSD_R* as exchange rate volatility measures, we go on to investigate the short-run relationship among the four variables corresponding to each of the two export equations (Table 6.5). The results are similar for the two equations. All the (contemporaneous) volatilities, foreign income (*gdpw*) and relative price (*rp*) have negative effects on Australia's exports. The effect of volatilities is significant at the 10 per cent level, and the effect of foreign income (*gdpw*) is significant at the 5 per cent level, and the effect of relative price (*rp*) is not significant.

Table 6.2: The ECM-ARDL results for the export equations with the four volatility measures

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c					-0.4876	*	-0.4996	*
D_*export*(-1)	-0.1619		-0.1624		-0.2283	*	-0.2426	*
D_*export*(-2)	-0.0163		-0.0132		-0.0778		-0.0822	
D_*export*(-3)	-0.1882	*	-0.1846	*	-0.2853	**	-0.2662	**
D_*export*(-4)	0.3819	***	0.3864	***	0.3368	***	0.3404	***
D_*gdpw*	-0.8041	**	-0.7819	**	-0.6973	**	-0.7016	**
D_*gdpw*(-1)	-0.9202	**	-0.8884	**	-0.7413	**	-0.7610	**
D_*gdpw*(-2)	-0.5786	*	-0.5459	*	-0.5042		-0.5306	
D_*gdpw*(-3)					-0.2733		-0.2737	
D_*gdpw*(-4)					-0.0166		0.0025	
D_*rp*	-0.1754		-0.1689		-0.1959		-0.2075	
D_*rp*(-1)	0.7401	**	0.7426	**	0.4177		0.3773	
D_*rp*(-2)					0.1588		0.2134	
D_*rp*(-3)					-0.0009		-0.0320	
D_*rp*(-4)					-0.2577		-0.2711	
D_*V*	0.0207		0.0204		-0.0399		-0.0442	
D_*V*(-1)					-0.0333		-0.0229	*
D_*V*(-2)					0.0043		-0.0030	
D_*V*(-3)					-0.0175		-0.0182	
D_*V*(-4)					-0.0125		-0.0113	
export(-1)	-0.1261	**	-0.1246	**	-0.0807		-0.0818	
gdpw(-1)	0.2699	*	0.2659	*	0.1263		0.1292	
rp(-1)	-0.0001		-0.0052		0.0809		0.0817	
V(-1)	0.0666	***	0.0625	***	-0.0054		-0.0058	
Diagnostic statistics								
R^2	0.5233		0.5192		0.5397		0.5337	
R^2_{adj}	0.4428		0.4380		0.3817		0.3736	
AIC	-3.2215		-3.2130		-3.0368		-3.0237	
SC	-2.8352		-2.8267		-2.3746		-2.3615	
HQC	-3.0657		-3.0571		-2.7696		-2.7566	
$\chi^2_N(2)$	1.2921	[0.5241]	1.2921	[0.5241]	1.2512	[0.5349]	1.8440	[0.3977]
$\chi^2_{SC}(2)$	0.6142	[0.7356]	0.7062	[0.7025]	1.4096	[0.4942]	2.0791	[0.3536]
$\chi^2_H(1)$	0.8373	[0.3602]	0.9128	[0.3394]	0.4357	[0.5092]	0.5605	[0.4541]
$\chi^2_{FF}(2)$	0.4815	[0.4877]	0.6791	[0.4099]	0.0139	[0.9063]	0.0005	[0.9826]

Note: ***, ** and * in the table denote that the coefficients are statistically significant at the 1, 5 and 10 per cent level, respectively. R^2 and R^2_{adj} are the squared and adjusted squared multiple correlation coefficients. AIC, SC and HQC are Akaike's, Schwarz's and Hannan-Quinn's information criteria. χ^2_N, χ^2_{SC}, χ^2_H and χ^2_{FF} denote chi-squared statistics to test for normal errors, no residual serial correlation, homoscedasticity and no functional form mis-specification respectively. The numbers within the round brackets are degrees of freedom and those within the square brackets are P-values.

Table 6.3: Long-run multipliers for the two export equations with GARCH-derived volatilities

Volatility used In equations	*gdpw*	*rp*	Volatility
CV_N	2.1412	-0.0011	0.5283
CV_R	2.1337	-0.0420	0.5015

Note: Compiled by author.

6.3.3 CUSUM and CUSUMSQ stability tests

The cumulative sum (CUSUM) test is based on the cumulative sum of recursive residuals based on the first set of n observations. It is updated recursively and is plotted against the break points. If the plot of the CUSUM statistic stays within the 5 per cent significance level, then estimated coefficients are said to be stable. A similar procedure is used to carry out the CUSUMSQ that is based on the squared recursive residuals.

Figures 6.1, 6.2 and 6.3 are plots of CUSUM and CUSUMSQ for coefficient stability for the ECM model for the export equation. Since the time series constituting the ARDL equation are potentially of mixed order of integration, I(0) and I(1), it is natural to detect heteroscedasticity (Shrestha & Chowdhury, 2005). The cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) plots from a recursive estimation of the model also indicate stability in the coefficients over the sample period. Since the plots of the CUSUM and CUSUMSQ statistic for all variables data series do not cross the critical value lines, it is safe to conclude that the aggregated export equation is stable at the 5 per cent significance level.

Table 6.4: The ECM results for the export equation with *CV_N* and *CV_R* as volatility measures

Variable	*CV_N*		*CV_R*	
D_*export*(-1)	-0.1619	*	-0.1624	*
D_*export*(-2)	-0.0163		-0.0132	
D_*export*(-3)	-0.1882	**	-0.1846	**
D_*export*(-4)	0.3819	***	0.3864	***
D_*gdpw*	-0.8041	***	-0.7819	***
D_*gdpw*(-1)	-0.9202	***	-0.8884	***
D_*gdpw*(-2)	-0.5786	*	-0.5458	*
D_*rp*	-0.1754		-0.1689	
D_*rp*(-1)	0.7401	**	0.7426	**
D_*V*	0.0207		0.0204	
EC(-1)	-0.1261	***	-0.1246	***
Diagnostic statistics				
R^2	0.5233		0.5192	
R^2_{adj}	0.4637		0.4591	
AIC	-3.2875		-3.2789	
SC	-2.9839		-2.9754	
HQC	-3.1650		-3.1565	
$\chi^2_N(2)$	1.2922	[0.5241]	1.4283	[0.4896]
$\chi^2_{SC}(2)$	0.2527	[0.7773]	0.2886	[0.7501]
$\chi^2_H(1)$	1.1529	[0.3333]	1.1330	[0.3477]
$\chi^2_{FF}(2)$	0.3568	[0.5560]	0.5100	[0.4773]

Note: The meanings of the diagnostic statistics are the same as those in Table 6.2.

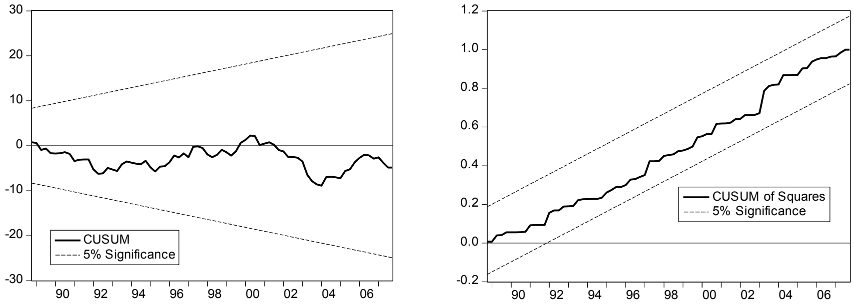
Table 6.5: The short-run relationship among the four variables of the export equations with *MSD_N* and *MSD_R* as volatility measures

Variable	*MSD_N*		*MSD_R*	
c	0.0220	***	0.0259	***
D_*export*(-1)	-0.2156	**	-0.2203	**
D_*export*(-2)	-0.0500		-0.0485	
D_*export*(-3)	-0.2402	**	-0.2444	**
D_*export*(-4)	0.3941	***	0.3761	***
D_*gdpw*	-0.5974	**	-0.6848	**
D_*gdpw*(-1)			-0.4382	
D_*rp*	-0.0131		-0.2143	
D_*rp*(-1)			0.5314	*
D_*V*	-0.0319	*	-0.0294	*
D_*V*(-1)	-0.0215		-0.0173	
Diagnostic statistics				
R^2	0.4490		0.4708	
R^2_{adj}	0.3953		0.4046	
AIC	-3.1867		-3.1829	
SC	-2.9383		-2.8794	
HQC	-3.0865		-3.0605	
DW-statistic	1.9949		2.0187	
$\chi^2_N(2)$	3.5118	[0.1727]	0.5239	[0.7695]
$\chi^2_{SC}(2)$	0.4892	[0.6149]	0.7313	[0.4845]
$\chi^2_H(1)$	0.8388	[0.5713]	0.9911	[0.4581]
$\chi^2_{FF}(2)$	0.4068	[0.5254]	0.4061	[0.5258]

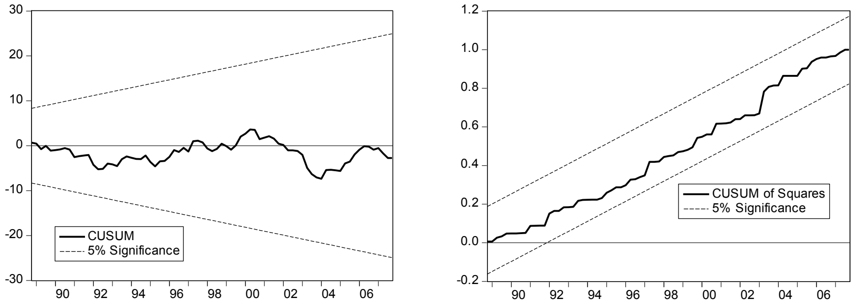
Note: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Figure 6.1: Recursive estimates in the stability test for the UECMs corresponding to the export equations

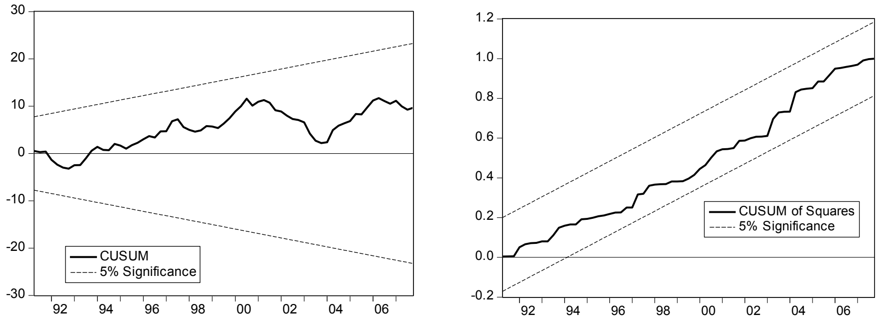
Export_*CV_N*_bounds_test:



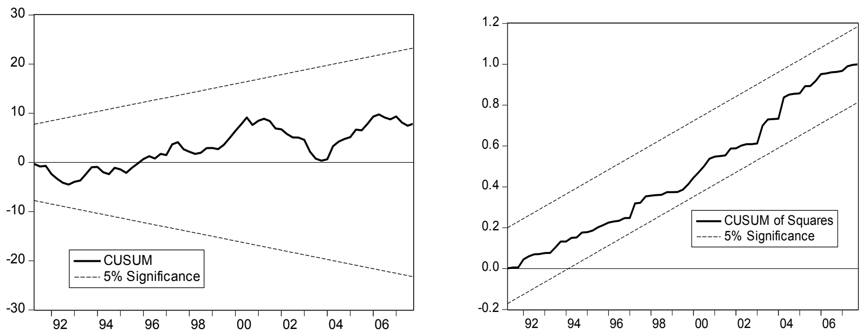
Export_*CV_R*_bounds_test:



Export_*MSD_N*_bounds_test:



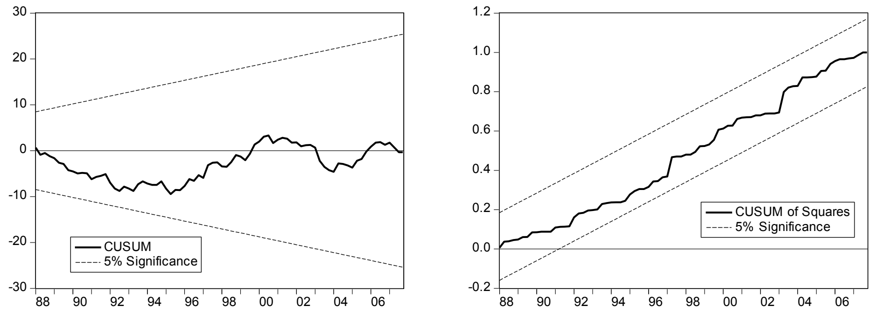
Export_*MSD_R*_bounds_test:



Note: The straight lines represent critical bounds at the 5 per cent significance level.

Figure 6.2: Recursive estimates in the stability test for the ECM corresponding to the export equations

ECM_*CV_N*:



ECM_*CV_R*:

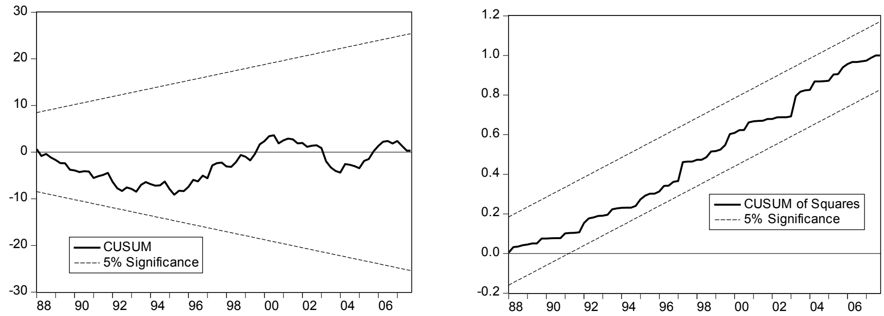
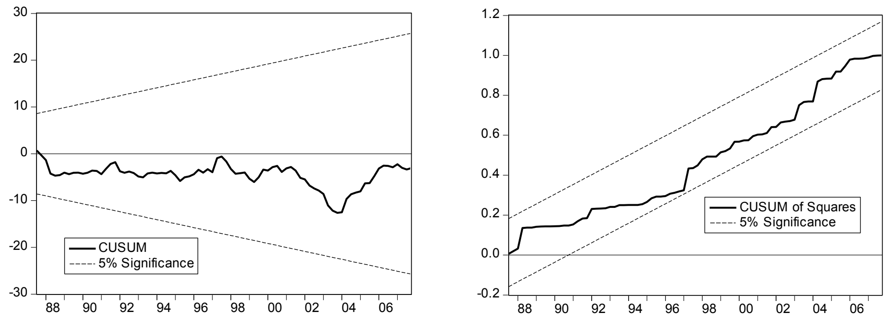
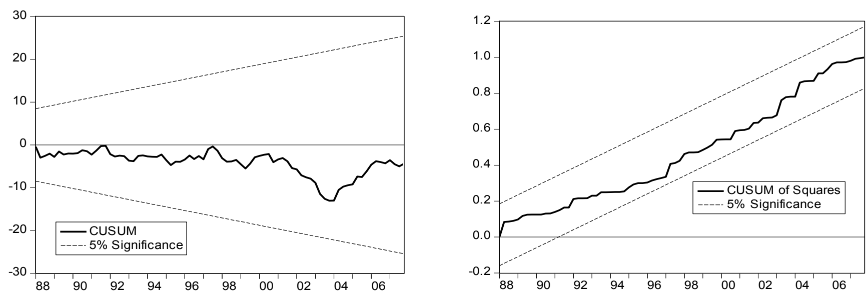


Figure 6.3: Recursive estimates in the stability test for the first difference models corresponding to the export equations

MSD_N:



MSD_R:



Note: The straight lines represent critical bounds at the 5 per cent significance level.

6.4 Estimation Results for Import Equation

6.4.1 Bounds test for cointegration

As discussed in the first section of this chapter, all the variables involved in the import equation can be considered as integrated in the order of no more than 1, therefore, the bounds test can be applied. The lag lengths selected for the UECMs corresponding to the four import equations using *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the exchange rate volatility measures are 4 for the first two and 7 for the last two. The results for the four UECMs are shown in Table 6.6. The values of the *F*-test statistic corresponding to the four import equations are 1.45, 1.48, 3.56 and 3.36. The first two *F* values are less than the lower critical value at the 10 per cent significance level (2.72). This means that there is no cointegration among the four variables with GARCH-derived exchange rate volatility. The last two *F* values are greater than the upper critical value at the 10 per cent significance level (3.10) and between the lower (2.45) and upper (3.63) critical values at the 5 per cent significance level. This means that it is inconclusive whether there is cointegration among the variables or not with MSD-derived exchange rate volatility. The *t*-statistic values for the last two UECMs are 0.096 and 0.0473, which are much smaller in (absolute) magnitude than the bound critical value -1.62 at the one per cent significance level. Therefore, cointegration does not exist among the variables of the two import equations.

As a cross check, for the last two sets of variables with MSD-derived exchange rate volatility, we also estimate a restricted ECM for each set of variables. The results are shown in Table 6.7. Although the *EC* terms in the two models are significant, their signs are all positive. This does not support the existence of a cointegration long-run relationship among each set of the four variables.

We proceed to estimate the short-run effects of other variables on Australia's aggregate imports. The results are shown in Table 6.8. From the first two columns of Table 6.8, it can be seen that the first difference of the two volatility measures (*CV_N* and *CV_R*) have positive short-run effects on the imports, but only one lagged first difference has marginal significant effects; the first difference of Australia's income also has a positive short-run effect on Australia's aggregate imports, while the contemporaneous first difference of the relative price has an insignificant negative short-run effect on imports, and the lagged first difference of the relative price has a positive effect on imports. From the last two columns of Table 6.8, it can be seen that exchange rate volatility derived from the MSD method (*MSD_N* and *MSD_R*) has a negative effect on imports, but these effects are all insignificant. Except one lagged first difference of Australia's income, which has an insignificant negative effect on imports, all the contemporaneous and lagged first differences of Australia's income and the relative price have positive effects on imports.

Table 6.6: The ECM-ARDL results for the import equations with the four volatility measures

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c	-1.4723	*	-1.4848	*				
D_*import*(-1)	0.0693		0.0743		-0.2852	**	-0.3226	**
D_*import*(-2)	-0.1099		-0.1074		-0.3812	***	-0.3673	***
D_*import*(-3)	-0.0136		-0.0108		-0.2688	**	-0.2704	**
D_*import*(-4)	0.4598	***	0.4603	***	0.1015		0.1046	
D_*import*(-5)					-0.2042		-0.2118	
D_*import*(-6)					-0.3017	**	-0.3230	**
D_*import*(-7)					-0.1469		-0.1690	
D_*gdpau*	1.3817	*	1.3900	*	0.9735		1.1556	
D_*gdpau*(-1)	-0.7752		-0.7348		-0.1012		0.0036	
D_*gdpau*(-2)	0.1871		0.2009		0.5777		0.5160	
D_*gdpau*(-3)	1.5000	**	1.5194	**	2.3872	***	2.3934	***
D_*gdpau*(-4)	-0.9259		-0.9488		0.6352		0.5670	
D_*gdpau*(-5)					0.1154		0.1100	
D_*gdpau*(-6)					0.0255		0.0583	
D_*gdpau*(-7)					0.4511		0.3967	
D_*rp*	-0.1444		-0.1417		0.2538		0.2431	
D_*rp*(-1)	0.3305		0.3080		0.2561		0.2442	
D_*rp*(-2)	0.5402	*	0.5324	*	0.8832	***	0.8918	***
D_*rp*(-3)	0.1173		0.1252		0.4556		0.4698	
D_*rp*(-4)	-0.4356		-0.4257		-0.2110		-0.2199	
D_*rp*(-5)					-0.0448		-0.0184	
D_*rp*(-6)					0.1683		0.1181	
D_*rp*(-7)					-0.4366		-0.4196	
D_*V*	-0.0009		-0.0007		-0.0472	**	-0.0406	*
D_*V*(-1)	0.0304		0.0257		0.0927	**	0.0875	**
D_*V*(-2)	0.0263		0.0227		0.0756	**	0.0750	**
D_*V*(-3)	0.0312		0.0263		0.0921	***	0.0804	**
D_*V*(-4)	0.0370	*	0.0343	*	0.0406		0.0451	*
D_*V*(-5)					0.1018	***	0.0887	***
D_*V*(-6)					0.0153		0.0218	
D_*V*(-7)					0.0660	***	0.0599	***
import(-1)	-0.2597	**	-0.2649	**	0.0040		0.0020	
gdpau(-1)	0.5533	*	0.5657	**	-0.1043		-0.0801	
rp(-1)	-0.0215		-0.0227		-0.0201		-0.0380	
V(-1)	-0.0254		-0.0232		-0.1361	***	-0.1296	***
Diagnostic statistics								
R^2	0.6280		0.6267		0.7451		0.7343	
R^2_{adj}	0.5003		0.4986		0.5815		0.5638	
AIC	-3.4017		-3.3982		-3.5227		-3.4812	
SC	-2.7395		-2.7360		-2.5373		-2.4959	
HQC	-3.1345		-3.1311		-3.1257		-3.0843	
$\chi^2_N(2)$	2.0441	[0.3599]	2.3181	[0.3138]	0.6820	[0.7111]	0.7836	[0.6759]
$\chi^2_{SC}(2)$	0.9376	[0.3968]	1.0953	[0.3405]	0.6432	[0.5298]	0.4638	[0.6315]
$\chi^2_H(1)$	1.1503	[0.3201]	1.1467	[0.3234]	0.9032	[0.6202]	0.8476	[0.6943]
$\chi^2_{FF}(2)$	1.2586	[0.2260]	1.1304	[0.2916]	0.0301	[0.8630]	0.0017	[0.9670]

Note: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Table 6.7: The ECM results for the import equations with *MSD_N* and *MSD_R* as volatility measures

Variable	*MSD_N*		*MSD_R*	
D_*import*(-1)	-0.2852	**	-0.3226	**
D_*import*(-2)	-0.3812	***	-0.3673	***
D_*import*(-3)	-0.2688	**	-0.2704	**
D_*import*(-4)	0.1014		0.1045	
D_*import*(-5)	-0.2042	*	-0.2118	*
D_*import*(-6)	-0.3017	**	-0.3230	***
D_*import*(-7)	-0.1469		-0.1690	
D_*gdpau*	0.9735		1.1556	*
D_*gdpau*(-1)	-0.1012		0.0036	
D_*gdpau*(-2)	0.5777		0.5160	
D_*gdpau*(-3)	2.3873	***	2.3935	***
D_*gdpau*(-4)	0.6352		0.5670	
D_*gdpau*(-5)	0.1154		0.1100	
D_*gdpau*(-6)	0.0255		0.0583	
D_*gdpau*(-7)	0.4511		0.3967	
D_*rp*	0.2538		0.2431	
D_*rp*(-1)	0.2561		0.2442	
D_*rp*(-2)	0.8832	***	0.8918	***
D_*rp*(-3)	0.4556		0.4698	
D_*rp*(-4)	-0.2110		-0.2199	
D_*rp*(-5)	-0.0448		-0.0184	
D_*rp*(-6)	0.1683		0.1181	
D_*rp*(-7)	-0.4366		-0.4196	
D_*V*	-0.0472	**	-0.0406	*
D_*V*(-1)	0.0927	***	0.0875	***
D_*V*(-2)	0.0756	**	0.0750	**
D_*V*(-3)	0.0921	***	0.0804	**
D_*V*(-4)	0.0406		0.0451	*
D_*V*(-5)	0.1018	***	0.0887	***
D_*V*(-6)	0.0153		0.0218	
D_*V*(-7)	0.0660	***	0.0599	***
EC(-1)	0.0040	***	0.0020	***
Diagnostic statistics				
R^2	0.7451		0.7343	
R^2_{adj}	0.6039		0.5872	
AIC	-3.5908		-3.5494	
SC	-2.6900		-2.6486	
HQC	-3.2279		-3.1865	
$\chi^2_N(2)$	0.6819	[0.7111]	0.7835	[0.6759]
$\chi^2_{SC}(2)$	0.6391	[0.5317]	0.4535	[0.6378]
$\chi^2_H(1)$	0.9875	[0.5048]	0.9139	[0.6009]
$\chi^2_{FF}(2)$	0.0293	[0.8647]	0.0017	[0.9673]

Note: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Table 6.8: The short-run relationship among the four variables of the import equations with the four volatility measures

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
D_*import*(-1)	-0.1564		-0.1546		-0.1719	*	-0.1719	*
D_*import*(-2)	-0.2412	**	-0.2399	**	-0.2445	**	-0.2550	**
D_*import*(-3)	-0.2358	**	-0.2337	**	-0.2342	**	-0.2317	**
D_*import*(-4)	0.1761	*	0.1754	*	0.1417		0.1435	
D_*import*(-5)	-0.1632	*	-0.1636	*	-0.1349		-0.1383	
D_*import*(-6)	-0.3504	***	-0.3516	***	-0.3634	***	-0.3608	***
D_*gdpau*	1.5924	**	1.5645	**	1.3381	**	1.3745	**
D_*gdpau*(-1)	0.0998		0.1165		-0.0192		0.0104	
D_*gdpau*(-2)	0.4205		0.4270		0.5175		0.5147	
D_*gdpau*(-3)	1.5491	**	1.5598	**	1.8666	***	1.8194	***
D_*rp*	-0.0810		-0.0701		0.0187		0.0240	
D_*rp*(-1)	0.3948		0.3826		0.2937		0.2881	
D_*rp*(-2)	0.6248	**	0.6226	**	0.6430	**	0.6431	**
D_*V*	0.0013		0.0020		-0.0009		-0.0005	
D_*V*(-1)	0.0136		0.0115		-0.0226		-0.0178	
D_*V*(-2)	0.0077		0.0067					
D_*V*(-3)	0.0187		0.0158					
D_*V*(-4)	0.0339	*	0.0318	*				
Diagnostic statistics								
R^2	0.6476		0.6465		0.6322		0.6285	
R^2_{adj}	0.5633		0.5618		0.5626		0.5582	
AIC	-3.5849		-3.5816		-3.6094		-3.5993	
SC	-3.0816		-3.0783		-3.1899		-3.1799	
HQC	-3.3820		-3.3788		-3.4403		-3.4303	
$\chi^2_N(2)$	0.3831	[0.8257]	0.6055	[0.7388]	0.7409	[0.6904]	0.6812	[0.7113]
$\chi^2_{SC}(2)$	1.3656	[0.5052]	1.7194	[0.4233]	1.6264	[0.4434]	1.4664	[0.4804]
$\chi^2_H(1)$	2.1608	[0.1416]	2.0808	[0.1492]	1.8259	[0.1766]	1.7379	[0.1874]
$\chi^2_{FF}(2)$	0.3590	[0.5490]	0.3266	[0.5677]	0.1149	[0.7346]	0.0848	[0.7709]

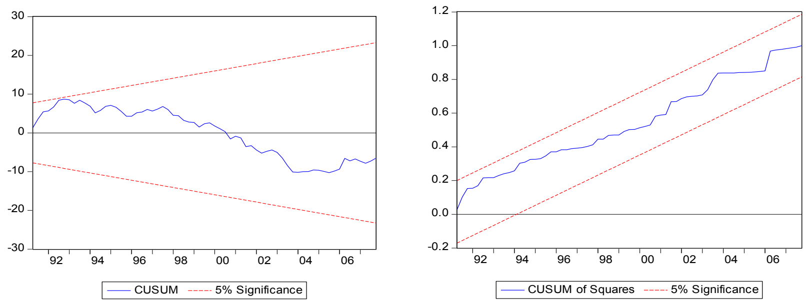
Note: The meanings of the diagnostic statistics are the same as those in Table 6.2.

6.4.2 CUSUM and CUSUMSQ stability test

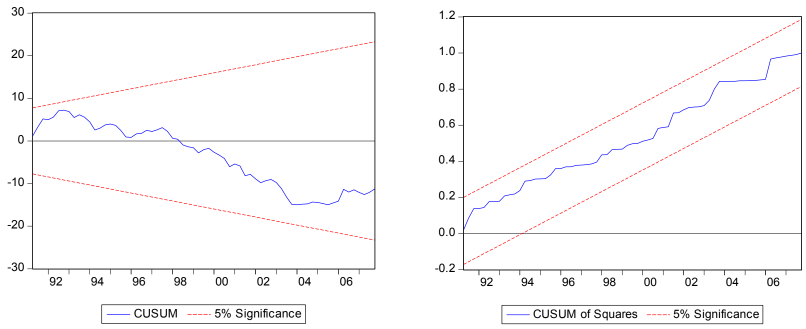
A CUSUM and CUSUMSQ stability test is conducted for all the models described above. The results are shown in Figure 6.4 for the ECM-ARDL, in Figure 6.5 for the ECM, and in Figure 6.6 for the short-run models. Since the plots of the CUSUM and CUSUMSQ statistics for all the models do not cross the 5 per cent critical bound value lines, it is safe to conclude that the estimated models are stable over the study period at the 5 per cent significance level.

Figure 6.4: Recursive estimates in the stability test for the UECMs corresponding to the import equations

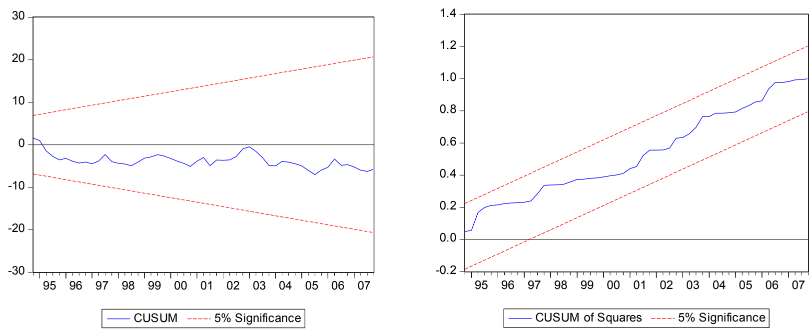
ECM-ARDL_import_*CV_N*



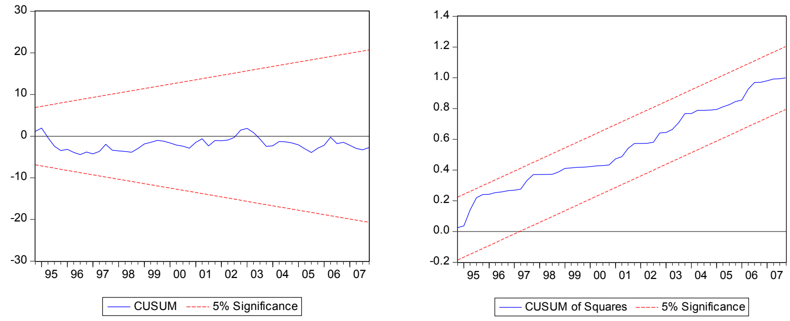
ECM-ARDL_import_*CV_R*



ECM-ARDL_import_*MSD_N*



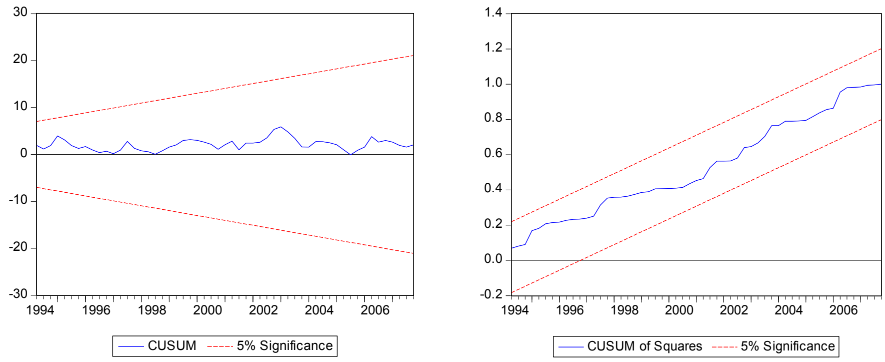
ECM-ARDL_import_*MSD_R*



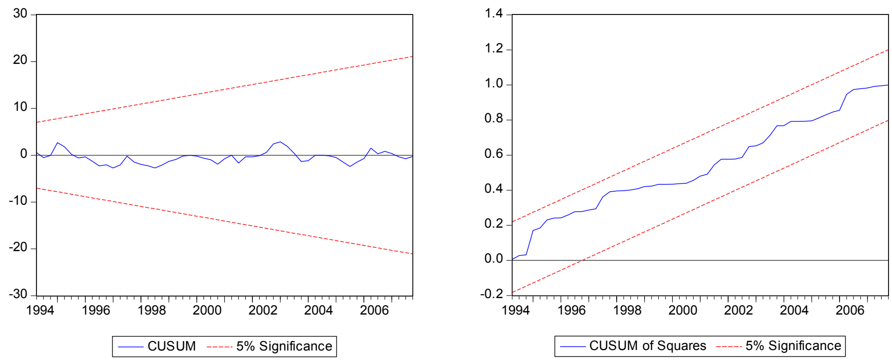
Note: The straight lines represent critical bounds at 5 per cent significance level.

Figure 6.5: Recursive estimates in the stability test for the ECMs corresponding to the import equations

ECM_import_*MSD_N*



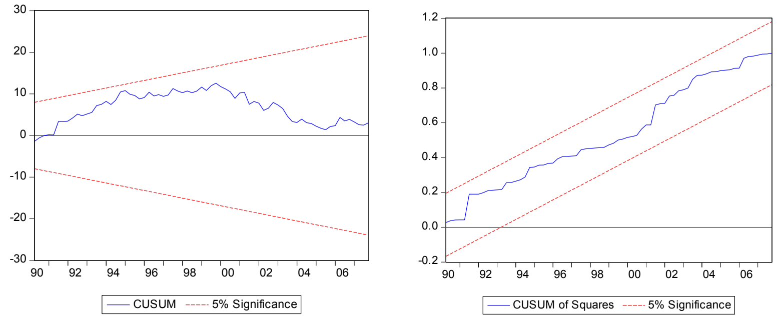
ECM_import_*MSD_R*



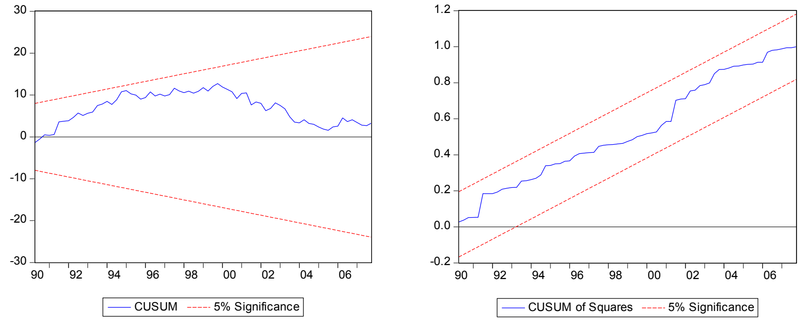
Note: The straight lines represent critical bounds at the 5 per cent significance level.

Figure 6.6: Recursive estimates in the stability test for the first difference models (i.e. short-run models) corresponding to the import equations

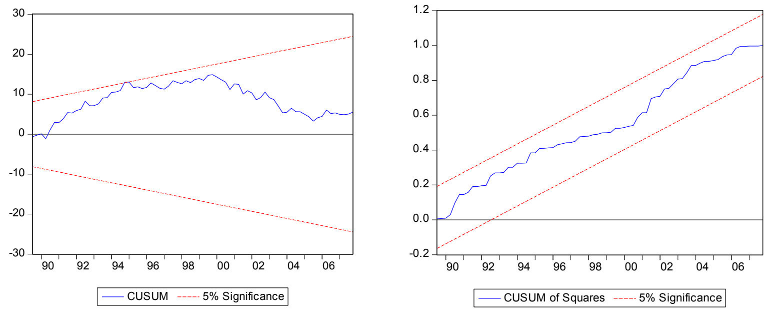
Short-run_import_*CV_N*



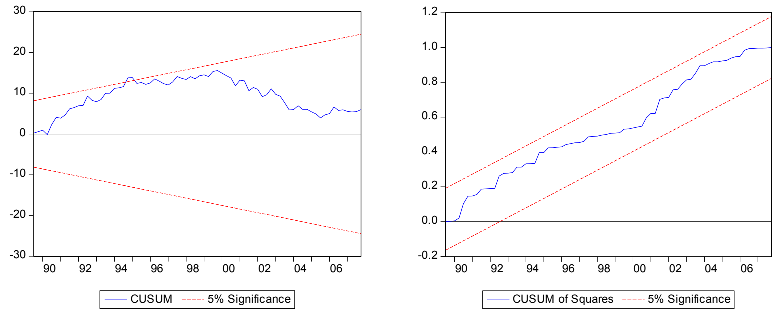
Short-run_import_*CV_R*



Short-run_import_*MSD_N*



Short-run_import_*MSD_R*



Note: The straight lines represent critical bounds at the 5 per cent significance level.

6.5 Concluding Remarks

In this chapter, unit root test are conducted for the nine variables (*export*, *import*, *gdpw*, *gdpau*, *rp*, *CV_N*, *CV_R*, *MSD_N* and *MSD_R*) involved in the export and import equations at the aggregated level using six unit root test methods. While the test results are inconsistent among the methods, all the variables can be considered to be reasonably as integrated at the order of no more than 1, so that the bounds test can be used to test the cointegration among the variables involved in each of the export and import equations. The test indicates that cointegration exists among the set of four variables: *export*, *gdpw*, *rp* and *CV_N*, and another set of four variables: *export*, *gdpw*, *rp* and *CV_R*. The results show that both of the two volatility measures *CV_N* and *CV_R* have significant positive long-run effect on the exports, and foreign income also has a significant positive effect on the exports, which is consistent with economic theory; however, relative price has no significant effect on the exports.

The short-run effect of the volatility and other variables on exports and imports is also investigated. While GARCH-derived exchange rate volatility has no significant short-run effect on exports, MSD-derived exchange rate volatility has a marginally significant negative effect on exports; and while foreign income has a significant negative short-run effect on exports, relative price has a marginally significant positive effect on exports. The results also show that all four volatility measures have no significant short-run effect on imports, and both Australia's income and relative price have significant positive short-run effects on imports, which is consistent with the expected signs.

Chapter 7
Empirical Results at the Sectoral Trade Data Level

7.1 Introduction

The purpose of this chapter is to examine whether exchange rate volatility affects Australia's trade flow and presents the empirical results at the sectoral trade data level. The error correction model outlined by equations 5.27 and 5.28 is estimated for three export sectors and three import sectors that trade between Australia and the rest of the world.

This chapter is organised as follows. Section two tests all thirteen variables for unit roots with six methods. Section three displays bounds test results for all the three export sectors. Section four presents bounds test results for all the three import sectors. Section five draws conclusions.

7.2 Unit Root Test Results

All thirteen variables (*man*, *res*, *rur*, *cap*, *csm*, *intmd*, *gdpw*, *gdpau*, *rp*, *CV_N*, *CV_R*, *MSD_N*, *MSD_R*) are tested for unit roots with the six methods ADF, ERS, PP, KPSS, ERSPO and NP. The results for the first six variables are shown in Table 7.1, and the results for the last seven variables have been shown in Table 6.1. *man*, *rur* and *cap* are detected as I(1), which is consistent among all six methods. *res* is detected as I(1) by PP, KPSS, ERSPO and NP, but it is detected as I(0) by ADF; and it seems that its first difference still has unit root as detected by ERS. *csm* is detected as I(0) by PP, but it is detected as I(1) by the other five methods. *intmd* is detected as I(0) by ADF and ERS, but it is detected as I(1) by the other four methods. From the results of both Table 6.1 and 7.1, it can be reasonably assumed that the integration order of all the above thirteen variables at the sectoral data level is no more than 1.

Table 7.1: Results of various unit root tests

Test methods						
Variables	ADF	ERS	PP	KPSS	ERSPO	NP
EXPORT						
man						
Level	-1.7558 (10)	-0.8217 (1)	4.3696 (10)	0.2981***(8)	37.4663 (1)	-0.6601 (1)
Difference	-5.4074***(7)	-12.4551***(0)	-12.9095***(6)	0.3909* (12)	2.1445***(0)	-5.7165***(0)
res						
Level	-4.1481***(8)	-0.8099 (1)	-2.3664 (1)	0.2973***(8)	466.4195 (1)	-1.2647 (0)
Difference	-5.8453***(7)	-0.0945 (11)	-14.5924***(8)	0.0685 (11)	2.3526***(0)	-3.2213***(4)
rur						
Level	-1.6148 (4)	-1.6990 (4)	-2.4350 (13)	0.1725** (8)	8.3065 (0)	-2.3129 (0)
Difference	-7.4145***(3)	-7.3974***(3)	-10.2554***(45)	0.3330 (53)	2.5412** (0)	-3.9621***(0)
IMPORT						
cap						
Level	-2.8448 (1)	-1.4702 (1)	-3.2646* (2)	0.2409***(6)	25.0718 (1)	-1.4558 (1)
Difference	-12.7044***(0)	-12.2451***(0)	-12.6826***(1)	0.1961 (3)	2.5329***(0)	-4.5829***(0)
csm						
Level	3.6581 (12)	-2.3153 (1)	-3.8156** (3)	0.2058** (6)	11.4486 (12)	-2.3165 (1)
Difference	-3.9445***(11)	-6.3094***(0)	-7.2216***(0)	0.1035 (3)	2.0520***(3)	-4.3078***(0)
intmd						
Level	-3.7081** (3)	-3.5540** (3)	-2.9382 (4)	0.0987 (6)	9.3149 (0)	2.3380 (1)
Difference	-4.5375***(8)	-7.5159***(0)	-8.2335***(3)	0.0436 (4)	2.4907***(0)	-2.6225***(2)

Notes:

1. The test statistic of NP is MZ_t.
2. The numbers in the parentheses after test statistic value are the selected bandwidth for PP and KPSS and the number of selected lags for the other test methods.
3. The maximum lag is set at 12, and the optimal lag was selected using AIC.
4. For PP and KPSS, the Bartlett Kernel method is used for spectral estimation, and the Newey-West Bandwidth method is used for bandwidth selection.
5. For spectral estimation, the AR spectral OLS method is used for ERSPO, and the AR GLS-detrended method is used for NP.
6. Use the smallest AIC in the regression result to decide whether to include intercept or trend or none of them.
7. ***, ** and * in the table denote statistical significant coefficients at the 1 per cent, 5 per cent and 10 per cent level, respectively.

7.3 Estimation Results for Export Sectors

Since all the variables involved in the export equations are integrated in the order of no more than 1, we can proceed to test the cointegration among the variables involved in each of the four export equations of the three sectors by using ARDL bounds test method (Pesaran et al., 2001). In this section we estimate the error correction model outlined by equation 5.27 using quarterly data from the 1984-2008.

7.3.1 Manufactures export sector

The lag lengths selected for the unrestricted error correction models (UECMs) corresponding to the four export equations using *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the exchange rate volatility measures are all 4. The results from the UECMs are shown in Table 7.2. The corresponding Bounds test statistic F values are 21.0675, 21.2045, 9.0753, 8.9840, which are higher than the upper critical bound value at the 1 per cent level (4.84 for the first two and 6.36 for the last two). Thus, the null hypothesis that all the four coefficients corresponding to the four lagged level variables are zero is rejected. We proceed to conduct the *t*-test. Their *t*-statistic values are -5.6884, -5.6580, -4.8895 and -4.8606 respectively, which are all beyond the bound critical value at the 1 per cent level (-3.97 for the first two and -4.73 for the last two). Therefore, cointegration exists among the four variables involved in each of the export equations for the Manufactures export sector. This is confirmed by the results from the restricted error correction model (RECM) in Table 7.3, where all the error correction (*EC*) terms are significant and their signs are negative.

The long-run relationships among the variables can be estimated and the results are presented in Table 7.8. From Table 7.2 it can be seen that for the Manufactures export sector, exchange rate volatility is significant at the 5 per cent level and has a negative effect on the export whereas foreign income is significant at the 1 per cent level with a positive effect on exports. Relative price is significant at the 1 per cent level but with a negative effect on exports. The empirical results suggest that all three variables are important for the Manufactures export sector and the signs of both foreign income and relative price are consistent with the model expectation. In other words, if foreign income increases, the demand for Australia's manufactures export will also increase; if relative price increases, the demand for Australia's manufactures exports will decrease. Empirically, the volatility of exchange rate from four measures depresses Australia's manufactures exports.

As a robustness check, finally the CUSUM and CUSUMSQ tests are applied to the residuals of each and every estimated error correction model to establish the stability of the estimated short-run as well as the long-run coefficients. Figures 7.1 and 7.2 are plots of CUSUM and CUSUMQ for coefficient stability for the UECM and RECM models for the Manufactures export sector. Since the plots of the CUSUM and CUSUMQ statistics for all the estimated models do not cross the critical value lines, it is safe to conclude that the estimated Manufactures sector export equations are stable at the 5 per cent significance level.

Table 7.2: Bounds test for the Manufactures sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c					1.2362	*	1.2597	*
Trend					0.0022		0.0022	
D_*man*(-1)	-0.2426	***	-0.2475	***	-0.2332	***	-0.2389	**
D_*man*(-4)	-0.1762	**	-0.1776	**	-0.1816	**	-0.1796	**
D_*gdpw*(-1)	-1.2622	***	-1.2511	***	-1.2997	***	-1.3104	***
D_*gdpw*(-2)	-1.0140	***	-1.0163	***	-1.0563	***	-1.0732	***
D_*rp*(-3)	0.4754	*	0.4689	*	0.8147	***	0.8042	***
D_*V*(-1)	0.0516	**	0.0509	**				
D_*V*(-2)	0.0440	**	0.0419	**	0.0530	***	0.0515	***
man(-1)	-0.1852	***	-0.1837	***	-0.2453	***	-0.2431	***
gdpw(-1)	0.7241	***	0.7177	***	0.6500	***	0.6410	***
rp(-1)	-0.3853	***	-0.3845	***	-0.4901	***	-0.4886	***
V(-1)	-0.0402	**	-0.0415	**	-0.0414	**	-0.0375	**
Diagnostic statistics								
R^2	0.4447		0.4459		0.4699		0.4699	
R^2_{adj}	0.3770		0.3783		0.3979		0.3979	
AIC	-3.3732		-3.3753		-3.3981		-3.3981	
SC	-3.0737		-3.0758		-3.0713		-3.0713	
HQC	-3.2523		-3.2544		-3.2662		-3.2661	
$\chi^2_N(2)$	4.7097	[0.0949]	4.9207	[0.0854]	1.3805	[0.5015]	1.5829	[0.4532]
$\chi^2_{SC}(2)$	0.2318	[0.7936]	0.1831	[0.8331]	0.5493	[0.5795]	0.4582	[0.6341]
$\chi^2_H(1)$	0.9874	[0.4648]	0.9692	[0.4809]	0.8791	[0.5638]	0.8032	[0.6365]
$\chi^2_{FF}(2)$	0.5097	[0.4773]	0.5970	[0.4420]	1.4581	[0.2308]	1.5606	[0.2152]

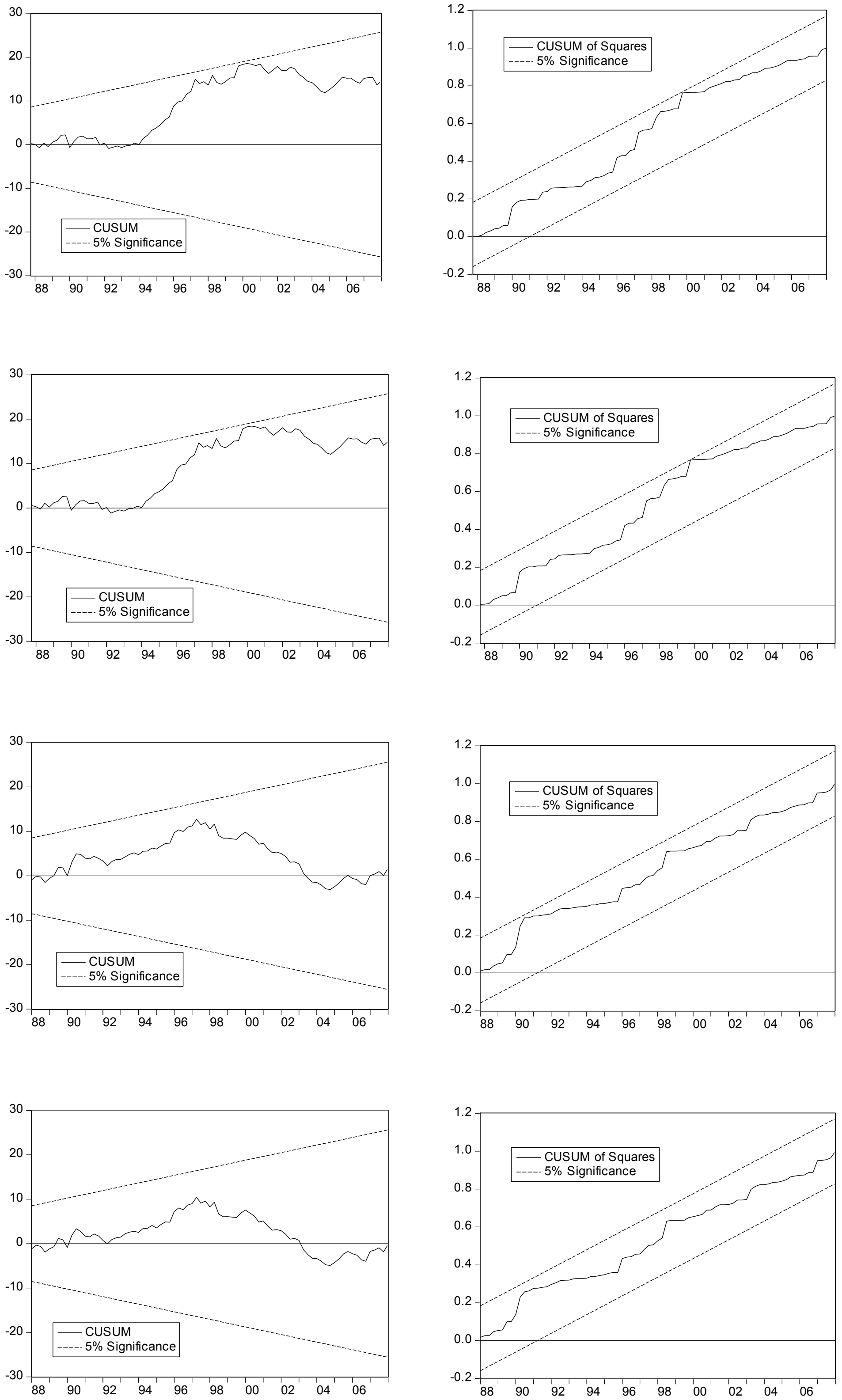
Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Table 7.3: Error correction representation for the selected model for the Manufactures sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c					1.2362	***	1.2597	***
Trend					0.0022	***	0.0022	***
D_*man*(-1)	-0.2426	***	-0.2475	***	-0.2332	***	-0.2389	***
D_*man*(-4)	-0.1762	**	-0.1776	**	-0.1816	**	-0.1796	**
D_*gdpw*(-1)	-1.2621	***	-1.2511	***	-1.2997	***	-1.3104	***
D_*gdpw*(-2)	-1.0140	***	-1.0163	***	-1.0563	***	-1.0732	***
D_*rp*(-3)	0.4754	**	0.4689	**	0.8147	***	0.8042	***
D_*V*(-1)	0.0516	***	0.0509	***				
D_*V*(-2)	0.0440	***	0.0419	***	0.0530	***	0.0515	***
EC(-1)	-0.1852	***	-0.1837	***	-0.2453	***	-0.2431	***
Diagnostic statistics								
R^2	0.4447		0.4459		0.4699		0.4699	
R^2_{adj}	0.3990		0.4003		0.4194		0.4194	
AIC	-3.4377		-3.4398		-3.4626		-3.4626	
SC	-3.2199		-3.2220		-3.2176		-3.2175	
HQC	-3.3498		-3.3519		-3.3637		-3.3636	
$\chi^2_N(2)$	4.7103	[0.0949]	4.9207	[0.0854]	1.3805	[0.5015]	1.5829	[0.4532]
$\chi^2_{SC}(2)$	0.2121	[0.8093]	0.1670	[0.8465]	0.5575	[0.5748]	0.4661	[0.6291]
$\chi^2_H(1)$	1.0615	[0.3978]	1.0010	[0.4416]	0.8471	[0.5642]	0.7404	[0.6556]
$\chi^2_{FF}(2)$	0.4574	[0.5007]	0.5405	[0.4643]	1.4820	[0.2269]	1.5851	[0.2116]

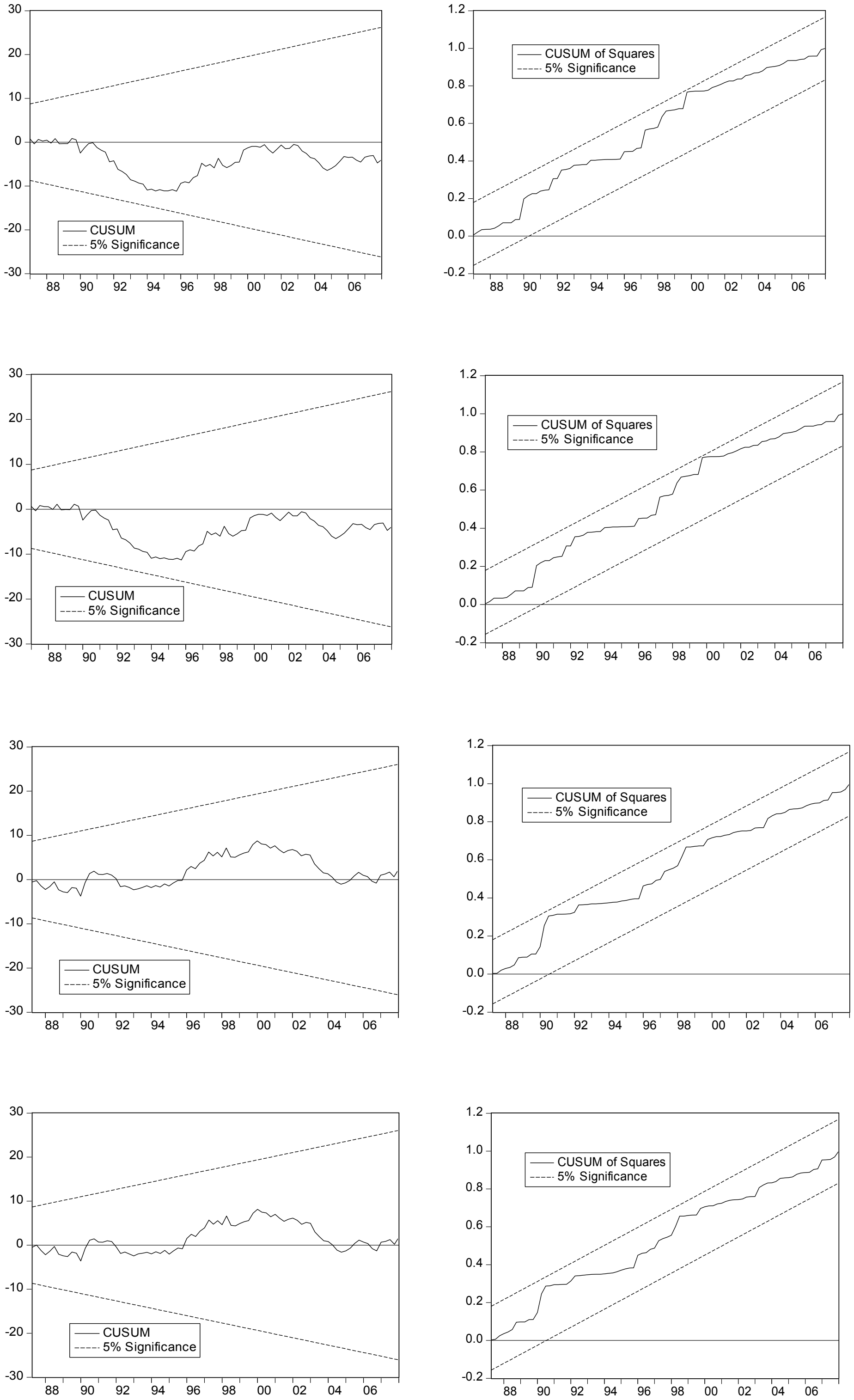
Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Figure 7.1: Plot of CUSUM and CUSUMQ for coefficient stability for the UECM models for the Manufactures sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measures respectively



Note: The straight lines represent critical bounds at the 5 per cent significance level.

Figure 7.2: Plot of CUSUM and CUSUMQ for coefficient stability for the RECM models for the Manufactures sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measures respectively



Note: The straight lines represent critical bounds at the 5 per cent significance level.

7.3.2 Resources export sector

The lag lengths selected for the UECMs corresponding to the four export equations using *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the exchange rate volatility measures are all 3. The results from the UECMs are shown in Table 7.4. The corresponding bounds test statistic *F* values are 10.4212, 14.4428, 8.7332 and 11.2518, and all are above the upper critical bound value at the 1 per cent significance level (4.84). We proceed to conduct *t*-test. The *t*-statistic values are -3.7158, -3.5019, -3.8141 and -3.5114 respectively, which are all beyond the bound critical value at the 5 per cent level (-3.33). Therefore, there is a cointegration among the four variables involved in each of the export equations for the Resources sector. This is confirmed by the results from the restricted error correction model in Table 7.5, where all the *EC* terms are significant and their signs are negative.

The long-run relationships can be estimated and the results are presented in Table 7.8. From Table 7.4 it can be seen that for the Resources sector, exchange rate volatility is only significant at the 1 or 5 per cent level and has a positive effect on exports, while relative price has a positive effect on exports, but it is only significant in the two equations with *MSD_R* and *MSD_N* as volatility measures. Foreign income is not significant and the signs of the coefficient are different among the equations.

The empirical results suggest that the volatility of the exchange rate stimulates Australia's export of resources, but the effect on the export of resources from foreign income depends on the method used to measure the volatility of exchange rate. When volatility is measured by MSD methods, if relative price increases, the demand for Australia's Resources exports will increase significantly, whereas if volatility is measured by GARCH methods, the effect from relative price is not significant.

As a robustness check, Figures 7.3 and 7.4 are plots of CUSUM and CUSUMQ for coefficient stability for the unrestricted ECM and restricted ECM models for the Resources export sector. Since the plots of CUSUM and CUSUMQ statistics for all data series do not cross the critical value lines, it is safe to conclude that the Resources sector export equation is stable during the study period at the 5 per cent significance level.

Table 7.4: Bounds test for the Resources sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
D_*res*(-1)	-0.3468	***	-0.3071	***	-0.3802	***	-0.3708	***
D_*res*(-2)	-0.1663	*	-0.1587	*	-0.2683	**	-0.2605	**
D_*res*(-3)	-0.1279		-0.1168		-0.1839	*	-0.1811	*
D_*gdpw*	-0.2363		-0.2666		-0.2840		-0.2638	
D_*gdpw*(-1)	-0.7548	***	-0.7888	***	-0.8142	***	-0.7591	***
D_*gdpw*(-2)					-0.1613			
D_*gdpw*(-3)					-0.4248		-0.3612	
D_*v*	0.0204		0.0197		-0.0296	*	-0.0248	
D_*v*(-1)	0.0717	***	0.0536	***	0.0308	*	0.0331	**
D_*v*(-2)	0.0163				0.0397	**	0.0400	**
res(-1)	-0.0559	*	-0.0426	***	-0.0201		-0.0121	
gdpw(-1)	0.0399				-0.0808		-0.0901	
rp(-1)	0.0125		0.0416		0.0978	***	0.0871	***
v(-1)	-0.0469	*	-0.0348	**	-0.0366	*	-0.0371	*
Diagnostic statistics								
R^2	0.3686		0.3579		0.3662		0.3585	
R^2_{adj}	0.2828		0.2892		0.2605		0.2611	
AIC	-3.7272		-3.7369		-3.6675		-3.6772	
SC	-3.4004		-3.4663		-3.2837		-3.3209	
HQC	-3.5952		-3.6276		-3.5126		-3.5334	
$\chi^2_N(2)$	51.6424	[0]	36.0430	[0]	5.2992	[0.0707]	5.3995	[0.0672]
$\chi^2_{SC}(2)$	1.4903	[0.2316]	1.7482	[0.1805]	0.5799	[0.5624]	0.8988	[0.4113]
$\chi^2_H(1)$	1.1226	[0.3541]	0.9945	[0.4550]	1.1865	[0.3027]	1.2140	[0.2857]
$\chi^2_{FF}(2)$	0.1475	[0.7019]	0.1251	[0.7245]	0.8250	[0.3666]	0.5005	[0.4814]

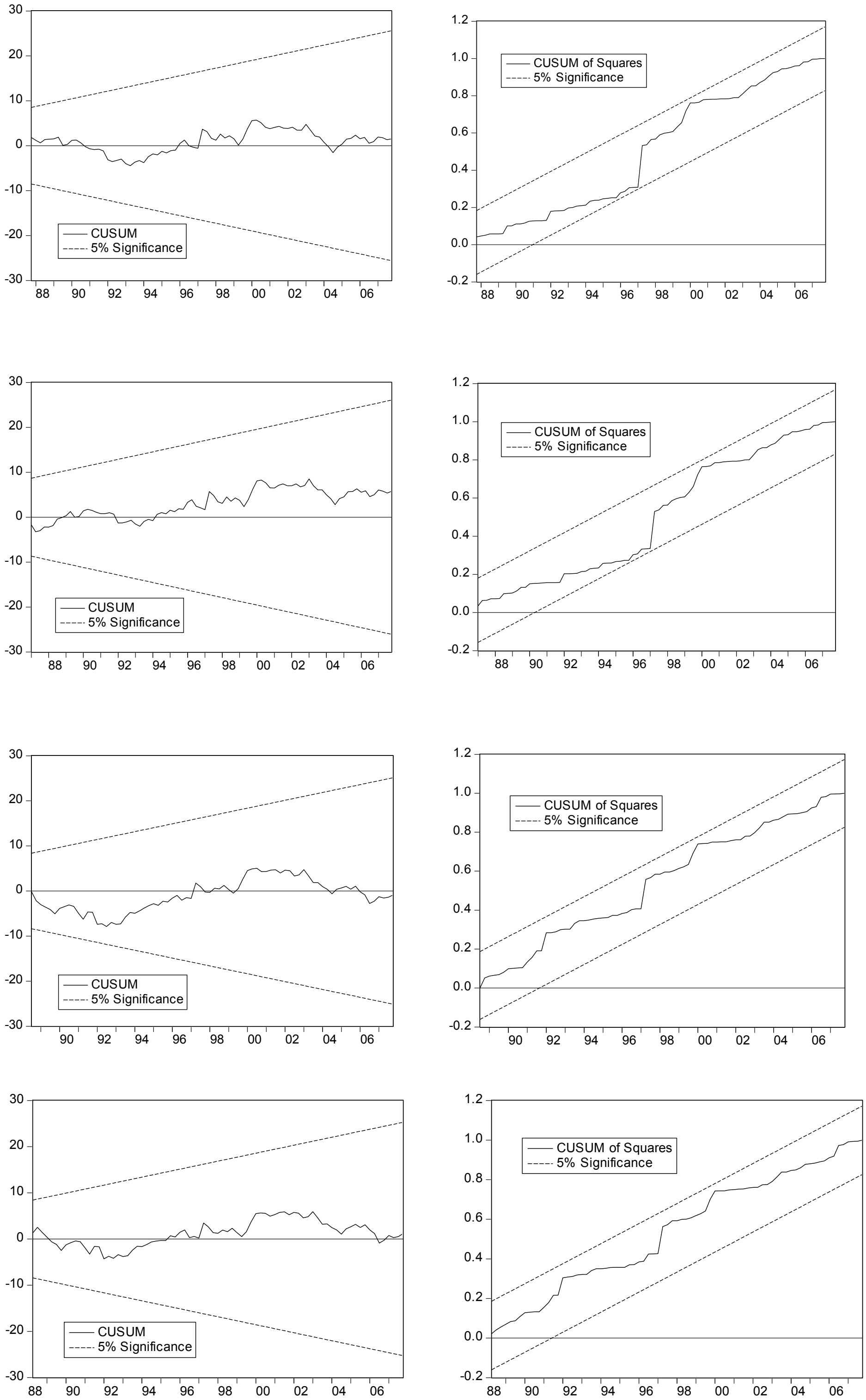
Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Table 7.5: Error correction representation for the selected model for the Resources sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
D_*res*(-1)	-0.3468	***	-0.3071	***	-0.3802	***	-0.3708	***
D_*res*(-2)	-0.1663	*	-0.1587	*	-0.2683	**	-0.2605	**
D_*res*(-3)	-0.1279		-0.1168		-0.1839	*	-0.1811	*
D_*gdpw*	-0.2363		-0.2665		-0.2840		-0.2638	
D_*gdpw*(-1)	-0.7548	***	-0.7888	***	-0.8142	***	-0.7591	***
D_*gdpw*(-2)					-0.1613			
D_*gdpw*(-3)					-0.4248	*	-0.3612	
D_*V*	0.0204		0.0197		-0.0296	*	-0.0248	*
D_*V*(-1)	0.0717	***	0.0536	***	0.0308	**	0.0331	**
D_*V*(-2)	0.0163				0.0397	***	0.0400	***
EC(-1)	-0.0559	***	-0.0426	***	-0.0201	***	-0.0121	***
Diagnostic statistics								
R^2	0.3686		0.3579		0.3662		0.3585	
R^2_{adj}	0.3084		0.3057		0.2879		0.2881	
AIC	-3.7917		-3.7794		-3.7327		-3.7424	
SC	-3.5466		-3.5630		-3.4312		-3.4683	
HQC	-3.6927		-3.6920		-3.6110		-3.6318	
$\chi^2_N(2)$	51.6466	[0]	36.0450	[0]	5.2995	[0.0707]	5.3996	[0.0672]
$\chi^2_{SC}(2)$	1.5035	[0.2284]	1.7540	[0.1794]	0.5408	[0.5844]	0.8998	[0.4107]
$\chi^2_H(1)$	1.0422	[0.4142]	1.1459	[0.3417]	1.0378	[0.4220]	1.1719	[0.3219]
$\chi^2_{FF}(2)$	0.1471	[0.7023]	0.1260	[0.7235]	0.8248	[0.3665]	0.5061	[0.4789]

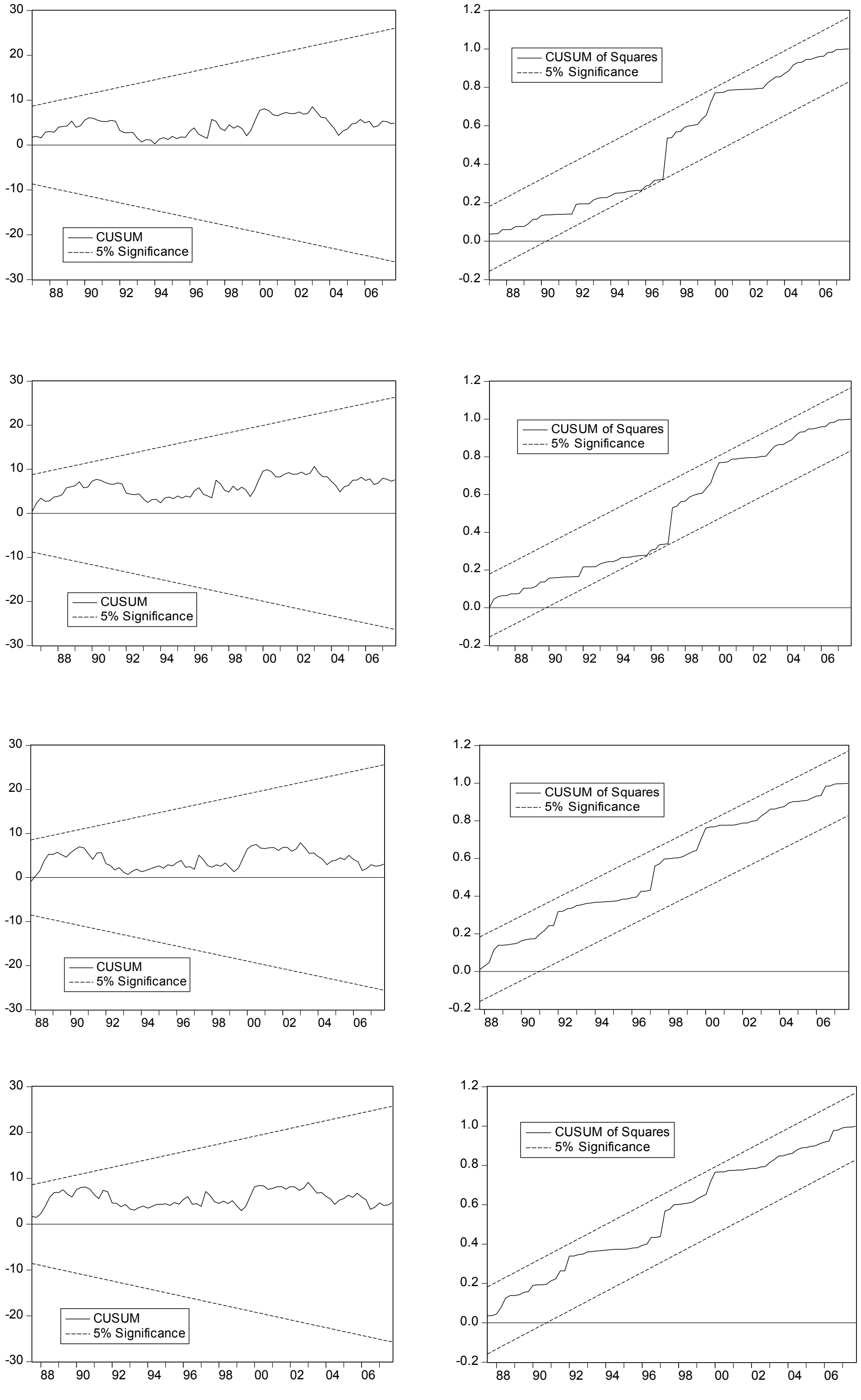
Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Figure 7.3: Plot of CUSUM and CUSUMQ for coefficient stability for the UECM model for the Resources sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measure respectively



Note: The straight lines represent critical bounds at the 5 per cent significance level.

Figure 7.4: Plot of CUSUM and CUSUMQ for coefficient stability for the RECM model for the Resources sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measure respectively



Note: The straight lines represent critical bounds at the 5 per cent significance level.

7.3.3 Rural goods export sector

The lag lengths selected for the UECMs corresponding to the four export equations using *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the exchange rate volatility measures are all 5. The results from the UECM are shown in Table 7.6 for the Rural Goods export sector using *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the exchange rate volatility measures. The corresponding bounds test statistic *F* values are 4.7803, 4.7431, 4.6487 and 4.8205 for the Rural Goods sector. All the *F* values are above the upper critical bound value at the 2.5 per cent level. We further proceed to conduct *t*-test. The *t* statistic values are -4.1914, -4.2052, -4.2625 and -4.2975 respectively, which are beyond the bound critical value at the 5 per cent level (-4.16). Therefore, cointegration exists among the four variables involved in each of the export equations for the Rural Goods export sector. This is confirmed by the results from the restricted error correction model in Table 7.7, where all the *EC* terms are significant and their signs are negative.

The long-run relationships can be estimated and the results are presented in Table 7.8. From Table 7.6 it can be seen that the results from the four equations with the four different volatilities are very similar; all three variables of foreign income (*gdpw*), relative price (*rp*) and exchange rate volatility have a positive effect on the export; foreign income (*gdpw*) has a very significant effect on the Rural Goods export sector, whereas the effects of relative price (*rp*) and exchange rate volatility are not significant at all.

Therefore, if foreign income increases, the demand for Australia's Rural Goods exports will increase; this is consistent with the model expectation. If relative price increases, the demand for Australia's Rural Goods exports will also increase; this is different from the model expectation. If exchange rate volatility increases, the demand for Australia's Rural Goods exports will increase, but insignificantly.

As a robustness check, Figures 7.5 and 7.6 are plots of CUSUM and CUSUMQ for coefficient stability for the unrestricted ECM and restricted ECM models for the Rural Goods export sector. Since the plots of CUSUM and CUSUMQ statistics for all data series do not cross the critical value lines, it is safe to conclude that the Rural Goods sector export equation is stable at the 5 per cent significance level.

Table 7.6: Bounds test for the Rural Goods sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c	5.6679	***	5.7295	***	5.9545	***	5.9748	***
Trend	0.0081	***	0.0081	***	0.0083	***	0.0083	***
D_*rur*(-1)	0.3282	***	0.3298	***	0.3145	***	0.3006	***
D_*rur*(-3)	0.1240		0.1234		0.1149		0.1028	
D_*rur*(-4)	-0.2356	**	-0.2331	**	-0.2332	**	-0.2432	***
D_*rur*(-5)	0.2226	**	0.2224	**	0.2198	**	0.2397	**
D_*gdpw*(-3)	-1.3398	***	-1.3391	***	-1.3607	***	-1.3865	***
D_*gdpw*(-3)	0.6685	*	0.6599	*	0.6017	*	0.5872	
D_*rp*(-1)	0.4970		0.5077		0.3342			
D_*rp*(-2)	-0.6140	*	-0.6117	*	-0.4113			
D_*V*(-1)	0.0453	*	0.0406					
rur(-1)	-0.3784	***	-0.3801	***	-0.3887	***	-0.3855	***
gdpw(-1)	-0.6623	***	-0.6643	***	-0.6793	***	-0.6794	***
rp(-1)	-0.1102		-0.1117		-0.1131		-0.1264	
V(-1)	-0.0217		-0.0170		-0.0088		-0.0114	
Diagnostic statistics								
R^2	0.4475		0.4451		0.4215		0.4094	
R^2_{adj}	0.3471		0.3442		0.3251		0.3282	
AIC	-2.8775		-2.8732		-2.8533		-2.8760	
SC	-2.4663		-2.4620		-2.4695		-2.5471	
HQC	-2.7115		-2.7072		-2.6984		-2.7433	
$\chi^2_N(2)$	0.7267	[0.6954]	0.7115	[0.7006]	1.7983	[0.4069]	0.9893	[0.6098]
$\chi^2_{SC}(2)$	0.0152	[0.9849]	0.0170	[0.9831]	0.2531	[0.7770]	0.1852	[0.8313]
$\chi^2_H(1)$	1.1620	[0.3213]	1.2201	[0.2787]	0.9481	[0.5090]	0.8731	[0.5695]
$\chi^2_{FF}(2)$	0.5103	[0.4772]	0.4444	[0.5070]	0.6972	[0.4063]	0.2483	[0.6197]

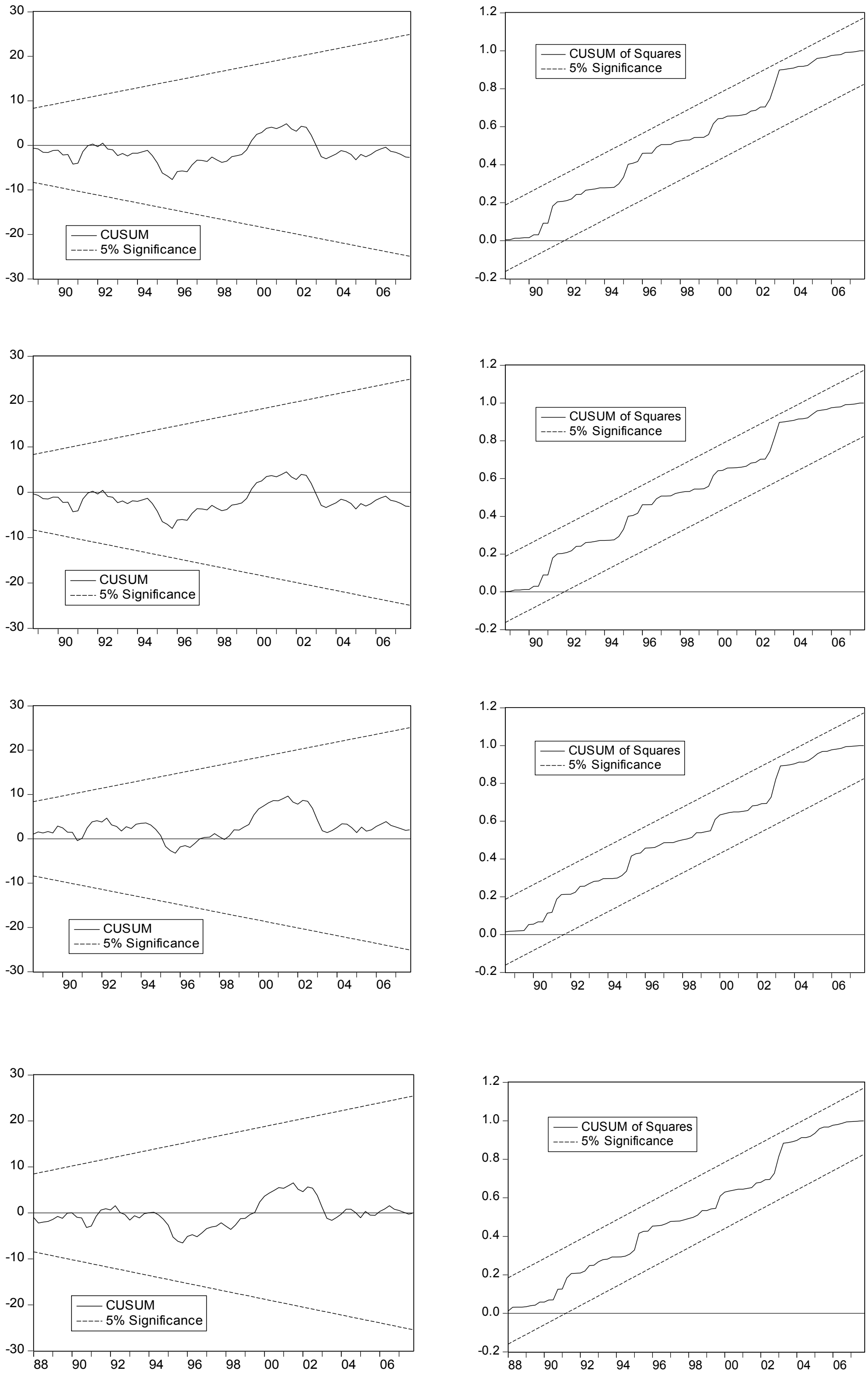
Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Table 7.7: Error correction representation for the selected model for the Rural Goods sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c	5.6679	***	5.7295	***	5.9545	***	5.9748	***
Trend	0.0081	***	0.0081	***	0.0083	***	0.0083	***
D_*rur*(-1)	0.3282	***	0.3298	***	0.3145	***	0.3006	***
D_*rur*(-3)	0.1240		0.1234		0.1149		0.1028	
D_*rur*(-4)	-0.2356	***	-0.2331	***	-0.2332	**	-0.2432	***
D_*rur*(-5)	0.2226	**	0.2224	**	0.2198	**	0.2397	**
D_*gdpw*(-3)	-1.3398	***	-1.3391	***	-1.3607	***	-1.3865	***
D_gdpw(-5)	0.6685	*	0.6599	*	0.6017	*	0.5872	*
D_*rp*(-1)	0.4970		0.5077		0.3342			
D_*rp*(-2)	-0.6140	*	-0.6117	*	-0.4113			
D_*V*(-1)	0.0453	**	0.0406	**				
EC(-1)	-0.3784	***	-0.3801	***	-0.3887	***	-0.3855	***
Diagnostic statistics								
R^2	0.4475		0.4451		0.4215		0.4094	
R^2_{adj}	0.3716		0.3688		0.3501		0.3525	
AIC	-2.9427		-2.9384		-2.9185		-2.9412	
SC	-2.6138		-2.6095		-2.6170		-2.6945	
HQC	-2.8100		-2.8056		-2.7968		-2.8417	
$\chi^2_N(2)$	0.7267	[0.6954]	0.7115	[0.7006]	1.7983	[0.4069]	0.9893	[0.6098]
$\chi^2_{SC}(2)$	0.0152	[0.9849]	0.0170	[0.9832]	0.2445	[0.7837]	0.1802	[0.8354]
$\chi^2_H(1)$	1.0715	[0.3946]	1.1323	[0.3480]	1.0843	[0.3840]	0.9336	[0.4935]
$\chi^2_{FF}(2)$	0.4941	[0.4842]	0.4298	[0.5140]	0.6839	[0.4107]	0.2440	[0.6226]

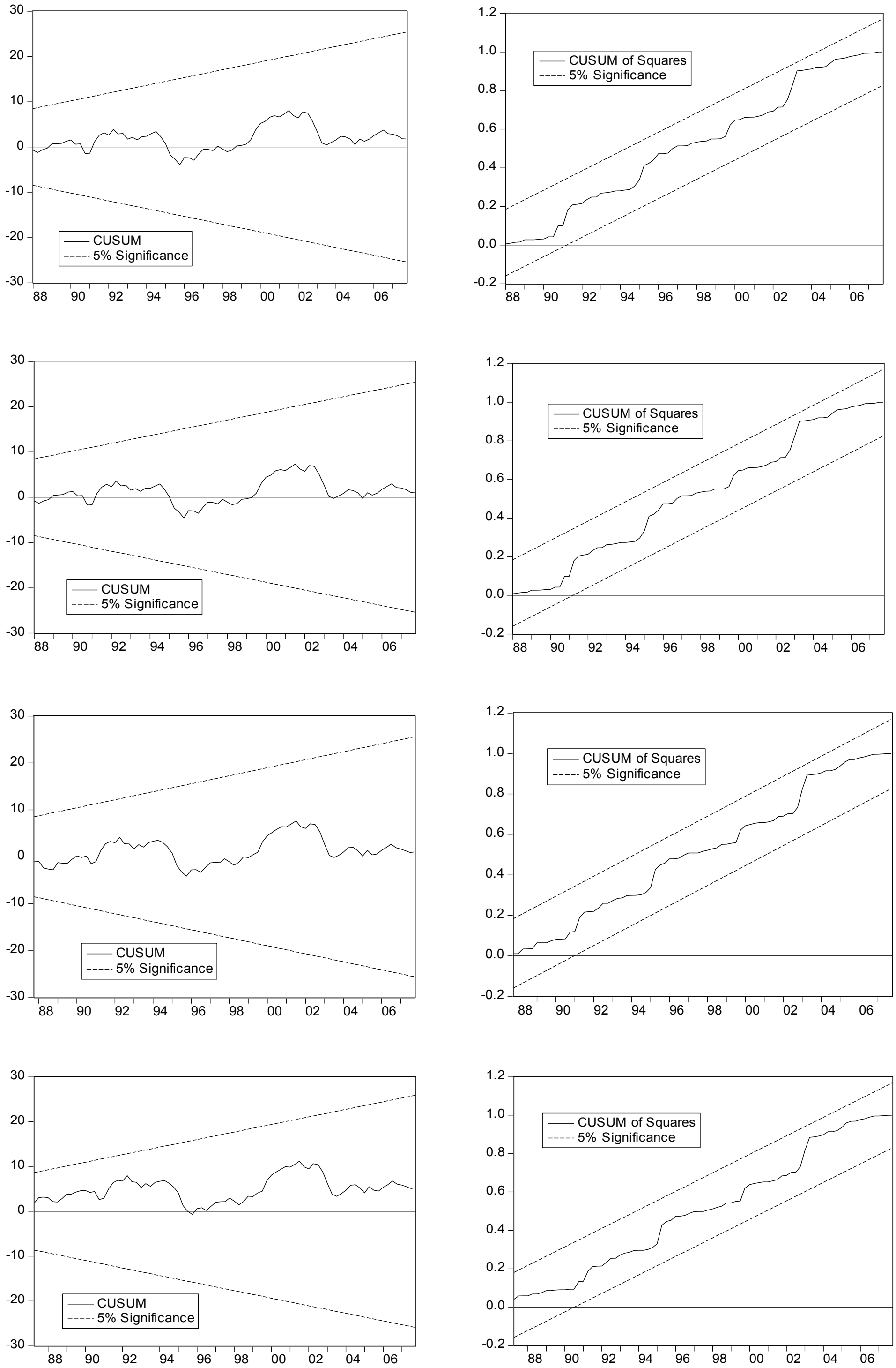
Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Figure 7.5: Plot of CUSUM and CUSUMQ for coefficients stability for the UECM model for the Rural Goods sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measure respectively



Note: The straight lines represent critical bounds at 5 per cent significance level.

Figure 7.6: Plot of CUSUM and CUSUMQ for coefficients stability for the RECM model for the Rural Goods sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measure respectively



Note: The straight lines represent critical bounds at the 5 per cent significance level.

Table 7.8: Long-run multipliers for export equations of three sectors (Manufactures, Resources and Rural Goods)

Sector	Volatility used in equations	*gdpw*	*rp*	Volatility
Manufactures	*CV_N*	3.9098	-2.0805	-0.2171
	CV_R	3.9069	-2.0931	-0.2259
	MSD_N	2.6498	-1.9980	-0.1688
	MSD_R	2.6368	-2.0099	-0.1543
Resources	*CV_N*	0.7138	0.2236	-0.8390
	CV_R		0.9765	-0.8169
	MSD_N	-4.0199	4.8657	-1.8209
	MSD_R	-7.4463	7.1983	-3.0661
Rural Goods	*CV_N*	-1.7503	-0.2912	-0.0574
	CV_R	-1.7477	-0.2939	-0.0447
	MSD_N	-1.7476	-0.2910	-0.0226
	MSD_R	-1.7624	-0.3279	-0.0296

Note: Compiled by author.

7.4 Estimation Results for Import Sectors

Since all the variables involved in the import equations are integrated in the order of no more than 1, the bounds test method can be applied to test the cointegration among the variables involved in each import equation.

7.4.1 Capital import sector

The lag lengths selected for the UECMs corresponding to the four import equations using *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the exchange rate volatility measures are all 5. The results from the UECM are shown in Table 7.9 for the Capital import sector using the four volatilities: *CV_N*, *CV_R*, *MSD_N* and *MSD_R*. The *F*-test statistic values are 14.7567, 14.4889, 12.6856 and 12.5268 for the Capital sector, which are above the upper critical bound at the 1 per cent significance level (4.84 for the first one and 6.36 for the last three). We further proceed to conduct *t*-test. The *t*-statistic values are -7.1937, -7.1027, -6.9155 and -6.8585 respectively, which are all beyond the bound critical values (-3.97 for the first one and -4.73 for the last three). Therefore, cointegration exists among the four variables in each import equation for the Capital import sector. The existence of cointegration in the relevant equations is confirmed by the results from the restricted error correction model presented in Table 7.10, in which the *EC* term is very significant and negative.

The long-run multipliers for the variables can be estimated and are presented in Table 7.15. From Table 7.9, it can be seen that Australia's domestic income (*gdpau*), relative price (*rp*) and exchange rate volatility have a positive effect on the Capital import sector, and while Australia's domestic income (*gdpau*) and relative price (*rp*) are very significant, the effect of exchange rate volatility is not significant on Capital imports.

Table 7.9: Bounds test for the Capital sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c	-5.0174	***	-3.4749	**	-4.7943	***	-4.7605	***
Trend			0.0032		0.0023		0.0022	
D_*cap*(-2)	0.2399	***	0.2686	***	0.2973	***	0.2894	***
D_*cap*(-3)	0.1609	*	0.1941	**	0.2005	**	0.1801	*
D_*cap*(-4)	0.3266	***	0.3437	***	0.2430	**	0.2494	***
D_*cap*(-5)	0.1860	**	0.1992	**	0.1864	**	0.2020	**
D_*gdpau*	2.2368	**	1.8426	*	2.1000	*	2.0671	*
D_*V*					0.0324		0.0328	
D_*V*(-1)	-0.1188	**	-0.1215	**	-0.0277		-0.0227	
D_*V*(-2)	-0.0962	***	-0.0886	***	-0.0796	**	-0.0770	**
D_*V*(-4)	0.0839	***	0.0803	***				
cap(-1)	-0.6725	***	-0.6650	***	-0.6927	***	-0.6853	***
gdpau(-1)	1.9704	***	1.5622	***	1.7582	***	1.7432	***
rp(-1)	0.5443	***	0.5591	***	0.5541	***	0.5490	***
V(-1)	0.0954		0.1030	*	0.0111		0.0108	
Diagnostic statistics								
R^2	0.5545		0.5569		0.5054		0.5047	
R^2_{adj}	0.4792		0.4746		0.4135		0.4127	
AIC	-2.6897		-2.6712		-2.5613		-2.5600	
SC	-2.3135		-2.2661		-2.1561		-2.1549	
HQC	-2.5384		-2.5083		-2.3984		-2.3971	
$\chi^2_N(2)$	0.7029	[0.7037]	1.1232	[0.5703]	0.7319	[0.6935]	0.7780	[0.6777]
$\chi^2_{SC}(2)$	0.4859	[0.6172]	0.1120	[0.8942]	0.4845	[0.6181]	0.5315	[0.5901]
$\chi^2_H(1)$	1.7314	[0.0780]	1.4864	[0.1445]	0.5645	[0.8738]	0.5839	[0.8589]
$\chi^2_{FF}(2)$	0.4637	[0.4981]	0.2722	[0.6035]	1.1727	[0.2826]	0.8659	[0.3553]

Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Therefore, the empirical results suggest that if Australia's domestic income and relative price increase, then the demand for Australia's Capital import sector will also increase, which is consistent with the model expectation.

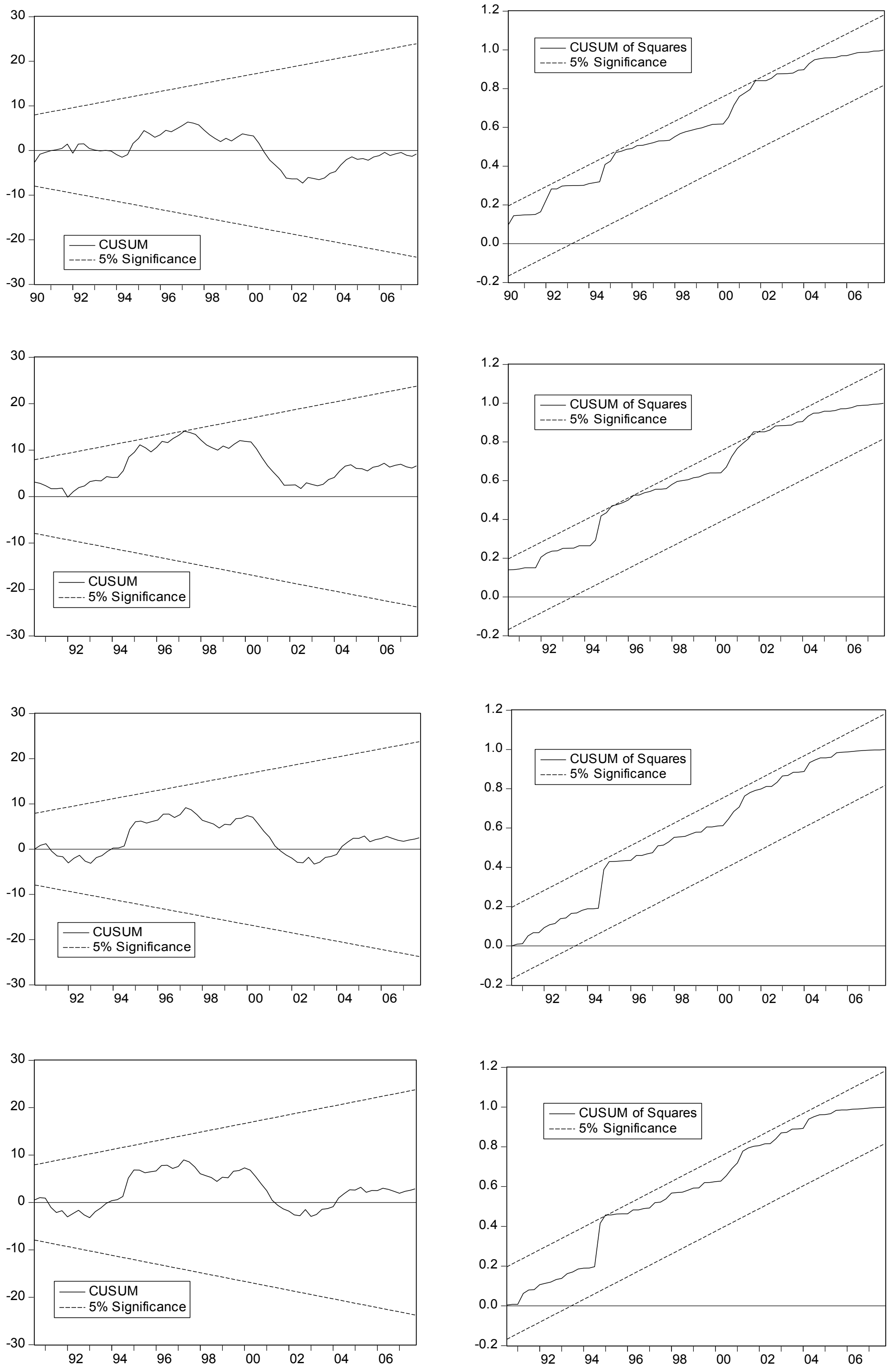
As a robustness check, Figures 7.7 and 7.8 are plots of CUSUM and CUSUMQ for coefficient stability for the unrestricted ECM and restricted ECM models for the Capital import sector. Since the plots of CUSUM and CUSUMQ statistics for all data series do not cross the critical value lines, it is safe to conclude that the Capital sector import equation is stable at the 5 per cent significance level.

Table 7.10: Error correction representation for the selected model for the Capital sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c	-5.0174	***	-3.4749	***	-4.7943	***	-4.7605	***
Trend			0.0032	***	0.0023	***	0.0022	***
D_*cap*(-2)	0.2399	***	0.2686	***	0.2973	***	0.2894	***
D_*cap*(-3)	0.1609	*	0.1941	**	0.2005	**	0.1801	**
D_*cap*(-4)	0.3266	***	0.3437	***	0.2430	***	0.2494	***
D_*cap*(-5)	0.1860	**	0.1992	**	0.1864	**	0.2020	**
D_*gdpau*	2.2368	**	1.8426	*	2.1000	*	2.0671	*
D_*V*					0.0324		0.0328	
D_*V*(-1)	-0.1188	***	-0.1215	***	-0.0277		-0.0227	
D_*V*(-2)	-0.0962	***	-0.0886	***	-0.0796	***	-0.0770	***
D_*V*(-4)	0.0839	***	0.0803	***				
EC(-1)	-0.6725	***	-0.6650	***	-0.6927	***	-0.6853	***
Diagnostic statistics								
R^2	0.5545		0.5569		0.5054		0.5047	
R^2_{adj}	0.5003		0.4961		0.4376		0.4369	
AIC	-2.7611		-2.7426		-2.6327		-2.6314	
SC	-2.4717		-2.4243		-2.3144		-2.3131	
HQC	-2.6448		-2.6147		-2.5047		-2.5035	
DW-statistic	1.9637		1.9698		1.9009		1.8791	
$\chi^2_N(2)$	0.7029	[0.7037]	1.1232	[0.5703]	0.7319	[0.6936]	0.7780	[0.6777]
$\chi^2_{SC}(2)$	0.5031	[0.6067]	0.1128	[0.8935]	0.5018	[0.6076]	0.5522	[0.5781]
$\chi^2_H(1)$	1.3813	[0.2121]	1.8270	[0.0707]	0.7512	[0.6743]	0.7636	[0.6628]
$\chi^2_{FF}(2)$	0.4225	[0.5177]	0.2602	[0.6116]	1.2016	[0.2767]	0.8821	[0.3508]

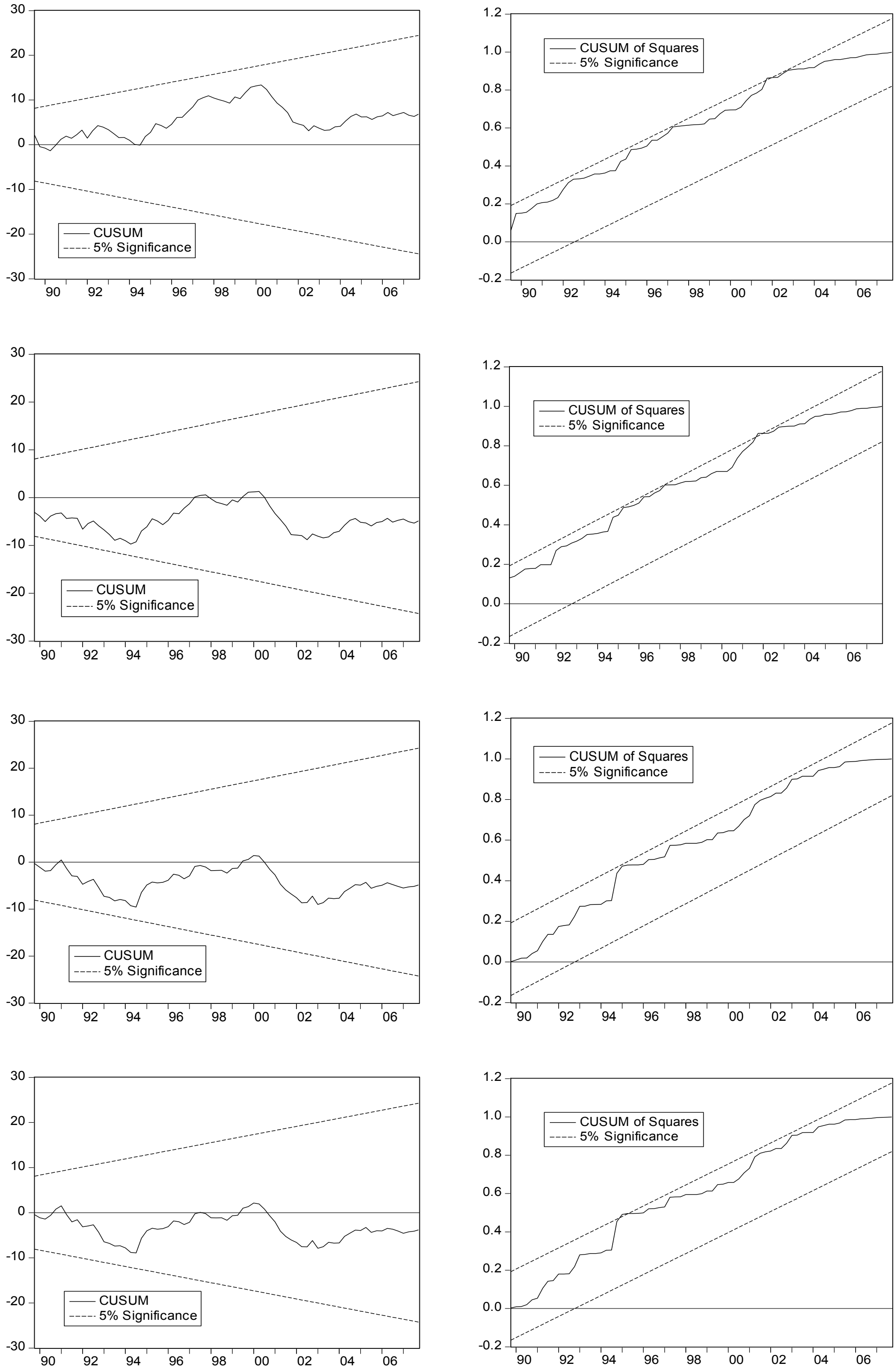
Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Figure 7.7: Plot of CUSUM and CUSUMQ for coefficient stability for the UECM model for the Capital sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measure respectively



Note: The straight lines represent critical bounds at the 5 per cent significance level.

Figure 7.8: Plot of CUSUM and CUSUMQ for coefficient stability for the RECM model for the Capital sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measure respectively



Note: The straight lines represent critical bounds at the 5 per cent significance level.

7.4.2 Consumption import sector

The lag lengths selected for the UECMs corresponding to the four import equations using *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the exchange rate volatility measures are all 5. The results from the UECM are shown in Table 7.11. The *F*-test statistic values are 5.4824, 5.4827, 5.4858 and 5.5036 for the Consumption sector. The *F* values from the four equations are above the upper critical bound at the 5 per cent significance level (5.07). We further proceed to conduct *t*-test. The *t*-statistic values are -4.5141, -4.5148, -4.5211 and -4.5023 respectively. Therefore, cointegration exists among the four variables in each import equation for the Consumption import sector. The existence of cointegration in the relevant equations is confirmed by the results from the restricted error correction model in Table 7.12, in which the *EC* term is very significant and negative.

The long-run multipliers for the variables can be estimated and the results are presented in Table 7.15. From Table 7.11, it can be seen that Australia's domestic income (*gdpau*) and relative price (*rp*) have a significant positive effect on the Consumption import sector, and exchange rate volatility has an insignificant negative effect on Consumption imports.

The empirical results suggest that if Australia's domestic income and relative price increase, then the demand for Australia's Consumption import sector will increase significantly, which is consistent with the model expectation. But exchange rate volatility dampens the demand for Australia's Consumption import sector slightly.

As a robustness check, Figures 7.9 and 7.10 are plots of CUSUM and CUSUMQ for coefficient stability for the unrestricted ECM and restricted ECM models for the Consumption import sector. Since the plots of CUSUM and CUSUMQ statistics for all data series do not cross the critical value lines, it is safe to conclude that the Consumption sector import equation is stable at the 5 per cent significance level.

Table 7.11: Bounds test for the Consumption sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c	1.2415		1.2427		1.2753		1.2860	*
Trend	0.0076	***	0.0076	***	0.0077	***	0.0077	***
D_*csm*(-1)	0.2732	**	0.2732	**	0.2725	**	0.2710	**
D_*csm*(-2)	0.2213	**	0.2210	**	0.2196	**	0.2167	*
D_*csm*(-3)	0.2145	*	0.2147	*	0.2114	*	0.2081	*
D_*csm*(-4)	0.2030	*	0.2031	*	0.2016	*	0.2006	*
D_*csm*(-5)	0.1354		0.1353		0.1346		0.1331	
D_*gdpau*(-1)	0.5847		0.5839		0.5864		0.5942	
D_*gdpau*(-5)	0.4253		0.4248		0.4104		0.4081	
D_*rp*	0.2068		0.2069		0.2061		0.2078	
D_*rp*(-2)	0.3290		0.3291		0.3351		0.3416	
D_*rp*(-3)	-0.2897		-0.2896		-0.2876		-0.2880	
D_*rp*(-5)	-0.5574	**	-0.5576	**	-0.5535	**	-0.5473	**
csm(-1)	-0.5728	***	-0.5728	***	-0.5729	***	-0.5712	***
gdpau(-1)	0.4218	**	0.4216	**	0.4163	**	0.4112	*
rp(-1)	0.2960	***	0.2958	***	0.2971	***	0.2977	***
V(-1)	-0.0014		-0.0014		0.0015		0.0029	
Diagnostic statistics								
R^2	0.4645		0.4645		0.4646		0.4650	
R^2_{adj}	0.3367		0.3367		0.3368		0.3373	
AIC	-4.0834		-4.0834		-4.0836		-4.0844	
SC	-3.5914		-3.5915		-3.5916		-3.5924	
HQC	-3.8856		-3.8857		-3.8858		-3.8866	
$\chi^2_N(2)$	0.5525	[0.7586]	0.5494	[0.7598]	0.5602	[0.7557]	0.5985	[0.7414]
$\chi^2_{SC}(2)$	2.3507	[0.1034]	2.3338	[0.1050]	2.4339	[0.0956]	2.3146	[0.1069]
$\chi^2_H(1)$	1.2617	[0.2479]	1.2617	[0.2479]	1.4180	[0.1604]	1.4520	[0.1453]
$\chi^2_{FF}(2)$	1.6729	[0.2004]	1.6765	[0.1999]	1.9155	[0.1710]	2.0474	[0.1572]

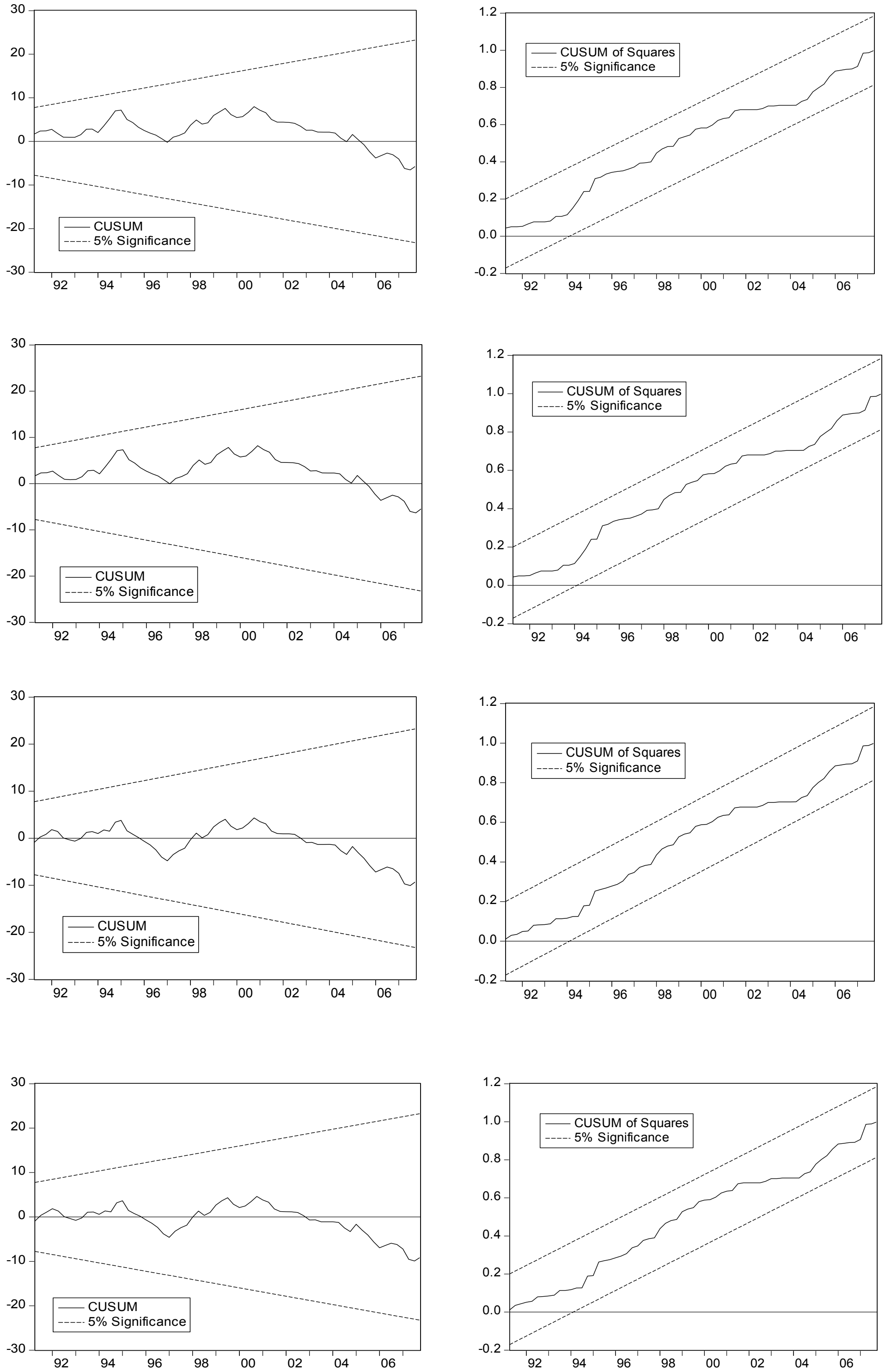
Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Table 7.12: Error correction representation for the selected model for the Consumption sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c	1.2414	***	1.2427	***	1.2753	***	1.2860	***
Trend	0.0076	***	0.0076	***	0.0077	***	0.0077	***
D_*csm*(-1)	0.2732	**	0.2732	**	0.2725	**	0.2710	**
D_*csm*(-2)	0.2213	**	0.2210	**	0.2196	**	0.2167	**
D_*csm*(-3)	0.2145	*	0.2147	*	0.2114	*	0.2081	*
D_*csm*(-4)	0.2030	*	0.2031	*	0.2016	*	0.2006	*
D_*csm*(-5)	0.1354		0.1353		0.1346		0.1331	
D_*gdpau*(-1)	0.5847		0.5839		0.5864		0.5942	
D_*gdpau*(-5)	0.4253		0.4248		0.4104		0.4082	
D_*rp*	0.2068		0.2069		0.2061		0.2078	
D_*rp*(-2)	0.3290		0.3291		0.3351		0.3416	
D_*rp*(-3)	-0.2897		-0.2896		-0.2876		-0.2880	
D_*rp*(-5)	-0.5574	**	-0.5576	**	-0.5535	**	-0.5474	**
EC(-1)	-0.5728	***	-0.5728	***	-0.5729	***	-0.5712	***
Diagnostic statistics								
R^2	0.4645		0.4645		0.4646		0.4650	
R^2_{adj}	0.3651		0.3651		0.3652		0.3657	
AIC	-4.1548		-4.1548		-4.1550		-4.1558	
SC	-3.7497		-3.7497		-3.7498		-3.7506	
HQC	-3.9920		-3.9920		-3.9921		-3.9929	
$\chi^2_N(2)$	0.5525	[0.7586]	0.5494	[0.7598]	0.5602	[0.7557]	0.5985	[0.7414]
$\chi^2_{SC}(2)$	2.1878	[0.1200]	2.1821	[0.1206]	2.1888	[0.1199]	2.1082	[0.1293]
$\chi^2_H(1)$	1.5827	[0.1112]	1.5832	[0.1110]	1.5869	[0.1099]	1.5870	[0.1099]
$\chi^2_{FF}(2)$	1.5289	[0.2205]	1.5187	[0.2220]	1.6066	[0.2092]	1.7181	[0.1943]

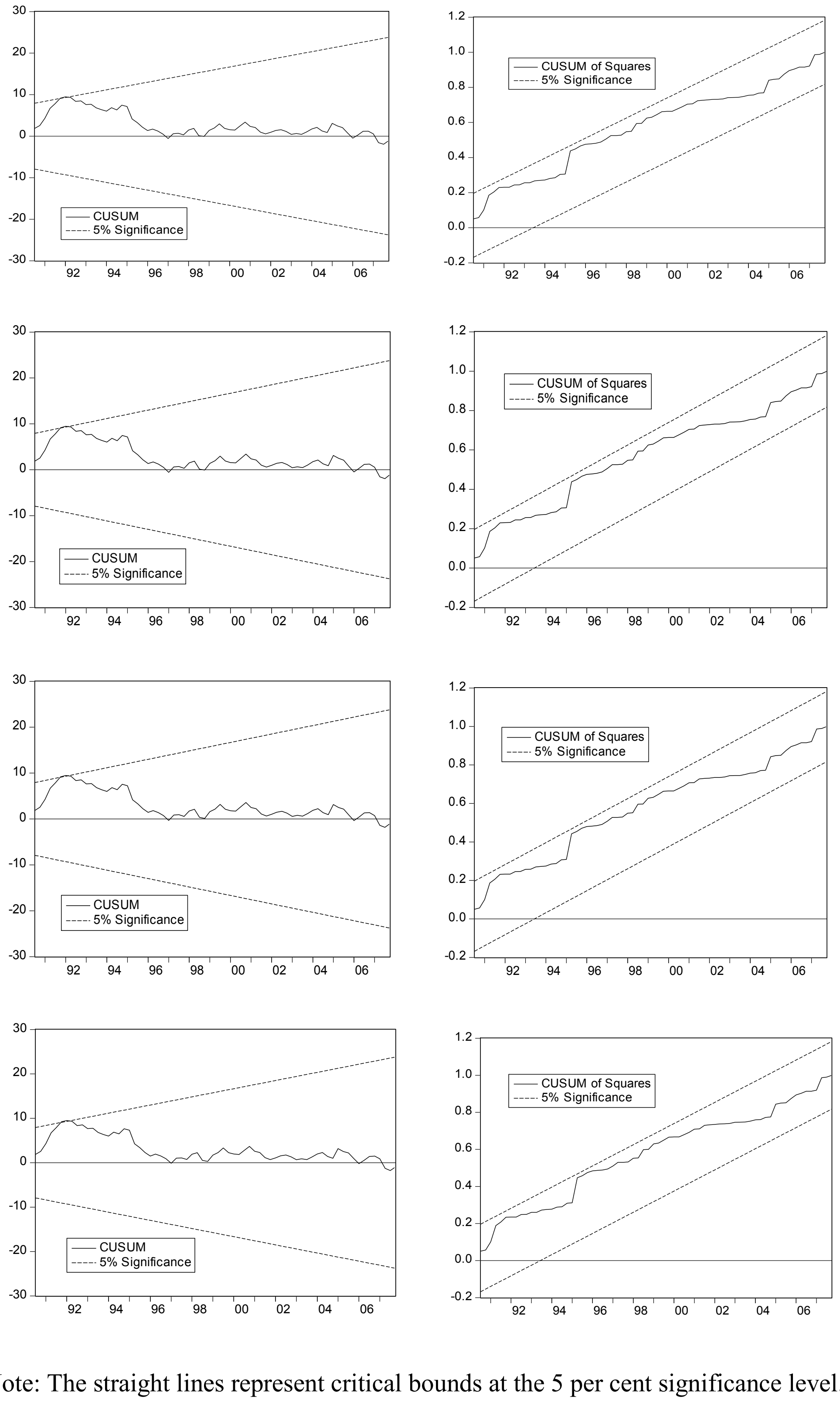
Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Figure 7.9: Plot of CUSUM and CUSUMQ for coefficient stability for the UECM model for the Consumption sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measure respectively



Note: The straight lines represent critical bounds at the 5 per cent significance level.

Figure 7.10: Plot of Cusum and Cusumq for coefficient stability for the RECM model for the Consumption sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measure respectively



Note: The straight lines represent critical bounds at the 5 per cent significance level.

7.4.3 Intermediate Goods import sector

The lag lengths selected for the UECMs corresponding to the four import equations using *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the exchange rate volatility measures are all 5. The results from the UECM are shown in Table 7.13. The *F*-test statistic values are 4.3510, 4.4144, 4.6348 and 4.6787 for the Intermediate Goods sector. The first two *F* values are between the lower and upper critical bound values at the 5 and 10 per cent significance levels; therefore, the existence of cointegration among the four variables is inconclusive for each of the two import equations with *CV_N* and *CV_R* as volatilities for the Intermediate Goods sector. The last two *F* values are bigger than the upper critical bound at the 10 per cent significance level. The *t*-test statistic values corresponding to the last two equations are -3.9222 and -3.9425, which are beyond the bound critical value at the 10 per cent level (-3.84); therefore, cointegration exists among the four variables for each of the two import equations with *MSD_N* and *MSD_R* as volatilities for the Intermediate Goods sector. The *t*-test statistic values corresponding to the first two equations are -3.8648 and -3.8933, which are also beyond the bound critical value at the 10 per cent level (-3.84). The *EC* term in all the four RECMs (Table 7.14) is very significant and negative. This confirms the existence of cointegration in the import equations with *MSD_N* and *MSD_R* as volatilities, and it also indicates the existence of cointegration in the import equations with *CV_N* and *CV_R* as volatilities.

The long-run multipliers for the variables can be estimated and are presented in Table 7.15. From Table 7.13, we can only tentatively say that all three variables of Australia's domestic income (*gdpau*), relative price (*rp*) and exchange rate volatility have an insignificant negative effect on the Intermediate Goods import sector. Therefore, the empirical results suggest that if Australia's domestic income and relative price increase, the demand for Australia's Intermediate Goods import sector will reduce slightly, which is not consistent with the model expectation. Exchange rate volatility will dampen the trade of the Intermediate Goods sector insignificantly.

As a robustness check, Figures 7.11 and 7.12 are plots of CUSUM and CUSUMQ for coefficient stability for the unrestricted ECM and restricted ECM models for the Intermediate Goods import sector. Since the plots of CUSUM and CUSUMQ statistics for all data series do not cross the critical value lines, it is safe to conclude that the regression coefficients in the Intermediate Goods sector import equation are generally stable at the 5 per cent significance level.

Table 7.13: Bounds test for the Intermediate Goods sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c	2.1585	**	2.1627	**	2.7082	***	2.7226	***
Trend	0.0047	**	0.0048	***	0.0053	***	0.0054	***
D_*intmd*(-1)	0.2049	*	0.2019	*	0.1240		0.1267	
D_*intmd*(-3)	0.2368	*	0.2357	**	0.1811	*	0.1845	*
D_*intmd*(-4)	-0.0647		-0.0622					
D_*gdpau*	0.7241		0.7349		0.7506		0.7448	
D_*gdpau*(-2)	1.2442	**	1.2677	**	1.1356	**	1.1326	**
D_*gdpau*(-3)	0.3728		0.4030		0.5763		0.5708	
D_*gdpau*(-4)	-0.5630		-0.5486		-0.4434		-0.4468	
D_*gdpau*(-5)	1.1783	**	1.1532	**	0.6892		0.6758	
D_*rp*	0.4556	**	0.4548	**	0.3707	**	0.3674	**
D_*rp*(-1)	-0.2921		-0.2743					
D_*rp*(-2)	0.3401		0.3324		0.2708		0.2706	
D_*V*	-0.0182		-0.0183					
D_*V*(-1)	0.0270		0.0292					
D_*V*(-2)	0.0199		0.0209					
D_*V*(-3)	0.0257		0.0240					
D_*V*(-4)	0.0265		0.0238					
D_*V*(-5)	0.0343	**	0.0321	**				
intmd(-1)	-0.2504	***	-0.2536	***	-0.2337	***	-0.2353	***
gdpau(-1)	-0.1086		-0.1046		-0.2024		-0.2010	
rp(-1)	-0.0054		-0.0091		-0.0123		-0.0146	
V(-1)	-0.0422		-0.0448		-0.0073		-0.0077	
Diagnostic statistics								
R^2	0.4694		0.4694		0.4022		0.4034	
R^2_{adj}	0.2812		0.2812		0.2844		0.2858	
AIC	-4.2713		-4.2712		-4.3369		-4.3388	
SC	-3.6103		-3.6103		-3.9088		-3.9108	
HQC	-4.0054		-4.0054		-4.1646		-4.1666	
$\chi^2_N(2)$	0.4149	[0.8126]	0.4241	[0.8089]	0.6089	[0.7375]	0.6136	[0.7358]
$\chi^2_{SC}(2)$	2.7099	[0.0747]	2.6951	[0.0757]	0.1050	[0.9004]	0.0893	[0.9147]
$\chi^2_H(1)$	0.9760	[0.5051]	1.0352	[0.4387]	1.5282	[0.1234]	1.5216	[0.1257]
$\chi^2_{FF}(2)$	2.6178	[0.1108]	2.2991	[0.1346]	0.3429	[0.5601]	0.3687	[0.5457]

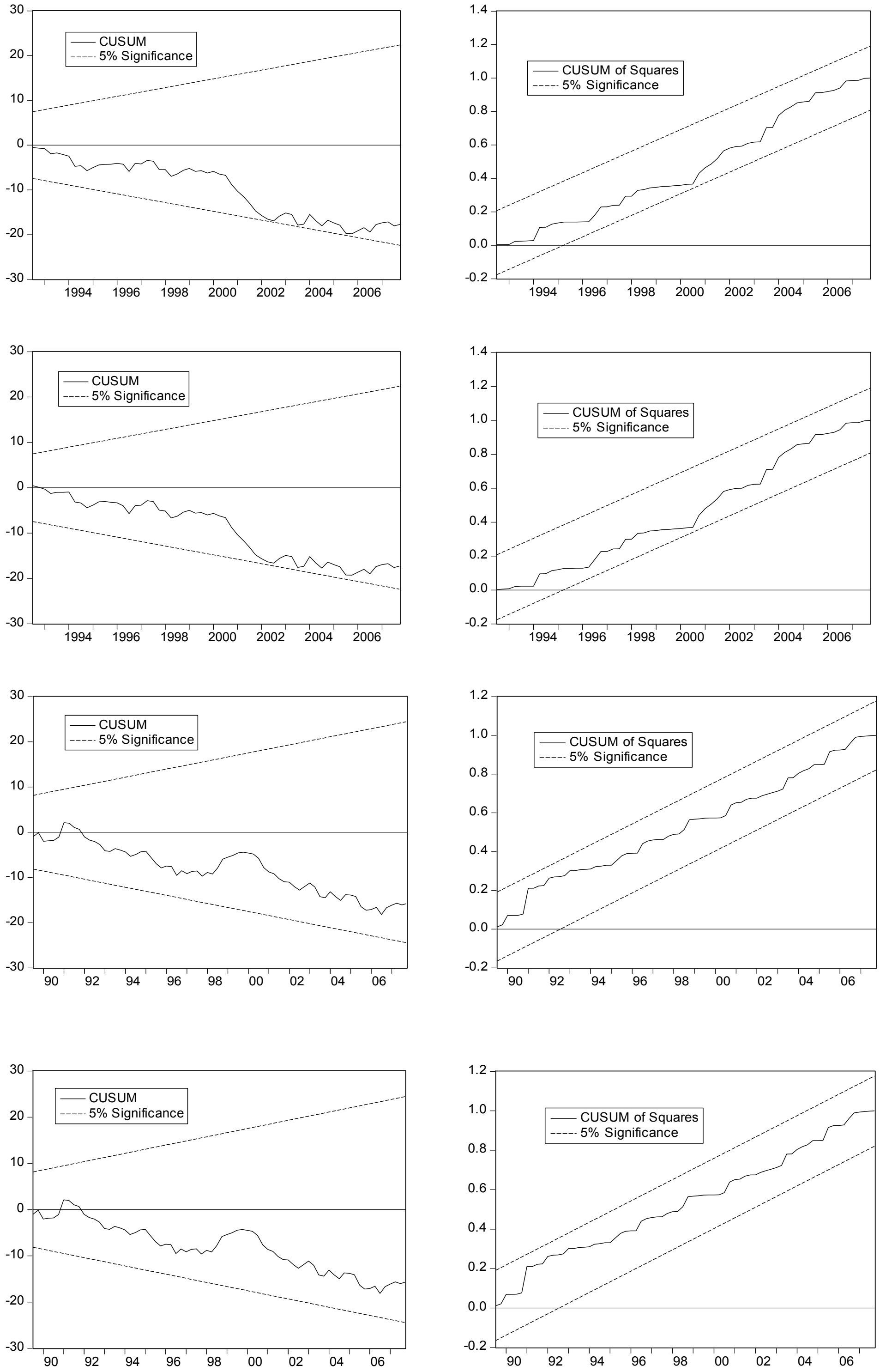
Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Table 7.14: Error correction representation for the selected model for the Intermediate Goods sector

Variable	*CV_N*		*CV_R*		*MSD_N*		*MSD_R*	
c	2.1585	***	2.1627	***	2.7082	***	2.7226	***
Trend	0.0047	***	0.0048	***	0.0053	***	0.0054	***
D_*intmd*(-1)	0.2049	*	0.2019	*	0.1240		0.1267	
D_*intmd*(-3)	0.2368	**	0.2357	**	0.1811	*	0.1845	*
D_*intmd*(-4)	-0.0647		-0.0622					
D_*gdpau*	0.7241		0.7349		0.7506		0.7448	
D_*gdpau*(-2)	1.2442	***	1.2677	***	1.1356	**	1.1326	**
D_*gdpau*(-3)	0.3728		0.4030		0.5763		0.5708	
D_*gdpau*(-4)	-0.5630		-0.5486		-0.4434		-0.4468	
D_*gdpau*(-5)	1.1783	**	1.1532	**	0.6892		0.6758	
D_*rp*	0.4556	**	0.4548	**	0.3707	**	0.3674	**
D_*rp*(-1)	-0.2921		-0.2743					
D_*rp*(-2)	0.3401	*	0.3324	*	0.2708		0.2706	
D_*V*	-0.0182		-0.0183					
D_*V*(-1)	0.0270		0.0292	*				
D_*V*(-2)	0.0199		0.0209					
D_*V*(-3)	0.0257		0.0240					
D_*V*(-4)	0.0265		0.0238					
D_*V*(-5)	0.0343	***	0.0321	***				
EC(-1)	-0.2504	***	-0.2536	***	-0.2337	***	-0.2353	***
Diagnostic statistics								
R^2	0.4694		0.4694		0.4022		0.4034	
R^2_{adj}	0.3144		0.3143		0.3134		0.3147	
AIC	-4.3418		-4.3418		-4.4067		-4.4086	
SC	-3.7671		-3.7671		-4.0642		-4.0661	
HQC	-4.1107		-4.1106		-4.2688		-4.2708	
$\chi^2_N(2)$	0.4149	[0.8126]	0.4241	[0.8089]	0.6089	[0.7375]	0.6136	[0.7358]
$\chi^2_{SC}(2)$	2.6792	[0.0764]	2.6944	[0.0754]	0.1086	[0.8973]	0.0923	[0.9119]
$\chi^2_H(1)$	0.8598	[0.6306]	0.8861	[0.6004]	1.0198	[0.4380]	1.0253	[0.4333]
$\chi^2_{FF}(2)$	2.4164	[0.1250]	2.1276	[0.1496]	0.3159	[0.5758]	0.3419	[0.5605]

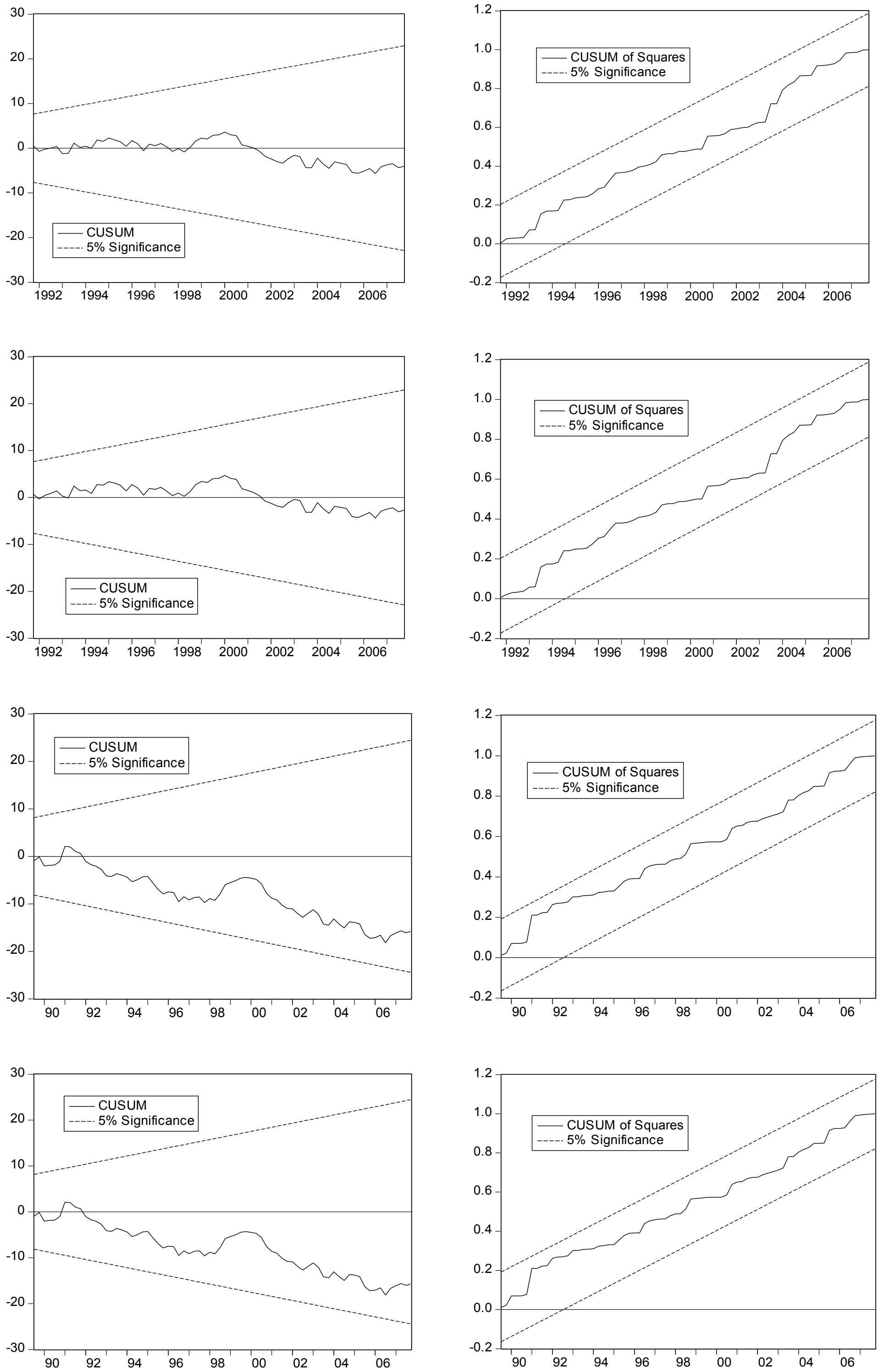
Notes: The meanings of the diagnostic statistics are the same as those in Table 6.2.

Figure 7.11: Plot of CUSUM and CUSUMQ for coefficient stability for the UECM model for the Intermediate Goods sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measure respectively



Note: The straight lines represent critical bounds at the 5 per cent significance level.

Figure 7.12: Plot of CUSUM and CUSUMQ for coefficient stability for the RECM model for the Intermediate Goods sector. The four rows are for *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as the volatility measure respectively



Note: The straight lines represent critical bounds at the 5 per cent significance level.

Table 7.15: Long-run multipliers for the import equations for the three sectors (Capital, Consumption and Intermediate Goods)

Sector	Volatility used in equations	*gdpau*	*rp*	Volatility
Capital	*CV_N*	2.9300	0.8094	0.1419
	CV_R	2.3492	0.8408	0.1549
	MSD_N	2.5382	0.7999	0.0160
	MSD_R	2.5437	0.8011	0.0158
Consumption	*CV_N*	0.7364	0.5168	-0.0024
	CV_R	0.7360	0.5164	-0.0024
	MSD_N	0.7267	0.5186	0.0026
	MSD_R	0.7199	0.5212	0.0051
Intermediate	*CV_N*	-0.4337	-0.0216	-0.1685
Goods	*CV_R*	-0.4125	-0.0359	-0.1767
	MSD_N	-0.8661	-0.0526	-0.0312
	MSD_R	-0.8542	-0.0621	-0.0327

Note: Compiled by author.

7.5 Concluding Remarks

In this section unit root tests are conducted for thirteen variables (*gdpw*, *gdpau*, *rp*, *CV_N*, *CV_R*, *MSD_N* and *MSD_R* as well as *export* for the three sectors of Manufactures, Resources and Rural Goods (*man*, *res* and *rur*), and *import* for the three sectors of Capital, Consumption and Intermediate Goods (*cap*, *csm* and *intmd*) involved in the sectoral export and import equations using six unit root test methods. While the test results are inconsistent among the methods, all the variables can be reasonably considered as integrated at the order of no more than 1 so that the bounds test can be applied to test the cointegration among the variables involved in each of the sectoral export and import equations. The test indicates that cointegration exists among the four variables involved in the sectoral export and import equations, except one import sector, Intermediate Goods.

The model estimation results show that exchange rate volatility has a significant positive impact on the Resources export sector and an insignificant positive impact on the Rural Goods export sector. As to the Manufactures export sector, exchange rate volatility has a significant negative impact. For all three import sectors, exchange rate volatility has an insignificant impact with a positive sign on Capital imports and negative signs on Consumption and Intermediate Goods imports. Foreign income (*gdpw*) has a significant and positive impact on the Manufactures and Rural Goods export sectors, but is inconclusive for the Resources export sector. Australia's domestic income (*gdpau*) has a significant and positive impact on the Capital and Consumption import sectors, but has an insignificant and negative sign for the Intermediate Goods import sector. Relative price has a significant and negative impact on the Manufactures export sector, a significant and positive impact on the Resources export sector, and an insignificant and positive impact on the Rural Goods export sector. For the Capital and Consumption import sectors, relative price has a significant and positive effect. For the Intermediate import sector, it has an insignificant and negative effect. In general, exchange rate volatility has a positive and mostly significant effect on sectoral exports, especially on Resources exports, and it has a mostly negative and insignificant effect on sectoral imports.

Chapter 8

Empirical Results at the Bilateral Trade Data Level

8.1 Introduction

In this chapter, we move away from aggregate trade and discuss a methodology that exploits the much richer variations in the data on bilateral trade and bilateral exchange rates that permit the identification of the distinct contribution of exchange rate volatility on trade.

This chapter analyses the impact of exchange rate volatility on Australian trade performance with its seven major trading partners, China, Japan, New Zealand, Singapore, South Korea, US and UK. The chapter is organised as follows. Unit root test results are presented in section two. Section three displays the empirical results from the cointegration test and parameter estimations, and section four draws the conclusions.

8.2 Unit Root Test Results

Nine unit root test methods are used: ADF, ERS, PP, KPSS, ERSPO, MZa, MZt, MSB and MPT. The results are shown in Table 8.1. Among the forty-three variables involved in the trade equations at the bilateral trade data level, fifteen are identified as I(1) by all the nine methods, which include *exp_jp*, *exp_nz*, *exp_sp*, *imp_jp*, *imp_sk*, *imp_sp*, *imp_uk*, *gdp_au*, *gdp_uk*, *rp_cn*, *rp_sk*, *rp_sp*, *CV_cn*, *CV_jp*, and *CV_sp*; four variables are identified as I(0) by all the nine methods, which include *CV_sk*, *MSD_cn*, *MSD_sk*, and *MSD_uk*. The results for the other twenty-four variables are inconsistent among the nine methods. According to the majority rule, twenty of them can be considered as I(1), including *exp_cn*, *exp_sk*, *exp_uk*, *exp_us*, *imp_cn*, *imp_nz*, *imp_us*, *gdp_cn*, *gdp_jp*, *gdp_nz*, *gdp_sp*, *gdp_us*, *rp_jp*, *rp_nz*, *rp_uk*, *rp_us*, *CV_nz*, *CV_us*, *MSD_nz*, and *MSD_us*; and the other four variables can be considered as I(0), including *gdp_sk*, *CV_uk*, *MSD_jp*, and *MSD_sp*.

Table 8.1: Results of various unit root tests

	Test Methods								
Variable	ADF	ERS	PP	KPSS	ERSPO	MZa	MZt	MSB	MPT
exp_cn									
Level	3.4719 (10)	-1.1213 (12)	2.0035 (43)	0.2678 *** (8)	334.2619 (3)	2.3348 (43)	1.4422 (43)	0.6177 (43)	109.461 (43)
Difference	-0.3418 (11)	0.8891 (11)	-12.904 ***(2)	0.6219 ** 10)	0.2015 *** (2)	-53.5400***(2)	-5.0661 ***(2)	0.0946***(2)	0.7246***(2)
CV_cn									
Level	-0.9497 (2)	-1.4630 (1)	-0.7999 (2)	0.2386 *** (8)	31.0508 (2)	-2.3509 (2)	-0.8983 (2)	0.3821 (2)	31.1116 (2)
Difference	-6.2972 ***(1)	-6.2878 ***(1)	-6.2291 ***(4)	0.2912 (3)	0.8505 *** (4)	-37.0655***(4)	-4.2365***(4)	0.1143***(4)	0.8589 *** (4)
gdp_cn									
Level	2.4851 (8)	-0.6004 (8)	0.2380 (15)	0.3070 *** (7)	121.0396 (15)	1.3320 (15)	0.8713 (15)	0.6541 (15)	108.6840 (15)
Difference	2.6066 (11)	3.0116 (11)	-11.8058 ***(31)	0.4484 * (27)	7.3661 (15)	-95.8084***(31)	-6.9209***(31)	0.2564***(31)	0.2564***(31)
rp_cn									
Level	-1.8256 (1)	-1.6344 (1)	-1.7544 (3)	0.1843 ** (8)	16.9704 (3)	-5.5457 (3)	-1.4731 (3)	0.2656 (3)	15.9800 (3)
Difference	-7.3867 *** (0)	-7.4247 ***(0)	-7.4061 *** (1)	0.2181 (2)	1.3446 *** (1)	-47.3671***(1)	-4.5630 ***(1)	0.0963***(1)	1.2922***(1)
MSD_cn									
Level	-3.5733 ** (2)	-3.5531 ** (2)	-4.6065 *** (4)	0.0805 (4)	3.7022 *** (4)	-27.8681 ***(4)	-3.6524 ***(4)	0.1311***(4)	3.7421***(4)
Difference	-10.4378 ***(1)	-1.4675 *** (6)	-14.1138 ***(35)	0.1843 (27)					
imp_cn									
Level	-2.0610 (0)	-1.1267 (0)	-2.0547 (1)	0.2120 ** (8)	39.8023 (1)	-2.3428 (1)	-0.9826 (1)	0.4194 (1)	34.5809 (1)
Difference	-9.8167 ***(0)	-9.8658 ***(0)	-9.8167 *** (1)	0.3564 * (1)	0.4901 ***(1)	-48.9918***(1)	-4.9493***(1)	0.1010***(1)	0.5001***(1)
gdp_au									
Level	-2.2981 (2)	-2.3331 (2)	-1.9774 (4)	0.1481 ** (7)	11.3963 (4)	-7.8565 (4)	-1.9725 (4)	0.2511 (4)	11.6250 (4)
Difference	-7.3116 ***(0)	-4.4083 ***(1)	-7.3515 *** (2)	0.0690 (3)	0.7121 ***(2)	-37.6694***(2)	-4.3280***(2)	0.1149***(2)	0.6847***(2)
CV_jp									
Level	0.5021 (0)	-0.8245 (1)	0.5312 (7)	0.1992 ** (7)	23.9949 (0)	-0.9163 (7)	-0.2194 (7)	0.2395 (7)	23.2976 (7)
Difference	-7.0914 ***(0)	-7.0995 ***(0)	-6.8448 *** (5)	0.4610 * (3)	2.3614 ** (0)	-39.0449***(5)	-3.8160***(5)	0.0977***(5)	2.2289 ** (5)
gdp_jp									
Level	-2.1910 (3)	-0.8782 (3)	-2.1090 (5)	0.2220 *** (8)	82.3093 (5)	-0.5884 (5)	-0.3373 (5)	0.5733 (5)	68.7005 (5)
Difference	-2.3420 (2)	-1.7872 * (2)	-7.8305 *** (6)	0.5810 ** (6)	1.3710 ***(6)	-60.7592***(6)	-5.1543***(6)	0.0848***(6)	1.2224*** (6)
rp_jp									
Level	-3.7257 ** (3)	-1.8774 (1)	-2.8116 (3)	0.1602 ** (8)	19.8496 (3)	-5.3811 (3)	-1.6090 (3)	0.2990 (3)	16.8368 (3)
Difference	-6.2081 ***(0)	-2.8242 ***(2)	-6.2756 *** (3)	0.1257 (4)	2.4311 ** (3)	-42.6230***(3)	-3.8996***(3)	0.0915***(3)	2.3951 ** (3)
exp_jp									
Level	-1.2037 (5)	-1.4009 (5)	-0.9030 (3)	0.2260 *** (8)	18.9312 (3)	-4.1529 (3)	-1.0471 (3)	0.2521 (3)	18.3616 (3)
Difference	-3.5574 ***(4)	-3.4005 ***(4)	-9.4028 *** (3)	0.3207 (3)	0.7050 ***(3)	-44.9886***(3)	-4.6795***(3)	0.1040***(3)	0.7140 ***(3)
MSD_jp									
Level	-3.4639 ** (2)	-1.7833 (4)	-3.7418 ** (13)	0.05689 (3)	6.9599 (13)	-15.3736 * (13)	-2.6387 * (13)	0.1716 * (13)	6.7211 (13)
Difference	-7.7797 ***(3)	-0.2756 (7)	-10.3220 ***(74)	0.2690 (55)	13.8911 (74)	-1.8040 (74)	-0.6515 (74)	0.3612 (74)	10.0588 (74)
imp_jp									
Level	-2.2565 (0)	-2.1921 (0)	-2.2237 (2)	0.1974 ** (8)	10.6981 (2)	-8.7146 (2)	-2.0472 (2)	0.2349 (2)	10.6055 (2)
Difference	-10.1045 ***(0)	-9.7392 ***(0)	-10.1879 ***(6)	0.0980 (6)	0.6494 ***(6)	-37.7516***(6)	-4.3446***(6)	0.1151***(6)	0.6490***(6)
exp_nz									
Level	-2.8330 (0)	-1.8645 (0)	-2.8964 (7)	0.1389 * (8)	9.0296 (7)	-10.6444 (7)	-2.3063 (7)	0.2167 (7)	8.5644 (7)
Difference	-3.2722 ** (7)	-2.7312 ***(7)	-12.8607 ***(21)	0.2417 (53)	1.1870 ***(21)	-22.0640***(21)	-3.3018***(21)	0.1496***(21)	1.1792***(21)

(Contd)

gdp_nz									
Level	-2.1418 (11)	-2.0327 (11)	-3.2894 * (3)	0.2053 ** (7)	10.9192 (3)	-9.4446 (3)	-2.1731 (3)	0.2301 (3)	9.6485 (3)
Difference	-3.1584 ** (11)	-0.5711 (11)	-12.4626 ***(4)	0.1089 (5)	2.9542 ** (4)	-11.1661 **(4)	-2.3564 ** (4)	0.2110 ** (4)	2.2200 ** (4)
rp_nz									
Level	-3.1740 * (1)	-3.2054 ** (1)	-2.6668 (3)	0.1339 * (7)	7.2885 (3)	-15.3499 * (3)	-2.5516 (3)	0.1662 ** (3)	7.2138 (3)
Difference	-6.2806 *** (3)	-6.7472 *** (0)	-6.2632 ***(8)	0.1757 (7)	2.9083 ** (8)	-19.2549***(8)	-2.6201***(8)	0.1361***(8)	2.8957 ** (8)
CV_nz									
Level	-3.2252 * (1)	-1.0760 (1)	-2.6167 (1)	0.2746 *** (8)	96.0813 (1)	-0.6421 (1)	-0.4021 (1)	0.6263 (1)	78.6111 (1)
Difference	-6.8316 ***(0)	-5.8946 *** (0)	-6.8952 ***(1)	0.6509 ** (4)	0.8916 ***(1)	-36.7782***(1)	-4.2467***(1)	0.1155***(1)	0.7870***(1)
MSD_nz									
Level	-1.4415 (8)	-0.6193 (8)	-3.1812 * (6)	0.2765 *** (6)	10.3474 (6)	-10.6798 (6)	-2.1514 (6)	0.2014 (6)	9.3080 (6)
Difference	-5.6430 ***(7)	-0.9418 (11)	-9.8864 ***(16)	0.3761 * (17)	3.6014 **(16)	-7.9302 * (16)	-1.9903**(16)	0.2510 * (16)	3.0931**(16)
imp_nz									
Level	-3.0655 (4)	-3.0613 ** (4)	-2.3084 (2)	0.1384 * (8)	8.9942 (2)	-10.3330 (2)	-2.2156 (2)	0.2144 (2)	9.0950 (2)
Difference	-4.4290 ***(6)	-2.9101 *** (3)	-10.1597 ***(6)	0.0835 (7)	0.6772 ***(6)	-39.7440***(6)	-4.4488***(6)	0.1119***(6)	0.6418***(6)
exp_sk									
Level	-2.7692 (0)	-2.7997 * (0)	-2.7692 (0)	0.0961 (7)	7.2500 (0)	-15.1249 * (0)	-2.5537 (0)	0.1688 ** (0)	7.1716 (0)
Difference	-11.0120 ***(0)	-10.8454 ***(0)	-11.0729 ***(3)	0.1336 (5)	0.8388 ***(3)	-42.6573***(3)	-4.5188***(3)	0.1059***(3)	0.8452***(3)
gdp_sk									
Level	-1.5154 (7)	-0.1422 (8)	-7.5660 *** (2)	0.2608 *** (9)	4.6417 ** (2)	-25.5077***(2)	-3.5307***(2)	0.1384***(2)	3.8161***(2)
Difference	-2.5546 (7)	0.2399 (7)	-38.0042 ***(14)	0.3493 * (13)					
rp_sk									
Level	-2.4199 (3)	-2.2744 (3)	-2.4287 (1)	0.1510 ** (8)	9.3063 (1)	-10.1268 (1)	-2.2178 (2)	0.2190 (2)	9.1516 (2)
Difference	-5.3168 ***(2)	-5.0484 ***(2)	-8.3657 ***(4)	0.0700 (2)	0.7691***(4)	-36.4903***(4)	-4.2334***(4)	0.1160***(4)	0.7823***(4)
CV_sk									
Level	-3.9506 ** (0)	-3.9828 *** (0)	-4.0360 ** (2)	0.0749 (6)	4.2930 ** (2)	-26.3876***(2)	-3.4796***(2)	0.1319***(2)	4.3506 ** (2)
Difference	-8.2090 ***(1)	-9.5174 *** (0)	-11.6212 ***(10)	0.1445 (12)	2.7482 **(10)	-15.8996***(10)	-2.5574**(10)	0.1608***(10)	2.4965**(10)
MSD_sk									
Level	-3.4918 ** (5)	-3.5914 ** (5)	-3.5042 ** (6)	0.0988 (5)	4.8310 ** (6)	-20.0122 ** (6)	-3.1085 **(6)	0.1553 ** (6)	4.8895 ** (6)
Difference	-5.2571 ***(8)	-4.3141 *** (5)	-8.2176 ***(23)	0.0982 (15)	3.0403 ** (23)	-8.8042 ** (23)	-2.0182**(23)	0.2292**(23)	3.0926**(23)
imp_sk									
Level	-2.5647 (4)	-2.5824 (4)	-4.0916 *** (2)	0.1314 * (8)	3.7888 *** (2)	-23.5761 ** (2)	-3.4333 *** (2)	0.1456 ** (2)	3.8654 ***(2)
Difference	-5.9077 ***(4)	-4.9304 *** (3)	-18.9142 ***(20)	0.3206 (55)	1.7929 ***(20)	-13.5484 **(20)	-2.6023***(20)	0.1921**(20)	1.8101 **(20)
exp_sp									
Level	-2.7822 (1)	-2.5763 (1)	-3.3346 * (2)	0.0900 (7)	5.9336 * (2)	-15.9829 * (2)	-2.8124 * (2)	0.1760 * (2)	5.7902 * (2)
Difference	-12.8061 ***(0)	-12.0887 ***(0)	-12.7989 *** (1)		0.5703 ***(1)	-43.6786 ***(1)	-4.6721***(1)	0.1070***(1)	0.5642***(1)
gdp_sp									
Level	-1.4712 (10)	-1.3442 (10)	-2.1401 (14)	0.2488 *** (7)	10.3807 (14)	-8.8875 (14)	-2.0541 (14)	0.2311 (14)	10.4602 (14)
Difference	-3.8260 ***(9)	-0.5307 (11)	-11.5271 ***(21)	0.5000 ** (96)	3.4921 * (21)	-10.9994 **(21)	-2.2700**(21)	0.2064**(21)	2.5240 **(21)
rp_sp									
Level	-2.8377 (1)	-2.0255 (1)	-2.7887 (2)	0.2279 *** (7)	16.3454 (2)	-6.4543 (2)	-1.7202 (2)	0.2665 (2)	14.1381 (2)
Difference	-6.0426 ***(0)	-5.1858 ***(0)	-5.9917 *** (2)	0.1194 (3)	2.3097 ** (2)	-33.5044 ***(2)	-3.5319***(2)	0.1054***(2)	2.3139 ** (2)
CV_sp									
Level	-0.3104 (0)	-1.3493 (1)	-0.6147 (3)	0.2388 *** (8)	16.5080 (3)	-4.8634 (3)	-1.1180 (3)	0.2299 (3)	16.6-73 (3)
Difference	-6.6537 ***(0)	-6.2405 ***(0)	-6.3809 *** (5)	0.2933 (3)	3.0523 **(5)	-35.1583 ***(5)	-3.4211***(5)	0.0973***(5)	2.7799 ** (5)

(Contd)

MSD_sp									
Level	-1.7467 (4)	-2.2157 (4)	-3.7431 ** (7)	0.1396 * (4)	5.1689 ** (7)	-21.2387 ** (7)	-3.1081 **(7)	0.1463 ** (7)	5.1992 ** (7)
Difference	-8.3294 ***(3)	-8.2393 ***(3)	-8.6260 *** (30)	0.2143 (29)					
imp_sp									
Level	-1.6597 (5)	-1.4507 (1)	-2.4266 (2)	0.2239 *** (8)	13.0068 (2)	-7.7461 (2)	-1.8435 (2)	0.2380 (2)	12.0815 (2)
Difference	-14.7053 ***(0)	-2.0314 ** (7)	-14.9276 *** (3)	0.2869 (13)	0.6948 ***(3)	-36.2753***(3)	-4.2570***(3)	0.1174***(3)	0.6808***(3)
exp_uk									
Level	-3.8006 ** (0)	-3.0924 ** (0)	-3.5690 ** (5)	0.2271 *** (7)	8.4946 (5)	-12.9832 (5)	-2.4456 (5)	0.1884 (5)	7.5957 (5)
Difference	-7.6897 ***(2)	-7.7246 ***(2)	-14.3058 ***(19)	0.3425 (23)	1.9605 **(19)	-13.0238 **(19)	-2.5257**(19)	0.1939**(19)	1.9841**(19)
gdp_uk									
Level	-2.6425 (3)	-2.6176 (3)	-1.8759 (6)	0.1276 * (7)	12.7413 (6)	-7.0744 (6)	-1.8623 (6)	0.2633 (6)	12.9096 (6)
Difference	-3.0512 ** (11)	-1.4052 (2)	-6.7482 *** (5)	0.0810 (6)	2.5282 ** (5)	-13.0066 ** (5)	-2.5430 **(5)	0.1955 **(5)	1.9118 **(5)
rp_uk									
Level	-2.5183 (11)	-2.4450 (11)	-2.5920 (1)	0.0921 (8)	11.2347 (1)	-8.7892 (1)	-2.0780 (1)	0.2364 (1)	10.4374 (1)
Difference	-3.6929 ***(8)	-3.4904 ***(8)	-6.7354 *** (4)	0.0701 (2)	1.5418 ***(4)	-34.9841 ***(4)	-3.9237***(4)	0.1122***(4)	1.4469***(4)
CV_uk									
Level	-2.4276 (2)	-2.2286 (2)	-6.9852 *** (5)	0.2177 *** (7)	2.9367 ***(5)	-49.5584 ***(5)	-4.7823***(5)	0.0965***(5)	2.8029***(5)
Difference	-5.8558 ***(5)	-0.9591 (6)	-26.7134 ***(16)	0.2825 (8)					
MSD_uk									
Level	-4.0325 ** (2)	-2.7613 * (2)	-4.6061 *** (5)	0.0585 (4)	6.1950 *** (5)	-16.9027 * (5)	-2.8899 * (5)	0.1710 * (5)	5.4969 ** (5)
Difference	-8.0522 ***(3)	-3.4947 ***(4)	-12.7323 ***(34)	0.1682 (27)	3.9651 ** (34)	-6.3253 * (34)	-1.7476 *(34)	0.2763 (34)	3.9782 * (34)
imp_uk									
Level	-2.4564 (0)	-2.4658 (0)	-2.3222 (1)	0.1622 ** (8)	9.3555 (1)	-10.8309 (1)	-2.1609 (1)	0.1995 (1)	9.2317 (1)
Difference	-8.9608 ***(1)	-11.0794 ***(0)	-11.7374 *** (4)	0.1718 (5)	0.7408 ***(4)	-36.0973***(4)	-4.2230***(4)	0.1170***(4)	0.7533***(4)
exp_us									
Level	-3.0952 (12)	-2.0291 (12)	-2.1839 (3)	0.1961 ** (8)	11.4435 (3)	-8.2680 (3)	-1.9623 (3)	0.2373 (3)	11.2500 (3)
Difference	-2.4639 (11)	-1.6695 * (11)	-11.9964 *** (4)	0.1403 (8)	0.5913 ***(4)	-42.6136***(4)	-4.6072***(4)	0.1081***(4)	0.5988***(4)
gdp_us									
Level	-1.1178 (2)	-1.2577 (2)	-1.2417 (4)	0.0970 (8)	20.2688 (4)	-4.0404 (4)	-1.0529 (4)	0.2606 (4)	18.8540 (4)
Difference	-3.6871 ***(1)	-0.7811 (3)	-6.7182 *** (2)	0.3179 (4)	3.5396 * (2)	-20.5242***(2)	-2.7092***(2)	0.1320***(2)	2.8269 ** (2)
rp_us									
Level	-3.1764 * (1)	-2.8815 * (1)	-2.9256 (3)	0.0747 (7)	8.3822 (3)	-12.3692 (3)	-2.3955 (3)	0.1937 (3)	7.8715 (3)
Difference	-5.2103 ***(0)	-4.6892 ***(0)	-5.2774 *** (3)	0.0725 (3)	2.3387 ** (3)	-33.9359***(3)	-3.5428***(3)	0.1044***(3)	2.3377 ** (3)
CV_us									
Level	-1.1135 (0)	-2.0176 (1)	-1.3401 (3)	0.2330 *** (7)	11.0437 (3)	-9.5667 (3)	-1.7639 (3)	0.1844 * (3)	11.2135 (3)
Difference	-7.8265 ***(0)	-7.8454 ***(0)	-7.6284 *** (6)	0.2285 (5)	2.0958 ** (6)	-40.1086***(6)	-3.9612***(6)	0.0988***(6)	1.9856 ** (6)
MSD_us									
Level	-2.4081 (5)	-2.7041 (5)	-2.7827 (9)	0.1849 ** (6)	6.8756 (9)	-15.8152 * (9)	-2.6056 (9)	0.1648 ** (9)	6.9770 (9)
Difference	-4.5759 ***(7)	-3.1545 ***(4)	-7.4555 ***(47)	0.2543 (28)	5.2533 (47)	-5.8354 * (47)	-1.3283 (47)	0.2276**(47)	5.2773 (47)
imp_us									
Level	-2.8063 (0)	-2.7723 * (0)	-2.8063 (0)	0.1332 * (8)	6.9300 (0)	-13.5016 (0)	-2.5680 (0)	0.1902 (0)	6.9250 (0)
Difference	-10.3807***(0)	-10.3064 ***(0)	-10.5251 ***(5)	0.0731 (6)	0.6903 ***(5)	-37.2944***(5)	-4.3022***(5)	0.1154***(5)	0.7034***(5)

Notes: 1, use AIC for lag selection, maximum lag is 12; also wether include intercept or trend depends the smallest AIC in the regression result.
2, PP and KPSS: Bartlett kernel method for spectral estimation; Newey-West Bandwidth method for bandwidth selection.
3, ERSPO: AR spectral OLS method for spectral estimation. 4, NP: AR GLS-detrended method for spectral estimation.

8.3 Cointegration Test and Parameter Estimation

Since all the trade (both export and import) variables are I(1) and all the other variables are either I(1) or I(0), cointegration tests are conducted with the bounds test approach. The results are shown in Table 8.2. When *CV* is used as the exchange rate volatility measure, cointegration is identified for some deterministic term setting and the maximum lags setting among the variables involved in the equations of exports to China, Japan, New Zealand, South Korea and US, and in the equations of imports from China, Japan, New Zealand, Singapore and UK. When *MSD* is used as the exchange rate volatility measure, cointegration is identified for some deterministic term setting and the maximum lags setting among the variables involved in the equations of exports to China, Japan, New Zealand, South Korea and US, and in the equations of imports from China, Japan, New Zealand, Singapore and US. For the variables involved in the other equations, the cointegration among the variables could not be identified. Therefore, it was considered that cointegration does not exist among the variables involved in these equations, and further analysis was not conducted for these equations.

For those trade equations where cointegration exists among the variables involved, the long-run parameters were estimated by selecting a parsimonious model for each equation using model selection criterion AIC. At each step of model selection, the diagnostic statistics were checked to make sure statistically valid models were obtained. The results of the models are shown in Appendix 8.1. Among the twenty estimated models, fifteen passed all the diagnostic tests, and the other five only failed the Ramsey RESET test, a situation which has also been encountered in the study of Pesaran et al. (2001).

The estimation of the long-run parameters is derived from these results (Table 8.3). Error correction terms are derived from these long-run parameters, and restricted error correction models (using the same structure as the previous unrestricted error correction models with the error terms replacing the linear combination of the level variables) are estimated again. The results are also shown in Table 8.3. All the error correction terms in all the models have a negative sign and are all highly significant, and most of them are of quite a large magnitude. These negative coefficients reflect the joint significance of the long-run coefficients. And the large magnitude indicates a quick adjustment to any disequilibrium in the short-run. The larger the magnitude (in absolute value), the faster the trade returns to the equilibrium once there has been a shock.

Volatility is only significant in a few equations, and is not significant in all the other equations. Volatility generated from GARCH has a negative impact on exports to China, Japan and New Zealand, and imports from Japan; it has a positive impact on exports to South Korea and US, and the imports from China, New Zealand, Singapore and UK. Volatility generated from MSD has a negative impact on exports to China and New Zealand, and imports from Japan and US; it has a positive impact on the exports to Japan, South Korea and US, and imports from China, New Zealand and Singapore.

When *CV* is used as the volatility measure, *gdp* of the destination countries has a positive impact on exports to them, and Australian *gdp* has a positive impact on imports from China, Japan and UK and a negative impact on imports from New Zealand and Singapore. Relative price has a positive impact on exports to New Zealand and imports from Japan, New Zealand, Singapore and UK, and it has a negative impact on exports to China, Japan, South Korea and US and imports from China.

When *MSD* is used as the volatility measure, *gdp* of the destination countries has a positive impact on exports to China, Japan, South Korea and US, and a negative impact on exports to New Zealand; and Australian *gdp* has a positive impact on imports from China, Japan and US, and a negative impact on imports from New Zealand and Singapore. Relative price has a positive impact on exports to New Zealand and US, and imports from China, Japan and US, and it has a negative impact on exports to China, Japan and South Korea and imports from New Zealand and Singapore.

Table 8.2: The results of cointegration test for the analysis at bilateral trade data level

Country	Volatility	Lag length	Deterministic term	F-statistic	t-statistic
Export					
China	*CV*	11		**4.4694**	**-6.6052**
	MSD	11		**5.2688**	**-8.3484**
Japan	***CV***	12		**3.7206**	**-10.9711**
	MSD	12	c & t	**4.5436**	**-4.3178**
New Zealand	*CV*	10	c	**3.8288**	**-3.8311**
	MSD	12	c & t	**6.0327**	**-12.5691**
South Korea	*CV*	12	c & t	**6.7951**	**-11.3260**
	MSD	12		**7.1521**	**-7.8398**
Singapore	*CV*	12		2.7873	-1.3983
	MSD	12		2.8379	-2.0341
UK	*CV*	1	c & t	4.2959	-3.9763
	MSD	9	c	**5.8208**	-1.0489
US	*CV*	12	c & t	**4.6246**	**-12.9907**
	MSD	12	c & t	**6.4977**	**-6.6348**
Import					
China	*CV*	12	c	**12.9760**	**-6.8760**
	MSD	12	c	**4.9140**	**-19.5904**
Japan	*CV*	12		**3.1795**	**-5.9715**
	MSD	12		**3.9516**	**-5.8833**
New Zealand	*CV*	12	c & t	**5.9092**	**-10.5593**
	MSD	12	c & t	**4.6938**	**-4.8046**
South Korea	*CV*	12	c & t	**4.3325**	-2.9991
	MSD	12	c & t	2.8047	0.4950
Singapore	*CV*	12	c & t	**4.6265**	**-8.5841**
	MSD	12	c & t	**6.4977**	**-6.6348**
UK	*CV*	10	c	**6.2707**	**-3.5240**
	MSD	12		1.6821	-1.7367
US	*CV*	12		2.6967	-2.9605
	MSD	12		**3.7434**	**-4.9510**

Note: The numbers in bold indicate the values of *F*-statistic and *t*-statistic from bounds test are significantly larger (in magnitude for t test) than the upper bound of the critical values at least at 10 per cent significance level, which are for *F*-statistic 3.1 (without deterministic terms), 3.77 (with intercept) and 4.45 (with both intercept and time trend), and for *t*-statistic -3 (without deterministic terms), -3.46 (with intercept) and -3.84 (with both intercept and time trend).

Table 8.3: Long-run coefficients estimated from the UECMs for the analysis at bilateral trade data level

			Country						
			CN	JP	NZ	SK	SP	UK	US
Export	*CV*	*gdp*	1.4821	2.2343	3.206	3.6255			11.3953
		rp	-1.3363	-0.4757	1.8926	-0.7884			-0.2243
		V	-0.0339	-0.3581	-0.0605	0.386			0.0822
		EC	-0.8278	-0.8028	-0.2074	-0.8785			-0.9857
			<0.0001	<0.0001	<0.0001	<0.0001			<0.0001
	MSD	*gdp*	1.4303	82.8398	-5.5723	1.7982			1.4106
		rp	-1.5764	-8.5744	0.2077	-0.1871			0.5945
		V	-0.2692	0.1731	-0.0984	0.2436			1.3915
		EC	-0.6576	-0.0277	-1.1067	-0.9868			-2.7566
			<0.0001	0.0027	<0.0001	<0.0001			<0.0001
Import	*CV*	*gdp*	0.7104	1.3647	-2.1308		-9.2579	8.0156	
		rp	-0.1707	0.1742	0.0936		1.7893	2.9718	
		V	0.1404	-0.0118	0.0307		0.1784	2.2443	
		EC	-1.227	-0.8111	-1.0425		-0.7821	-0.4048	
			<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	
	MSD	*gdp*	0.9966	1.3588	-3.9187		-10.1835		1.01
		rp	-0.2075	0.1684	0.4122		2.2798		-0.6017
		V	0.0813	-0.0363	0.2982		0.3024		-0.6147
		EC	-0.8181	-0.4168	-1.1014		-0.9375		-1.2153
			<0.0001	<0.0001	<0.0001		<0.0001		<0.0001

Note: Compiled by author.

8.4 Concluding Remarks

In this chapter, the impact of exchange rate volatility on Australian trade at the bilateral level was investigated using the ARDL bounds test approach with quarterly data. Since Germany changed its money during the study period, that data could not be analysed. Analysis was only done for the trade between Australia and its other seven major trade partners, China, Japan, New Zealand, South Korea, Singapore, UK and US. Two exchange rate volatility measures were used: the conditional variance (*CV*) from GARCH model and the moving standard deviation (*MSD*). Among the twenty-eight trade (both export and import) equations, cointegration was found among the variables involved in twenty trade equations. Long-run coefficients of the three trade determinants for each equation were estimated, and restricted error correction models (ECM) derived from these long-run coefficients were also estimated. Error correction terms are highly statistically significant and large in magnitude, reflecting the existence of cointegration and quick adjustment to equilibrium from disequilibrium after a shock. For most equations, exchange rate volatility is not significant, and there is no consistent pattern for its impact on trade. It has a positive impact on some trade variables and a negative impact on the others. However, *gdp* has a positive impact on trade in most cases, which is consistent with expectations.

Chapter 9
Concluding Remarks

9.1 Introduction

This study has moved through the definitional issues and empirical estimations of the impact of exchange rate volatility on Australia's trade performance. The current chapter seeks to provide a combination of general summary, policy implications, limitations of the study and avenues for future research.

The chapter has five sections. The introduction is followed by a general summary of the study, incorporating both the theoretical and empirical concerns of the study. Section three presents the major findings of the study, such as how the present study has contributed to the literature, and how the results from the ARDL bounds testing model gives evidence in favour of how exchange rate volatility can have either a positive or negative impact on trade flows no matter what trade data level is being used. Section four provides the policy implications of the study. The limitations of the study and the avenues for further research are identified in section five. A brief concluding remark in section six ends the chapter.

9.2 General Summary of the Thesis

This study itself has nine chapters. The first chapter gives an overview of the background, objectives and organisation of the study. A number of differences exist between the current study and earlier ones in terms of the impact of exchange rate volatility on Australia's trade flows. Most importantly, the country coverage in this study, which includes Australia's seven major trading partners, is considerably broader compared to McKenzie (1999) which includes the US as a major trading partner. During the past decade, measures used to generate exchange rate volatility and research methodology have developed, and this study reviews techniques used in the empirical studies. The core objective of this study is to investigate the relationship between exchange rate volatility and Australia's trade performance by estimating export and import models at three trade data levels, aggregate trade data, sectoral trade data and bilateral trade data, with different exchange rate volatility measures.

Chapter 2 attempts to present Australia's evolution of exchange rate system from a fixed to a floating stage and then up to the present, including a description of some relevant institutional developments, such as the removal of capital controls, the development of Australia's foreign exchange market, and Australia's changing trade direction both geographically and content-wise over the past two decades. In summarising Australian exchange rate policy, it is obvious that the rationale behind the policy changes on exchange rate regime and the abandonment of capital restrictions was the changing economic and monetary conditions both worldwide and domestically. This chapter documents the historical background of each regime and how each exchange rate regime worked in a specific stage. While discussing the major movements in the Australian dollar's exchange rate, attention has been paid to some particular influences, such as Australia's terms of trade, foreign indebtedness, domestic resources boom and interest differentials at both the short and long end (Blundell-Wignall, Fahrer & Heath, 1993). The statistical analysis of Australia's merchandise trade shows that Australia's trade pattern is experiencing a geographical change.

Chapter 3 provides different theories on the impact of exchange rate volatility on the trade of a country. In summarising the trade theory about the impact of exchange rate changes on trade, it is important to remember that every theory has some important assumptions. Besides overviewing foreign trade patterns in terms of standard trade theory, the Marshall-Lerner condition, the J-curve phenomenon and the exchange rate pass-through effect, this chapter also classifies some related empirical studies. The relationship between the exchange rate changes and the import and export level are explained. However, the exchange rate is a two-edged sword (Miller & Leptos, 1987, p. 69). While the relatively low home currency exchange rate may stimulate exports, it also makes off-shore activities more expensive with payment in the home currency.

Chapter 4 provides an overview of the empirical studies about the exchange rate volatility's impact on trade performance and describes in detail the measures used to generate exchange rate volatility, estimation techniques and estimation results. Some trends are observed in this specific field. First, there are some new volatility measures and more volatility measures being used. Among the measures reviewed, moving standard deviation and conditional variance from ARCH/GARCH model are the two most commonly used measures, each being used in more than fifty studies reviewed. Secondly, there are some new test and estimation methods being introduced. Many studies adopt the newer techniques based on panel data, including panel unit root tests and cointegration estimations, fixed effects and random effects estimations, and the bounds testing approach by Peseran et al. (2001). In addition, there are more studies using disaggregated data. The number of studies at each of the three data levels (from aggregate, bilateral to sectoral) is 17, 16 and 3 in McKenzie's (1999) review, 34, 25 and 16 in Bahmani-Oskooee & Hegerty's (2007) review, and 21, 30 and 23 in this review. It is obvious that both the proportion of studies using disaggregated data (i.e. at both bilateral and sectoral level) and that at the sectoral level have increased steadily during the last three decades. Though a large number of studies are reviewed in this chapter, it is still difficult to give a general definitive conclusion on whether there is any effect of exchange rate volatility on international trade because the results are inconsistent among the studies.

Chapter 5 employs standard export and import demand equations, including exports and imports as dependent variables, and Australian domestic income, foreign income, a relative price term and a measure of exchange rate volatility so that the impact of exchange rate volatility on the trade flows can be estimated. The main objective of this chapter is to establish models for the three trade data levels in Australia, aggregate trade data, sectoral trade data and bilateral trade data, to test the impact of exchange rate volatility on Australia's trade performance. The models for both import and export aspects of Australia's trade are presented in this chapter, as well as the estimation techniques used for the three data levels. The error correction model and the ARDL bounds testing approach are applied to test the cointegration among variables at different trade data levels. Four measures of exchange rate volatility are used at both aggregate and sectoral trade data levels and two are used at the bilateral trade data level. Derivations of variables, and sources and preparation of the three data levels are documented in detail.

Chapter 6 examines whether exchange rate volatility affects Australia's trade flow and presents the empirical results at the aggregate trade data level. The bounds testing approach indicates that cointegration exists among the set of four variables: *export*, *gdpw*, *rp* and *CV_N*, and another set of four variables: *export*, *gdpw*, *rp* and *CV_R*. The results show that both nominal and real exchange rate volatility (*CV_N* and *CV_R*) generated from the GARCH method have a significant positive long-run effect on exports, and foreign income also has a significant positive effect on exports, which is consistent with economic theory; however, relative price has no significant effect on exports.

Chapter 6 also investigates the short-run effect of the volatility and other variables on exports and imports. While GARCH-derived exchange rate volatility has no significant short-run effect on exports, MSD-derived exchange rate volatility has a marginally significant negative effect on exports; and while foreign income has a significant negative short-run effect on exports, relative price has a marginally significant positive effect on exports. The results also show that all four volatility measures have no significant short-run effect on imports, and both Australia's income and the relative price have significant positive short-run effects on imports, which is consistent with the expected signs.

Chapter 7 examines whether exchange rate volatility affects Australia's trade flow and reports the empirical results at the sectoral trade data level. Thirteen variables are conducted with six unit root test methods, all the variables can be reasonably considered as integrated at the order of no more than 1 so that the bounds testing approach is applied to test the cointegration among the variables involved in each of the sectoral export and import equations. The results indicate that cointegration exists among the four variables involved in the sectoral export and import equations, except one import sector, Intermediate Goods. Empirical results show that exchange rate volatility has a positive and mostly significant effect on sectoral exports, and it has a mostly negative and insignificant effect on sectoral imports; foreign income (*gdpw*) and Australia's domestic income (*gdpau*) often have significant and positive effects on Australia's sectoral exports and imports.

Chapter 8 investigates the impact of exchange rate volatility on Australia's trade at the bilateral trade data level using the ARDL bounds testing approach with quarterly data. Analysis has been done between Australia and its seven major trading partners, China, Japan, New Zealand, South Korea, Singapore, UK and US. Two measures of exchange rate volatility are employed, including the conditional variance from GARCH model (*CV*) and the moving standard deviation model (*MSD*). Among the twenty-eight export and import equations, cointegration is found among the variables involved in twenty export and import equations. Long-run coefficients of the three trade determinants for each equation are estimated, and restricted error correction models (RECM) derived from these long-run coefficients are also estimated. Error correction terms are highly statistically significant and large in magnitude, reflecting the existence of cointegration and quick adjustment to the equilibrium from disequilibrium after a shock. For most equations, exchange rate volatility is not significant, and there is no consistent pattern for its impact on trade. It has a positive impact on some trade variables and a negative impact on others. However, GDP has a positive impact on trade in most cases, which is consistent with the model expectations. The study ends with concluding remarks in this chapter.

9.3 Major Findings of the Thesis

The main findings are summarised based on empirical research that has been done to investigate the relationship between exchange rate volatility and trade.

Some trends are found through the literature review. First, some new exchange rate volatility measures have been introduced, and it is common to use more than one measure in the same study to check the robustness of the results to the measures used. Secondly, some new cointegration test and estimation methods have been introduced, for example, the techniques based on panel data, including panel unit root tests and cointegration estimations, and fixed effects and random effects estimations, in order to take advantage of using panel data to account for the unobservable cross-sectional effects. Thirdly, Peseran et al.'s (2001) bounds testing approach for cointegration has attracted more and more attention from empirical analysts because both stationary and unstationary variables can be incorporated in the analysis, which is advantageous over its competitors.

Some findings come out of this empirical study. First of all, in some situations the exchange rate volatility measures are I(0), for example at aggregated trade data level, and the GDP variable is generally I(1),which is consistent with previous studies. This also verifies that it is necessary to use Peseran et al.'s (2001) bounds test approach for cointegration. Secondly, among the sixty trade equations analysed in this study, forty-six equations have cointegration. This means that there exist long-run relationships between trade flows and their determinants in most cases. Thirdly, exchange rate volatility has some impact on Australia's trade flows. It has statistically significant impact on trade flows in twenty-one equations, which is less than half of the forty-six equations that have cointegrations.

Fourthly, the impact of exchange rate volatility on trade differs between different trade data levels. The percentages of the number of equations in which volatility has a statistically significant impact on trade flows among all the estimated equations for aggregate level and bilateral level are a quarter (2/8) and nearly a half (13/28) respectively, and it is less than a third (9/24) for sectoral level.

Fifthly, exchange rate volatility can have either a positive or negative impact on trade flows. For aggregate, sectoral and bilateral levels, volatility has a statistically significant positive impact on trade flows in 2, 1 and 9 equations respectively, and it has a statistically significant negative impact on trade flows in 0, 8 and 4 equations respectively. This indicates that exchange rate volatility has a statistically significant negative impact on trade flows in more cases at sectoral trade data level, and it has a statistically significant positive impact on trade flows in more cases at aggregated and bilateral trade data levels.

Sixthly, for all the equations analysed there are more export equations than import equations (15 vs 9) in which exchange rate volatility has a statistically significant impact on trade flows. This indicates that Australia's exports are more sensitive than imports to exchange rate volatility.

Seventhly, generally there is little overall difference between the results produced with GARCH-type volatility measures and those with MSD-type volatility measures. Specifically, the same amount of equations has cointegrations for all the equations analysed using either GARCH-type volatility measures or MSD-type volatility measures. As to the number of equations in which volatility has a statistically significant impact on trade flows, these numbers (using GARCH-type measures vs MSD-type measures) are 2 vs 0, 5 vs 4, and 5 vs 8 for aggregate, sectoral and bilateral levels respectively.

Eighthly, there is little difference between the results produced with the volatility measures derived from real exchange rates and from nominal exchange rates. Specifically, they produce the same, or almost the same, number of equations that have cointegrations and a statistically significant volatility impact on trade flows at aggregated level (1 vs 1 and 1 vs 1) and sectoral level (6 vs 6 and 5 vs 4).

Moreover, *gdp* generally has a positive impact on trade flows at all three trade data levels. The numbers of equations in which *gdp* has a statistically significant (positive vs negative) impact on trade flows are 4 vs 0, 12 vs 4, and 15 vs 5 at aggregate, sectoral and bilateral levels respectively.

In addition, relative price can have positive, negative or even no impact on trade flows. The numbers of equations in which relative price has a statistically significant (positive vs negative) impact on trade flows are 0 vs 0, 10 vs 4, and 10 vs 10 at aggregate, sectoral and bilateral levels respectively.

9.4 Policy Implications

This study so far has statistically analysed Australia's changing trade direction during the past decades in Chapter 2, and has empirically estimated the effect of exchange rate volatility on Australia's trade flows at three different trade data levels in Chapters 6, 7 and 8. Policy implications stemming from this research and empirical results are the following.

First, given the close relationship between the Australian dollar and Australia's terms of trade (Gruen & Wilkinson, 1994; Chen & Rogoff, 2002), the structure of Australia's economy and Australia are susceptible to highly volatile terms of trade, and there would be an automatic exchange rate depreciation occurring with a floating rate reducing those shrinking effects to some extent. Therefore, exchange rate fluctuations contribute greatly to smoothing the impact of the shocks on the terms of trade. Terms of trade (TOT) (in some equations relative price is a proxy of TOT) as a variable in these empirical models plays an important role in explaining the empirical results. The empirical results show that relative price has a significant and positive effect on the Resources export sector and the Capital and Consumption import sectors, whereas it has a significant negative effect on the Manufactures export sector. Policymakers should keep in mind that depreciation of Australia's dollar could avoid the inflationary pressures resulting from the rising of the terms of trade and enhance Australia's international competitiveness.

Secondly, after the floating of the exchange rate, debt-based capital inflows, with the percentage of the GDP increasing from 6 in 1980 to 52 in 2007, have gradually become the dominant form instead of the equity instrument in the previous exchange rate regime. Corresponding to the composition change in capital flows, policymakers should consider that Australia's domestic income and terms of trade have significant positive impacts on the import sectors of Capital and Consumption, which would help to make proper monetary policy. The empirical results also suggest that *gdp* always has a positive impact on Australia's trade flows at all three trade data levels; therefore, if either foreign income or domestic income increases, Australia's trade performance will be improved.

Since Australia is rich in the Resources sector, for example, Mineral fuels, mineral oils and products of their distillation, Ores, slag and ash, Natural or cultural pearls, precious or semi-precious stones, etc., and exchange rate volatility has a significant and positive effect on Resources exports, policymakers should pay more attention to trade policy and exchange rate policy to build this sector's exports. Combining the research results from Chapter 2, Australia's trade direction after 1980 has changed considerably, with China and ASEAN countries becoming increasingly important as export destinations for Australia's products. China as a world powerhouse is gaining more share for its products in Australia's market; therefore, a policy suggestion is that the Free Trade Agreement (FTA) between Australia and China may be expected to be achieved in the near future.

In application, the empirical results can be used to improve Australia's export and import activities further, if the following are utilised: macroeconomic policies which target the maintenance of a stable competitive real exchange rate, and reasonable policies that avoid overvaluation of the real exchange rate in order to decrease exchange rate volatility. In other words, policymakers should establish coherent policies that lead to a transparent exchange rate system, under which the stability of the real exchange rate will be achieved and maintained to boost Australia's overall trade and economic growth strategy.

In general, this study is important to policymakers for the design of both exchange rate and trade policies to enhance Australia's export sectors of Resources and Manufactures, and import sectors of Capital and Consumption growth, that can lead Australia's trade performance to a higher competitive level.

9.5 Limitations of the Thesis and Avenues for Further Research

There are a few limitations of this study due to the model restriction itself and other factors. First, while Pesaran et al.'s (2001) bounds testing approach for cointegration can deal with both I(1) and I(0) regressors, which is advantageous over its competitors, it cannot deal with more than one cointegration within a set of variables. These can be dealt with using Johnson's cointegration method. In future, it may be useful to select some cases where all variables are I(1) to compare the results from Johansen's cointegration method and those from this study, so that these can be more confidence in the reliability of these conclusions.

Secondly, since trade flows are expressed as linear functions of their determinants after logarithmic transformation, it is hard for the models to capture non-linear relationships as encountered by Pesaran et al. (2001). However, we only follow the general practice for the model formulation in this study. In future, we may adopt other approaches, for example the Poisson lag structure, to specifically formulate non-linear relationships for the variables to see whether the conclusion still maintains.

Another limitation is that because of the currency change for Germany, its trade with Australia is not analysed in this study, which is very unfortunate since it is one of Australia's major trading partners. In future, once any method can cope with such data, we would like to analyse it again.

As to the data used in this study, while it is difficult to collect monthly data, yearly data is easy to obtain. As time passes, there will be more yearly data. In future, similar analyses can be done with yearly data, to compare its results with those from this study. However, since the size of the yearly data will still be relatively small, the critical values for the bounds test from Pesaran et al. (2001) can no longer be used, and instead those from Narayan (2005) should be used.

9.6 Concluding Remarks

This study explores a range of different exchange rate volatility measures. Moreover, aside from examining aggregate trade data, the study divides Australia's exports into three main groups and Australia's imports into three groups, and tests whether exchange rate volatility has a different effect on them. First, the empirical specification employed in this study can overcome the drawbacks in the early studies which analyse the effect at the aggregate trade data level. Second, this study verifies the long-run relationship between exchange rate volatility and trade, thus avoiding problems of spurious regression. All in all, as presented in this study, there are significant findings from this study contributing to the current empirical literatures.

Appendices

Appendix (Tables for Chapter 8) Estimated ECM-ARDL with diagnostic tests for the analysis at bilateral level

Table A8.1: Estimated ECM-ARDL for export to China with *CV* as volatility measure.

Regressor	Coefficient	P-value
D_*exp_cn*(-1)	0.3205	0.0080
D_*exp_cn*(-2)	0.2039	0.0567
D_*exp_cn*(-5)	-0.2131	0.1005
D_*exp_cn*(-8)	0.3320	0.0074
D_*exp_cn*(-9)	0.1928	0.1136
D_*exp_cn*(-10)	0.2421	0.0434
D_*exp_cn*(-11)	0.3835	0.0017
D_*gdp_cn*	15.9125	0.0000
D_*gdp_cn*(-1)	12.2203	0.0002
D_*gdp_cn*(-2)	11.8925	0.0003
D_*gdp_cn*(-3)	11.2223	0.0004
D_*gdp_cn*(-4)	-20.6451	0.0000
D_*gdp_cn*(-5)	-11.9329	0.0024
D_*gdp_cn*(-6)	-8.0351	0.0415
D_*gdp_cn*(-7)	-9.5758	0.0100
D_*gdp_cn*(-8)	17.8196	0.0000
D_*gdp_cn*(-9)	13.7397	0.0000
D_*gdp_cn*(-10)	9.0803	0.0060
D_*gdp_cn*(-11)	12.3850	0.0001
D_*rp_cn*	-2.2792	0.0001
D_*rp_cn*(-3)	1.0207	0.0476
D_*rp_cn*(-6)	1.2275	0.0101
D_*rp_cn*(-8)	1.1230	0.0193
D_*rp_cn*(-9)	-0.4777	0.1864
D_*rp_cn*(-10)	0.5446	0.1262
D_*rp_cn*(-11)	0.6451	0.0509
D_*CV_cn*	-0.9716	0.0838
D_*CV_cn*(-1)	1.1382	0.0991
D_*CV_cn*(-2)	-0.9344	0.1381
D_*CV_cn*(-3)	1.7929	0.0144
D_*CV_cn*(-4)	-1.3090	0.1118
D_*CV_cn*(-5)	1.1255	0.1592
D_*CV_cn*(-8)	1.1907	0.1025
D_*CV_cn*(-9)	-0.8964	0.1264
D_*CV_cn*(-10)	1.3803	0.0034
D_*CV_cn*(-11)	-0.6314	0.0786
exp_cn(-1)	-0.8278	0.0000
gdp_cn(-1)	1.2268	0.0000
rp_cn(-1)	-1.1061	0.0000
CV_cn(-1)	-0.0280	0.5261
R^2	0.9081	
R^2_{adj}	0.7757	
F-statistic	5.0739	0.0000
$\chi^2_N(2)$	0.2736	0.8721
$\chi^2_{SC}(2)$	0.7642	0.6824
$\chi^2_H(1)$	0.1336	0.7147
$\chi^2_{FF}(2)$	3.1922	0.0740

Note: F-stat is the F-statistic to test the statistical significance of the regression model. The meanings of the other diagnostic statistics are the same as those in Table 6.2.

Table A8.2: Estimated ECM-ARDL for export to China with *MSD* as volatility measure.

Regressor	Coefficient	P-value
D_*exp_cn*(-1)	0.3426	0.0002
D_*exp_cn*(-7)	0.1822	0.0619
D_*exp_cn*(-8)	0.2737	0.0028
D_*exp_cn*(-9)	0.1346	0.1257
D_*exp_cn*(-10)	0.2157	0.0167
D_*exp_cn*(-11)	0.2343	0.0040
D_*gdp_cn*	12.5042	0.0000
D_*gdp_cn*(-1)	5.5979	0.0032
D_*gdp_cn*(-2)	11.8214	0.0000
D_*gdp_cn*(-3)	6.1632	0.0163
D_*gdp_cn*(-4)	-20.5125	0.0000
D_*gdp_cn*(-5)	-5.0708	0.0547
D_*gdp_cn*(-6)	-11.6754	0.0000
D_*gdp_cn*(-7)	-5.7661	0.0586
D_*gdp_cn*(-8)	16.8185	0.0000
D_*gdp_cn*(-9)	10.5373	0.0000
D_*gdp_cn*(-10)	8.2517	0.0009
D_*gdp_cn*(-11)	9.8598	0.0000
D_*rp_cn*	-1.4347	0.0000
D_*rp_cn*(-3)	0.8505	0.0049
D_*rp_cn*(-4)	0.8007	0.0084
D_*rp_cn*(-6)	0.3674	0.1385
D_*rp_cn*(-7)	0.9735	0.0004
D_*rp_cn*(-8)	0.3962	0.1056
D_*rp_cn*(-9)	-0.2695	0.2227
D_*rp_cn*(-11)	0.4304	0.0478
D_*MSD_cn*(-1)	0.1354	0.0143
D_*MSD_cn*(-2)	0.2750	0.0001
D_*MSD_cn*(-3)	0.0977	0.0768
D_*MSD_cn*(-4)	0.2761	0.0000
D_*MSD_cn*(-6)	0.1392	0.0067
exp_cn(-1)	-0.6575	0.0000
gdp_cn(-1)	0.9405	0.0000
rp_cn(-1)	-1.0366	0.0000
MSD_cn(-1)	-0.1770	0.0021
R^2	0.8645	
R^2_{adj}	0.7704	
F-statistic	4.9672	0.0000
$\chi^2_N(2)$	0.3194	0.8524
$\chi^2_{SC}(2)$	1.1950	0.5502
$\chi^2_H(1)$	0.1805	0.6710
$\chi^2_{FF}(2)$	14.9399	0.0001

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.3: Estimated ECM-ARDL for import from China with *CV* as volatility measure.

Regressor	Coefficient	P-value
c	5.6694	0.0000
D_*imp_cn*(-1)	0.3328	0.0168
D_*imp_cn*(-2)	-0.0512	0.2294
D_*imp_cn*(-3)	-0.0670	0.1032
D_*imp_cn*(-4)	0.1038	0.0201
D_*imp_cn*(-5)	0.0523	0.2670
D_*imp_cn*(-6)	0.0712	0.1721
D_*imp_cn*(-7)	-0.0647	0.1970
D_*imp_cn*(-9)	-0.1508	0.0014
D_*imp_cn*(-10)	-0.0697	0.1520
D_*imp_cn*(-11)	-0.0295	0.5776
D_*imp_cn*(-12)	-0.0857	0.0760
D_*rp_cn*(-1)	-0.2650	0.0552
D_*rp_cn*(-2)	0.0545	0.6605
D_*rp_cn*(-3)	-0.1410	0.3641
D_*rp_cn*(-4)	0.1298	0.3098
D_*rp_cn*(-5)	-0.1475	0.4482
D_*rp_cn*(-6)	0.5331	0.0056
D_*rp_cn*(-8)	0.0948	0.6133
D_*rp_cn*(-9)	-0.3012	0.0724
D_*rp_cn*(-10)	-0.1241	0.4216
D_*rp_cn*(-11)	-0.2195	0.1312
D_*rp_cn*(-12)	-0.1496	0.3180
D_*CV_cn*	0.0891	0.4240
D_*CV_cn*(-1)	-0.6030	0.0016
D_*CV_cn*(-3)	-0.7648	0.0007
D_*CV_cn*(-5)	-0.5738	0.0208
D_*CV_cn*(-6)	0.5032	0.0640
D_*CV_cn*(-7)	-0.5439	0.0224
D_*CV_cn*(-8)	0.4708	0.0690
D_*CV_cn*(-9)	-0.5287	0.0351
D_*CV_cn*(-10)	0.2594	0.2555
D_*CV_cn*(-11)	-0.3718	0.0684
D_*CV_cn*(-12)	0.2930	0.0328
imp_cn(-1)	-1.2269	0.0000
gdp_au(-1)	0.8716	0.0000
rp_cn(-1)	-0.2094	0.0112
CV_cn(-1)	0.1723	0.0054
R^2	0.8353	
R^2_{adj}	0.6579	
F-statistic	4.7085	0.0000
$\chi^2_N(2)$	2.4761	0.2899
$\chi^2_{SC}(2)$	3.5482	0.1696
$\chi^2_H(1)$	3.1650	0.0752
$\chi^2_{FF}(2)$	1.8981	0.1683

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.4: Estimated ECM-ARDL for import from China with *MSD* as volatility measure.

Regressor	Coefficient	P-value
c	2.5789	0.0000
D_*imp_cn*(-1)	-0.0508	0.2334
D_*imp_cn*(-2)	-0.0819	0.0764
D_*imp_cn*(-3)	-0.1863	0.0004
D_*imp_cn*(-4)	-0.0419	0.4306
D_*imp_cn*(-6)	0.0828	0.0847
D_*imp_cn*(-7)	-0.0534	0.2893
D_*imp_cn*(-9)	-0.1591	0.0029
D_*imp_cn*(-10)	-0.1446	0.0109
D_*imp_cn*(-11)	0.0399	0.4645
D_*imp_cn*(-12)	-0.0282	0.6168
D_*gdp_au*	-0.7061	0.6451
D_*gdp_au*(-1)	4.9073	0.0043
D_*gdp_au*(-3)	-1.3531	0.3369
D_*gdp_au*(-4)	3.7455	0.0182
D_*gdp_au*(-5)	3.9632	0.0214
D_*gdp_au*(-6)	-1.7928	0.1926
D_*gdp_au*(-7)	-3.0258	0.0209
D_*gdp_au*(-8)	0.7559	0.6217
D_*gdp_au*(-9)	-1.7291	0.2133
D_*gdp_au*(-10)	-2.1882	0.1215
D_*gdp_au*(-11)	-1.3635	0.3048
D_*rp_cn*	-0.5935	0.0000
D_*rp_cn*(-1)	-0.1441	0.2019
D_*rp_cn*(-2)	0.5596	0.0000
D_*rp_cn*(-3)	0.3519	0.0047
D_*rp_cn*(-6)	0.3793	0.0024
D_*rp_cn*(-7)	0.0666	0.5549
D_*rp_cn*(-9)	-0.1564	0.1332
D_*rp_cn*(-11)	-0.0856	0.3900
D_*rp_cn*(-12)	-0.1218	0.2202
imp_cn(-1)	-0.8181	0.0000
gdp_au(-1)	0.8153	0.0000
rp_cn(-1)	-0.1698	0.0129
MSD_cn(-1)	0.0665	0.0007
R^2	0.9450	
R^2_{adj}	0.8997	
F-statistic	20.8891	0.0000
$\chi^2_N(2)$	0.0735	0.9639
$\chi^2_{SC}(2)$	2.1063	0.3488
$\chi^2_H(1)$	0.3425	0.5584
$\chi^2_{FF}(2)$	3.7644	0.0524

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.5: Estimated ECM-ARDL for export to Japan with *CV* as volatility measure.

Regressor	Coefficient	P-value
D_*exp_jp*(-2)	-0.2240	0.0124
D_*exp_jp*(-3)	-0.2358	0.0047
D_*exp_jp*(-4)	-0.1590	0.0785
D_*exp_jp*(-5)	-0.2633	0.0080
D_*exp_jp*(-6)	-0.3354	0.0010
D_*exp_jp*(-7)	-0.2104	0.0660
D_*exp_jp*(-9)	-0.2290	0.0419
D_*exp_jp*(-10)	-0.1987	0.0757
D_*exp_jp*(-11)	-0.1887	0.0399
D_*gdp_jp*(-5)	2.6227	0.0434
D_*gdp_jp*(-6)	4.7991	0.0006
D_*gdp_jp*(-7)	5.4818	0.0000
D_*gdp_jp*(-8)	4.6598	0.0012
D_*gdp_jp*(-9)	4.0119	0.0032
D_*gdp_jp*(-10)	3.9346	0.0046
D_*gdp_jp*(-12)	1.9129	0.0673
D_*rp_jp*	-0.2975	0.0162
D_*rp_jp*(-2)	-0.3852	0.0112
D_*rp_jp*(-3)	-0.3792	0.0048
D_*rp_jp*(-5)	-0.4622	0.0044
D_*rp_jp*(-7)	-0.5247	0.0003
D_*rp_jp*(-9)	-0.4211	0.0050
D_*rp_jp*(-10)	-0.2351	0.0687
D_*rp_jp*(-11)	-0.3359	0.0253
D_*CV_jp*	0.0982	0.1181
D_*CV_jp*(-1)	0.2989	0.0011
D_*CV_jp*(-2)	0.3998	0.0001
D_*CV_jp*(-3)	0.3534	0.0002
D_*CV_jp*(-4)	0.7319	0.0000
D_*CV_jp*(-6)	0.5683	0.0001
D_*CV_jp*(-7)	0.3381	0.0006
D_*CV_jp*(-8)	0.5575	0.0000
D_*CV_jp*(-9)	0.2594	0.0035
D_*CV_jp*(-10)	0.3865	0.0005
D_*CV_jp*(-11)	0.1564	0.0949
exp_jp(-1)	-0.8029	0.0000
gdp_jp(-1)	1.7939	0.0000
rp_jp(-1)	-0.3819	0.0000
CV_jp(-1)	-0.2875	0.0000
R^2	0.9525	
R^2_{adj}	0.8591	
F-statistic	16.2341	0.0000
$\chi^2_N(2)$	1.9898	0.3698
$\chi^2_{SC}(2)$	5.7415	0.0567
$\chi^2_H(1)$	2.9962	0.0835
$\chi^2_{FF}(2)$	3.3962	0.0653

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.6: Estimated ECM-ARDL for export to Japan with *MSD* as volatility measure.

Regressor	Coefficient	P-value
C	-8.8696	0.0058
Trend	-0.0055	0.0398
D_*exp_jp*(-1)	-0.5210	0.0036
D_*exp_jp*(-2)	-0.4527	0.0021
D_*exp_jp*(-3)	-0.4504	0.0018
D_*exp_jp*(-4)	-0.2202	0.1166
D_*exp_jp*(-5)	-0.3803	0.0031
D_*exp_jp*(-6)	-0.3567	0.0030
D_*exp_jp*(-7)	-0.2332	0.0409
D_*exp_jp*(-8)	-0.2408	0.0367
D_*exp_jp*(-9)	-0.3001	0.0075
D_*exp_jp*(-10)	-0.2523	0.0131
D_*exp_jp*(-11)	-0.2585	0.0125
D_*exp_jp*(-12)	-0.1008	0.2843
D_*gdp_jp*	0.4058	0.7192
D_*gdp_jp*(-1)	-0.7685	0.5394
D_*gdp_jp*(-2)	-0.7902	0.5126
D_*rp_jp*	-0.4033	0.0006
D_*rp_jp*(-1)	-0.1820	0.1193
D_*rp_jp*(-2)	-0.0424	0.6752
D_*rp_jp*(-3)	-0.0701	0.5027
D_*MSD_jp*	0.0228	0.4525
D_*MSD_jp*(-1)	-0.0114	0.7292
exp_jp(-1)	-0.0277	0.7520
gdp_jp(-1)	2.2918	0.0040
rp_jp(-1)	-0.2372	0.0182
MSD_jp(-1)	0.0048	0.8801
R^2	0.7096	
R^2_{adj}	0.5220	
F-statistic	3.7833	0.0000
$\chi^2_N(2)$	0.7874	0.6746
$\chi^2_{SC}(2)$	2.0767	0.3540
$\chi^2_H(1)$	0.0783	0.7796
$\chi^2_{FF}(2)$	6.5175	0.0107

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.7: Estimated ECM-ARDL for import from Japan with *CV* as volatility measure.

Regressor	Coefficient	P-value
D_*imp_jp*(-1)	0.1711	0.0223
D_*imp_jp*(-2)	0.1702	0.0309
D_*imp_jp*(-3)	0.1041	0.1173
D_*imp_jp*(-4)	0.1380	0.0396
D_*imp_jp*(-7)	0.1134	0.0870
D_*imp_jp*(-9)	0.1073	0.0718
D_*imp_jp*(-10)	0.1301	0.0587
D_*imp_jp*(-12)	0.2537	0.0003
D_*gdp_au*(-4)	2.0686	0.1328
D_*gdp_au*(-9)	-2.1117	0.1083
D_*rp_jp*	-0.3054	0.0028
D_*rp_jp*(-1)	-0.3836	0.0011
D_*rp_jp*(-4)	-0.2372	0.0426
D_*rp_jp*(-10)	-0.1640	0.1045
D_*CV_jp*(-4)	-0.1944	0.0171
D_*CV_jp*(-5)	-0.1846	0.0452
D_*CV_jp*(-6)	-0.1918	0.0314
D_*CV_jp*(-7)	-0.1514	0.0491
D_*CV_jp*(-8)	-0.2104	0.0090
D_*CV_jp*(-9)	-0.1642	0.0212
D_*CV_jp*(-10)	-0.1579	0.0298
imp_jp(-1)	-0.8112	0.0000
gdp_au(-1)	1.1070	0.0000
rp_jp(-1)	0.1413	0.0001
CV_jp(-1)	-0.0096	0.7514
R^2	0.7697	
R^2_{adj}	0.5558	
F-statistic	4.6732	0.0000
$\chi^2_N(2)$	0.1983	0.9056
$\chi^2_{SC}(2)$	5.5390	0.0627
$\chi^2_H(1)$	3.7036	0.0543
$\chi^2_{FF}(2)$	2.3864	0.1224

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.8: Estimated ECM-ARDL for import from Japan with *MSD* as volatility measure.

Regressor	Coefficient	P-value
D_*imp_jp*(-12)	0.2179	0.0000
D_*imp_jp*(-13)	0.0653	0.1626
D_*imp_jp*(-16)	0.1362	0.0043
D_*gdp_au*(-9)	-1.8739	0.0593
D_*rp_jp*	-0.2870	0.0006
D_*rp_jp*(-1)	-0.2350	0.0071
D_*rp_jp*(-3)	-0.0565	0.4715
D_*rp_jp*(-4)	-0.1869	0.0178
D_*rp_jp*(-6)	-0.1286	0.1058
D_*rp_jp*(-8)	-0.1053	0.1431
imp_jp(-1)	-0.4169	0.0000
gdp_au(-1)	0.5664	0.0000
rp_jp(-1)	0.0702	0.0000
MSD_jp(-1)	-0.0151	0.4232
R^2	0.6232	
R^2_{adj}	0.5512	
F-statistic	4.6521	0.0000
$\chi^2_N(2)$	0.7943	0.6722
$\chi^2_{SC}(2)$	2.6108	0.2711
$\chi^2_H(1)$	0.3921	0.5312
$\chi^2_{FF}(2)$	2.5305	0.1117

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.9: Estimated ECM-ARDL for export to to New Zealand with *CV* as volatility measure.

Regressor	Coefficient	P-value
c	-1.8423	0.0011
D_*exp_nz*(-2)	-0.1305	0.2473
D_*exp_nz*(-4)	0.3313	0.0083
D_*exp_nz*(-5)	0.1951	0.1660
D_*exp_nz*(-6)	-0.0995	0.4356
D_*exp_nz*(-7)	0.1846	0.1814
D_*exp_nz*(-8)	0.4335	0.0007
D_*exp_nz*(-10)	0.3024	0.0188
D_*gdp_nz*	2.2493	0.0359
D_*gdp_nz*(-1)	-2.3038	0.0316
D_*gdp_nz*(-3)	-2.0235	0.0289
D_*gdp_nz*(-4)	-1.7699	0.0641
D_*gdp_nz*(-6)	-1.1255	0.2183
D_*gdp_nz*(-7)	-3.2654	0.0035
D_*gdp_nz*(-8)	1.3003	0.2192
D_*gdp_nz*(-9)	-0.8587	0.3921
D_*gdp_nz*(-10)	2.3178	0.0142
D_*rp_nz*	-0.1323	0.6076
D_*rp_nz*(-2)	-0.3794	0.1500
D_*rp_nz*(-4)	-0.3422	0.1912
D_*rp_nz*(-5)	-0.4600	0.0394
D_*rp_nz*(-7)	-0.3990	0.0619
D_*rp_nz*(-8)	-0.6752	0.0043
D_*CV_nz*	-0.5547	0.0251
D_*CV_nz*(-2)	0.3016	0.2243
D_*CV_nz*(-3)	-0.4623	0.0268
D_*CV_nz*(-4)	0.1868	0.2665
D_*CV_nz*(-5)	-0.2084	0.2768
D_*CV_nz*(-6)	-0.2597	0.0971
D_*CV_nz*(-7)	0.1883	0.2442
D_*CV_nz*(-8)	0.3349	0.0355
D_*CV_nz*(-9)	-0.2886	0.0524
D_*CV_nz*(-10)	0.3799	0.0133
exp_nz(-1)	-0.2073	0.0022
gdp_nz(-1)	0.6647	0.0006
rp_nz(-1)	0.3924	0.0116
CV_nz(-1)	-0.0126	0.7998
R^2	0.8150	
R^2_{adj}	0.6845	
F-statistic	6.2425	0.0000
$\chi^2_N(2)$	0.0389	0.9807
$\chi^2_{SC}(2)$	3.4992	0.1738
$\chi^2_H(1)$	2.6048	0.1065
$\chi^2_{FF}(2)$	28.0878	0.0000

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.10: Estimated ECM-ARDL for export New Zealand with *MSD* as volatility measure.

Regressor	Coefficient	P-value
c	29.8999	0.0000
Trend	0.0679	0.0000
D_*exp_nz*(-1)	0.1069	0.2140
D_*exp_nz*(-2)	-0.2444	0.0022
D_*exp_nz*(-3)	-0.3402	0.0003
D_*exp_nz*(-4)	-0.1395	0.1063
D_*exp_nz*(-5)	-0.2743	0.0009
D_*exp_nz*(-6)	-0.1479	0.0726
D_*exp_nz*(-9)	-0.1880	0.0080
D_*exp_nz*(-12)	0.1477	0.0494
D_*gdp_nz*	-1.2481	0.1683
D_*gdp_nz*(-1)	5.4161	0.0000
D_*gdp_nz*(-2)	7.2933	0.0000
D_*gdp_nz*(-3)	7.8654	0.0000
D_*gdp_nz*(-4)	4.2974	0.0000
D_*gdp_nz*(-5)	4.4232	0.0000
D_*gdp_nz*(-6)	3.9928	0.0000
D_*gdp_nz*(-7)	4.4046	0.0000
D_*gdp_nz*(-8)	5.3757	0.0000
D_*gdp_nz*(-9)	4.3241	0.0000
D_*gdp_nz*(-10)	4.1469	0.0000
D_*gdp_nz*(-11)	3.3241	0.0000
D_*gdp_nz*(-12)	4.0523	0.0000
D_*rp_nz*(-3)	-0.2241	0.1418
D_*rp_nz*(-6)	0.2131	0.1199
D_*rp_nz*(-8)	-0.3641	0.0135
D_*rp_nz*(-10)	-0.2640	0.1131
D_*MSD_nz*(-1)	0.1046	0.0730
D_*MSD_nz*(-3)	0.1767	0.0031
D_*MSD_nz*(-4)	-0.0546	0.1235
D_*MSD_nz*(-5)	0.1251	0.0123
D_*MSD_nz*(-7)	0.1156	0.0055
D_*MSD_nz*(-8)	-0.0748	0.0388
D_*MSD_nz*(-11)	0.1334	0.0002
exp_nz(-1)	-1.1066	0.0000
gdp_nz(-1)	-6.1665	0.0000
rp_nz(-1)	0.2299	0.0075
MSD_nz(-1)	-0.1089	0.0091
R^2	0.9611	
R^2_{adj}	0.9138	
F-statistic	20.3159	0.0000
$\chi^2_N(2)$	5.7322	0.0569
$\chi^2_{SC}(2)$	4.0215	0.1339
$\chi^2_H(1)$	0.5406	0.4622
$\chi^2_{FF}(2)$	0.9027	0.3420

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.11: Estimated ECM-ARDL for import from New Zealand with *CV* as volatility measure.

Regressor	Coefficient	P-value
c	13.9946	0.0000
Trend	0.0356	0.0000
D_*imp_nz*(-1)	0.1695	0.0840
D_*imp_nz*(-2)	0.2318	0.0302
D_*imp_nz*(-3)	0.2769	0.0151
D_*imp_nz*(-4)	0.3202	0.0026
D_*imp_nz*(-5)	0.1856	0.1038
D_*imp_nz*(-8)	0.2849	0.0133
D_*imp_nz*(-9)	0.2825	0.0056
D_*imp_nz*(-10)	0.2761	0.0214
D_*imp_nz*(-11)	0.2406	0.0012
D_*imp_nz*(-12)	0.5479	0.0000
D_*gdp_au*(-2)	2.9487	0.0041
D_*gdp_au*(-3)	2.8235	0.0050
D_*gdp_au*(-4)	2.9579	0.0026
D_*gdp_au*(-5)	3.0322	0.0019
D_*gdp_au*(-6)	3.8979	0.0001
D_*gdp_au*(-7)	3.2968	0.0013
D_*gdp_au*(-9)	1.7783	0.0683
D_*rp_nz*	0.1990	0.0357
D_*rp_nz*(-3)	0.1336	0.2341
D_*rp_nz*(-4)	0.2277	0.0444
D_*rp_nz*(-5)	0.1642	0.1186
D_*rp_nz*(-6)	-0.1490	0.2186
D_*rp_nz*(-7)	0.1598	0.2150
D_*rp_nz*(-8)	0.2260	0.0684
D_*rp_nz*(-9)	0.1582	0.1236
D_*rp_nz*(-11)	0.1470	0.1617
D_*rp_nz*(-12)	0.2182	0.0586
D_*CV_nz*	-0.2732	0.0490
D_*CV_nz*(-1)	0.2100	0.0167
D_*CV_nz*(-2)	0.1339	0.2105
D_*CV_nz*(-3)	-0.2486	0.0393
D_*CV_nz*(-4)	-0.3313	0.0037
D_*CV_nz*(-5)	-0.2097	0.0758
D_*CV_nz*(-7)	-0.3385	0.0032
D_*CV_nz*(-8)	-0.2749	0.0252
D_*CV_nz*(-9)	-0.3693	0.0020
imp_nz(-1)	-1.0426	0.0000
gdp_au(-1)	-2.2215	0.0008
rp_nz(-1)	0.0975	0.2459
CV_nz(-1)	0.0321	0.4306
R^2	0.9598	
R^2_{adj}	0.9098	
F-statistic	19.1899	0.0000
$\chi^2_N(2)$	3.0522	0.2174
$\chi^2_{SC}(2)$	4.9598	0.0838
$\chi^2_H(1)$	0.0646	0.7993
$\chi^2_{FF}(2)$	0.1547	0.6941

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.12: Estimated ECM-ARDL for import from New Zealand with *MSD* as volatility measure.

Regressor	Coefficient	P-value
c	23.5724	0.0001
Trend	0.0559	0.0000
D_*imp_nz*(-1)	0.2542	0.2670
D_*imp_nz*(-2)	0.2146	0.2963
D_*imp_nz*(-4)	0.3150	0.1000
D_*imp_nz*(-11)	0.1645	0.2239
D_*imp_nz*(-12)	0.2436	0.0812
D_*gdp_au*(-1)	2.1790	0.1759
D_*gdp_au*(-2)	4.6114	0.0021
D_*gdp_au*(-3)	4.4591	0.0030
D_*gdp_au*(-4)	2.1978	0.0568
D_*gdp_au*(-5)	3.9746	0.0023
D_*gdp_au*(-6)	4.9735	0.0001
D_*gdp_au*(-7)	2.6620	0.0206
D_*gdp_au*(-9)	3.0937	0.0069
D_*gdp_au*(-10)	1.7658	0.1206
D_*rp_nz*	0.1588	0.2799
D_*rp_nz*(-1)	-0.3630	0.0100
D_*rp_nz*(-2)	-0.2369	0.0683
D_*rp_nz*(-3)	-0.3079	0.0286
D_*rp_nz*(-5)	-0.2055	0.1591
D_*rp_nz*(-6)	-0.1906	0.1520
D_*MSD_nz*(-1)	-0.2900	0.0025
D_*MSD_nz*(-2)	-0.2705	0.0024
D_*MSD_nz*(-3)	-0.2707	0.0032
D_*MSD_nz*(-4)	-0.3017	0.0007
D_*MSD_nz*(-5)	-0.2072	0.0122
D_*MSD_nz*(-6)	-0.2097	0.0080
D_*MSD_nz*(-7)	-0.1577	0.0264
D_*MSD_nz*(-8)	-0.1693	0.0248
D_*MSD_nz*(-10)	-0.1091	0.0677
D_*MSD_nz*(-11)	0.0325	0.3517
D_*MSD_nz*(-12)	-0.0598	0.1221
imp_nz(-1)	-1.1014	0.0000
gdp_au(-1)	-4.3161	0.0063
rp_nz(-1)	0.4540	0.0002
MSD_nz(-1)	0.3284	0.0003
R^2	0.9511	
R^2_{adj}	0.8821	
F-statistic	13.7801	0.0000
$\chi^2_N(2)$	4.2779	0.1178
$\chi^2_{SC}(2)$	1.7335	0.4203
$\chi^2_H(1)$	0.0632	0.8015
$\chi^2_{FF}(2)$	0.4236	0.5152

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.13: Estimated ECM-ARDL for export to South Korea with *CV* as volatility measure.

Regressor	Coefficient	P-value
c	-5.3070	0.0000
Trend	-0.0231	0.0000
D_*exp_sk*(-2)	0.2340	0.0061
D_*exp_sk*(-3)	0.3817	0.0000
D_*exp_sk*(-4)	0.2316	0.0092
D_*exp_sk*(-5)	0.2803	0.0006
D_*exp_sk*(-6)	0.2347	0.0021
D_*exp_sk*(-7)	0.2898	0.0006
D_*exp_sk*(-8)	0.1808	0.0179
D_*exp_sk*(-9)	0.1234	0.1018
D_*exp_sk*(-11)	0.1444	0.0405
D_*gdp_sk*	1.7279	0.0062
D_*gdp_sk*(-1)	1.7958	0.0133
D_*gdp_sk*(-2)	1.3986	0.0185
D_*gdp_sk*(-3)	0.4157	0.4073
D_*gdp_sk*(-4)	2.3063	0.0002
D_*gdp_sk*(-5)	1.5744	0.0104
D_*gdp_sk*(-6)	2.2405	0.0018
D_*gdp_sk*(-7)	2.8829	0.0001
D_*gdp_sk*(-11)	1.1521	0.0207
D_*gdp_sk*(-12)	2.1159	0.0000
D_*rp_sk*	-0.7269	0.0000
D_*rp_sk*(-1)	0.2758	0.0332
D_*rp_sk*(-2)	0.3321	0.0042
D_*rp_sk*(-3)	0.2847	0.0178
D_*rp_sk*(-7)	0.2653	0.0097
D_*rp_sk*(-8)	0.3475	0.0006
D_*rp_sk*(-9)	0.1689	0.0997
D_*rp_sk*(-10)	0.1945	0.0460
D_*rp_sk*(-11)	0.1184	0.1863
D_*rp_sk*(-12)	0.3212	0.0005
D_*CV_sk*	0.0991	0.0000
D_*CV_sk*(-1)	-0.1724	0.0000
D_*CV_sk*(-2)	-0.1648	0.0000
D_*CV_sk*(-3)	-0.1144	0.0000
D_*CV_sk*(-4)	-0.0355	0.0977
exp_sk(-1)	-0.8785	0.0000
gdp_sk(-1)	3.1850	0.0000
rp_sk(-1)	-0.6926	0.0000
CV_sk(-1)	0.3391	0.0000
R^2	0.9293	
R^2_{adj}	0.8569	
F-statistic	12.8325	0.0000
$\chi^2_N(2)$	1.4118	0.4937
$\chi^2_{SC}(2)$	1.3693	0.5043
$\chi^2_H(1)$	0.0811	0.7758
$\chi^2_{FF}(2)$	2.4794	0.1153

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.14: Estimated ECM-ARDL for export to South Korea with *MSD* as volatility measure.

Regressor	Coefficient	P-value
D_*exp_sk*(-1)	0.1682	0.1380
D_*exp_sk*(-2)	0.4930	0.0003
D_*exp_sk*(-3)	0.5633	0.0000
D_*exp_sk*(-4)	0.1575	0.2261
D_*exp_sk*(-5)	0.1758	0.1697
D_*exp_sk*(-6)	0.2695	0.0288
D_*exp_sk*(-7)	0.4121	0.0004
D_*exp_sk*(-8)	0.2184	0.0536
D_*gdp_sk*	2.5182	0.0074
D_*gdp_sk*(-1)	1.0643	0.2280
D_*gdp_sk*(-3)	0.8228	0.3382
D_*gdp_sk*(-4)	2.0002	0.0352
D_*gdp_sk*(-5)	2.8603	0.0056
D_*gdp_sk*(-6)	2.5522	0.0174
D_*gdp_sk*(-7)	2.0762	0.0239
D_*gdp_sk*(-8)	0.9639	0.2635
D_*gdp_sk*(-9)	0.7337	0.3752
D_*gdp_sk*(-10)	1.8331	0.0302
D_*gdp_sk*(-11)	2.2201	0.0102
D_*gdp_sk*(-12)	1.0293	0.1477
D_*rp_sk*	-0.4932	0.0009
D_*rp_sk*(-4)	-0.1820	0.2331
D_*rp_sk*(-5)	-0.1426	0.3658
D_*MSD_sk*	0.0475	0.3231
D_*MSD_sk*(-1)	-0.1235	0.0805
D_*MSD_sk*(-3)	-0.0808	0.3036
D_*MSD_sk*(-5)	0.1562	0.0518
D_*MSD_sk*(-6)	0.1327	0.1068
D_*MSD_sk*(-7)	0.2121	0.0094
D_*MSD_sk*(-9)	0.2126	0.0041
D_*MSD_sk*(-10)	0.1788	0.0159
D_*MSD_sk*(-11)	0.1771	0.0146
D_*MSD_sk*(-12)	0.1132	0.0806
exp_sk(-1)	-0.9869	0.0000
gdp_sk(-1)	1.7747	0.0000
rp_sk(-1)	-0.1847	0.0001
MSD_sk(-1)	0.2405	0.0003
R^2	0.8956	
R^2_{adj}	0.7513	
F-statistic	5.3476	0.0000
$\chi^2_N(2)$	2.0843	0.3527
$\chi^2_{SC}(2)$	1.6505	0.4381
$\chi^2_H(1)$	0.5617	0.4536
$\chi^2_{FF}(2)$	4.6589	0.0309

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.15: Estimated ECM-ARDL for import from Singapore with *CV* as volatility measure.

Regressor	Coefficient	P-value
c	31.0809	0.0002
Trend	0.1043	0.0000
D_*gdp_au*	4.2302	0.1637
D_*gdp_au*(-1)	3.8767	0.2138
D_*gdp_au*(-2)	4.4432	0.1737
D_*gdp_au*(-3)	6.3124	0.0611
D_*gdp_au*(-4)	7.9822	0.0139
D_*gdp_au*(-6)	8.3370	0.0148
D_*gdp_au*(-7)	7.5279	0.0225
D_*gdp_au*(-8)	4.3532	0.2040
D_*gdp_au*(-10)	14.1554	0.0000
D_*gdp_au*(-12)	5.9171	0.0583
D_*rp_sp*(-1)	-1.1395	0.0108
D_*rp_sp*(-2)	-0.7215	0.0758
D_*rp_sp*(-3)	-0.6492	0.1029
D_*rp_sp*(-4)	-0.7210	0.0236
D_*rp_sp*(-5)	-1.6266	0.0000
D_*rp_sp*(-6)	-0.8168	0.0130
D_*rp_sp*(-7)	-0.7711	0.0209
D_*rp_sp*(-9)	-0.8245	0.0106
imp_sp(-1)	-0.7821	0.0000
gdp_au(-1)	-7.2408	0.0002
rp_sp(-1)	1.3994	0.0000
CV_sp(-1)	0.1396	0.1693
R^2	0.6492	
R^2_{adj}	0.5006	
F-statistic	4.3676	0.0000
$\chi^2_N(2)$	0.6794	0.7120
$\chi^2_{SC}(2)$	2.0007	0.3677
$\chi^2_H(1)$	0.0424	0.8369
$\chi^2_{FF}(2)$	2.3302	0.1269

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.16: Estimated ECM-ARDL for import from Singapore with *MSD* as volatility measure.

Regressor	Coefficient	P-value
c	40.2124	0.0000
Trend	0.1375	0.0000
D_*gdp_au*	6.7148	0.0194
D_*gdp_au*(-1)	8.5681	0.0080
D_*gdp_au*(-3)	6.8773	0.0233
D_*gdp_au*(-4)	8.9779	0.0025
D_*gdp_au*(-5)	4.9771	0.0919
D_*gdp_au*(-6)	5.9518	0.0395
D_*gdp_au*(-7)	7.9244	0.0084
D_*gdp_au*(-8)	8.1496	0.0123
D_*gdp_au*(-10)	15.0583	0.0000
D_*gdp_au*(-12)	10.6936	0.0011
D_*rp_sp*(-1)	-1.8960	0.0000
D_*rp_sp*(-2)	-1.5857	0.0003
D_*rp_sp*(-3)	-1.1012	0.0088
D_*rp_sp*(-4)	-1.1541	0.0002
D_*rp_sp*(-5)	-2.0397	0.0000
D_*rp_sp*(-6)	-0.8227	0.0043
D_*rp_sp*(-7)	-1.3267	0.0004
D_*rp_sp*(-8)	-0.5672	0.0309
D_*rp_sp*(-9)	-0.9733	0.0016
D_*rp_sp*(-11)	-0.3225	0.2370
D_*MSD_sp*(-1)	-0.2748	0.0490
D_*MSD_sp*(-2)	-0.3431	0.0129
D_*MSD_sp*(-3)	-0.1616	0.1344
D_*MSD_sp*(-4)	-0.3189	0.0050
D_*MSD_sp*(-5)	0.1179	0.1696
D_*MSD_sp*(-6)	-0.2806	0.0019
D_*MSD_sp*(-9)	0.1606	0.0553
D_*MSD_sp*(-11)	0.2112	0.0096
D_*MSD_sp*(-12)	0.2193	0.0045
imp_sp(-1)	-0.9375	0.0000
gdp_au(-1)	-9.5467	0.0000
rp_sp(-1)	2.1372	0.0000
MSD_sp(-1)	0.2835	0.0315
R^2	0.7988	
R^2_{adj}	0.6479	
F-statistic	5.2945	0.0000
$\chi^2_N(2)$	0.0419	0.9793
$\chi^2_{SC}(2)$	0.3634	0.8339
$\chi^2_H(1)$	0.0008	0.9773
$\chi^2_{FF}(2)$	2.0234	0.1549

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.17: Estimated ECM-ARDL for export to US with *CV* as volatility measure.

Regressor	Coefficient	P-value
c	-39.0826	0.0000
Trend	-0.0729	0.0000
D_*exp_us*(-1)	0.0983	0.1485
D_*exp_us*(-2)	0.1775	0.0091
D_*exp_us*(-3)	0.1496	0.0180
D_*exp_us*(-4)	0.2635	0.0003
D_*exp_us*(-5)	0.2023	0.0041
D_*exp_us*(-6)	0.2418	0.0006
D_*exp_us*(-7)	-0.0684	0.2750
D_*exp_us*(-8)	0.2796	0.0000
D_*exp_us*(-9)	0.0720	0.2543
D_*exp_us*(-10)	-0.1077	0.0849
D_*exp_us*(-11)	-0.0813	0.1790
D_*exp_us*(-12)	0.0932	0.1928
D_*gdp_us*	2.6126	0.2159
D_*gdp_us*(-1)	-6.0928	0.0065
D_*gdp_us*(-2)	-6.6897	0.0047
D_*gdp_us*(-3)	-7.3085	0.0009
D_*gdp_us*(-4)	-7.6634	0.0004
D_*gdp_us*(-5)	-4.3919	0.0312
D_*gdp_us*(-6)	-8.4110	0.0001
D_*gdp_us*(-8)	-5.8706	0.0065
D_*gdp_us*(-9)	-6.6562	0.0030
D_*gdp_us*(-11)	-3.1215	0.1270
D_*gdp_us*(-12)	-4.5066	0.0384
D_*rp_us*	-0.7004	0.0000
exp_us(-1)	-0.9857	0.0000
gdp_us(-1)	11.2321	0.0000
rp_us(-1)	-0.2211	0.0207
CV_us(-1)	0.0810	0.0100
R^2	0.9159	
R^2_{adj}	0.8576	
F-statistic	15.7038	0.0000
$\chi^2_N(2)$	0.0460	0.9772
$\chi^2_{SC}(2)$	5.2221	0.0735
$\chi^2_H(1)$	0.0061	0.9379
$\chi^2_{FF}(2)$	1.7517	0.1857

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.18: Estimated ECM-ARDL for export to US with *MSD* as volatility measure.

Regressor	Coefficient	P-value
c	15.6321	0.0000
D_*exp_us*(-1)	1.6879	0.0001
D_*exp_us*(-2)	1.6146	0.0000
D_*exp_us*(-3)	1.5591	0.0000
D_*exp_us*(-4)	1.7180	0.0000
D_*exp_us*(-5)	1.5263	0.0002
D_*exp_us*(-6)	1.3884	0.0002
D_*exp_us*(-7)	0.8614	0.0006
D_*exp_us*(-8)	1.1413	0.0000
D_*exp_us*(-9)	0.8903	0.0006
D_*exp_us*(-10)	0.6309	0.0095
D_*exp_us*(-11)	0.3600	0.0851
D_*exp_us*(-12)	0.3987	0.0254
D_*gdp_us*(-4)	-5.6478	0.1109
D_*gdp_us*(-5)	-6.4158	0.0833
D_*gdp_us*(-6)	-10.4893	0.0261
D_*gdp_us*(-8)	-16.2967	0.0027
D_*gdp_us*(-9)	-18.6521	0.0019
D_*gdp_us*(-10)	-10.6830	0.0259
D_*gdp_us*(-11)	-10.9167	0.0261
D_*gdp_us*(-12)	-12.8716	0.0208
D_*rp_us*	-0.9774	0.0035
D_*rp_us*(-1)	-2.3611	0.0008
D_*rp_us*(-2)	-2.2163	0.0007
D_*rp_us*(-3)	-1.3555	0.0108
D_*rp_us*(-4)	-2.3494	0.0002
D_*rp_us*(-5)	-1.6880	0.0012
D_*rp_us*(-6)	-1.5017	0.0026
D_*rp_us*(-7)	-0.9670	0.0174
D_*rp_us*(-8)	-1.1565	0.0074
D_*rp_us*(-9)	-1.2272	0.0026
D_*rp_us*(-10)	-1.0189	0.0021
D_*MSD_us*	0.2690	0.0161
D_*MSD_us*(-1)	-3.5942	0.0000
D_*MSD_us*(-2)	-3.4234	0.0000
D_*MSD_us*(-3)	-3.1165	0.0000
D_*MSD_us*(-4)	-2.9828	0.0000
D_*MSD_us*(-5)	-2.5790	0.0001
D_*MSD_us*(-6)	-2.4250	0.0000
D_*MSD_us*(-7)	-2.0114	0.0001
D_*MSD_us*(-8)	-1.7653	0.0000
D_*MSD_us*(-9)	-1.3703	0.0002
D_*MSD_us*(-10)	-1.3623	0.0000
D_*MSD_us*(-11)	-0.9592	0.0008
D_*MSD_us*(-12)	-0.6896	0.0001
exp_us(-1)	-2.7566	0.0000
gdp_us(-1)	3.8884	0.0000
rp_us(-1)	1.6387	0.0028
MSD_us(-1)	3.8358	0.0000
R^2	0.9545	
R^2_{adj}	0.8061	
F-statistic	6.4327	0.0000
$\chi^2_N(2)$	2.7798	0.2491
$\chi^2_{SC}(2)$	2.6610	0.2644
$\chi^2_H(1)$	0.0386	0.8443
$\chi^2_{FF}(2)$	3.0074	0.0829

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Table A8.19: Estimated ECM-ARDL for import from UK with *CV* as volatility measure.

Regressor	Coefficient	P-value
c	-3.3396	0.0000
D_*imp_uk*(-1)	-0.2472	0.0712
D_*imp_uk*(-2)	-0.3208	0.0220
D_*imp_uk*(-3)	-0.2039	0.1296
D_*imp_uk*(-4)	-0.1682	0.1845
D_*imp_uk*(-5)	-0.4407	0.0017
D_*imp_uk*(-6)	-0.3061	0.0193
D_*imp_uk*(-7)	-0.3938	0.0019
D_*imp_uk*(-9)	-0.1733	0.1420
D_*imp_uk*(-10)	-0.2050	0.0706
D_*gdp_au*(-3)	-5.2214	0.0452
D_*gdp_au*(-4)	-3.0686	0.2488
D_*gdp_au*(-10)	-6.3519	0.0252
D_*rp_uk*	-0.7344	0.0091
D_*rp_uk*(-1)	-1.3584	0.0003
D_*rp_uk*(-2)	-1.1418	0.0021
D_*rp_uk*(-3)	-1.3538	0.0005
D_*rp_uk*(-4)	-0.7821	0.0196
D_*rp_uk*(-5)	-1.7730	0.0000
D_*rp_uk*(-6)	-0.3780	0.1989
D_*rp_uk*(-7)	-0.6532	0.0257
D_*rp_uk*(-8)	-0.3622	0.1784
D_*rp_uk*(-9)	-0.6750	0.0080
D_*CV_uk*(-1)	-1.0246	0.0000
D_*CV_uk*(-2)	-1.0411	0.0000
D_*CV_uk*(-3)	-1.0141	0.0000
D_*CV_uk*(-4)	-0.9126	0.0000
D_*CV_uk*(-5)	-0.8654	0.0000
D_*CV_uk*(-6)	-0.7344	0.0000
D_*CV_uk*(-7)	-0.5854	0.0000
D_*CV_uk*(-8)	-0.4626	0.0000
D_*CV_uk*(-9)	-0.2909	0.0004
imp_uk(-1)	-0.4048	0.0009
gdp_au(-1)	3.2448	0.0000
rp_uk(-1)	1.2030	0.0000
CV_uk(-1)	0.9085	0.0000
R^2	0.7389	
R^2_{adj}	0.5311	
F-statistic	3.5559	0.0000
$\chi^2_N(2)$	4.2099	0.1219
$\chi^2_{SC}(2)$	2.2469	0.3252
$\chi^2_H(1)$	1.8393	0.1750
$\chi^2_{FF}(2)$	38.8123	0.0000

Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

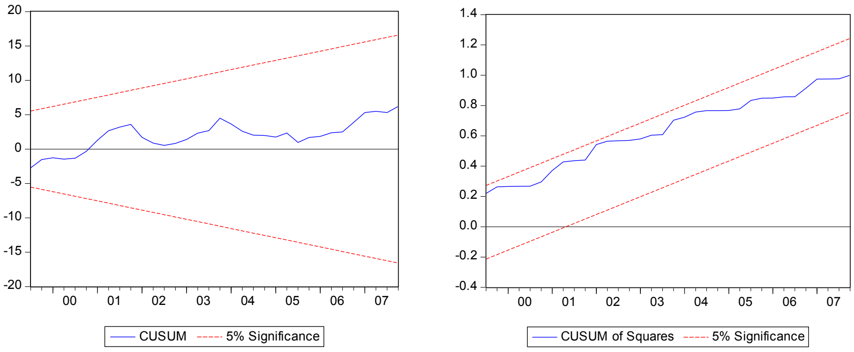
Table A8.20: Estimated ECM-ARDL for import from UK with *MSD* as volatility measure.

Regressor	Coefficient	P-value
D_*imp_us*(-1)	0.2587	0.0009
D_*imp_us*(-2)	0.0968	0.1448
D_*gdp_au*	3.1239	0.0359
D_*gdp_au*(-1)	1.4839	0.3339
D_*gdp_au*(-3)	1.8896	0.2397
D_*gdp_au*(-4)	2.6081	0.1044
D_*gdp_au*(-5)	2.4926	0.1071
D_*gdp_au*(-6)	4.5341	0.0051
D_*gdp_au*(-8)	3.3293	0.0268
D_*gdp_au*(-9)	4.4998	0.0013
D_*gdp_au*(-10)	4.8287	0.0012
D_*gdp_au*(-11)	3.9824	0.0082
D_*gdp_au*(-12)	1.8717	0.1945
D_*rp_us*	-0.3331	0.0159
D_*rp_us*(-1)	0.2876	0.1176
D_*rp_us*(-2)	0.2838	0.1268
D_*rp_us*(-3)	0.1772	0.2888
D_*rp_us*(-4)	0.2558	0.1062
D_*rp_us*(-5)	0.2416	0.1465
D_*rp_us*(-10)	-0.2480	0.0785
D_*MSD_us*(-1)	0.7395	0.0000
D_*MSD_us*(-2)	0.5853	0.0000
D_*MSD_us*(-3)	0.6295	0.0000
D_*MSD_us*(-4)	0.5152	0.0000
D_*MSD_us*(-5)	0.6025	0.0000
D_*MSD_us*(-6)	0.4354	0.0000
D_*MSD_us*(-7)	0.3182	0.0001
D_*MSD_us*(-8)	0.3665	0.0000
D_*MSD_us*(-9)	0.3589	0.0000
D_*MSD_us*(-10)	0.2246	0.0015
D_*MSD_us*(-11)	0.1795	0.0038
D_*MSD_us*(-12)	0.1378	0.0292
imp_us(-1)	-1.2152	0.0000
gdp_au(-1)	1.2273	0.0000
rp_us(-1)	-0.7312	0.0000
MSD_us(-1)	-0.7470	0.0000
R^2	0.9351	
R^2_{adj}	0.8522	
F-statistic	13.5426	0.0000
$\chi^2_N(2)$	0.2299	0.8914
$\chi^2_{SC}(2)$	0.0051	0.9974
$\chi^2_H(1)$	0.0009	0.9762
$\chi^2_{FF}(2)$	1.7201	0.1897

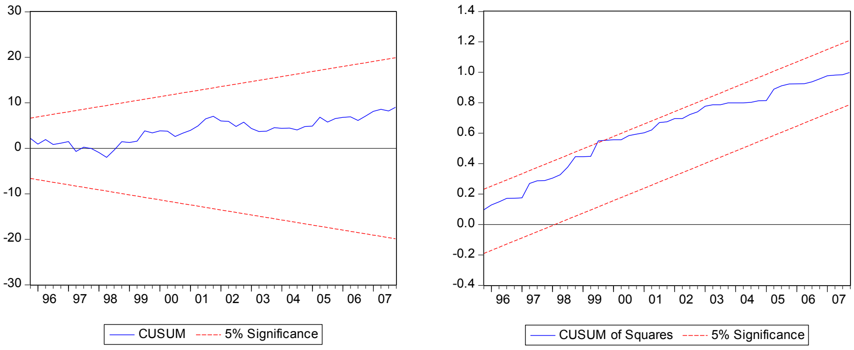
Note: The meanings of the other diagnostic statistics are the same as those in Table A8.1.

Appendix (Figures for Chapter 8)

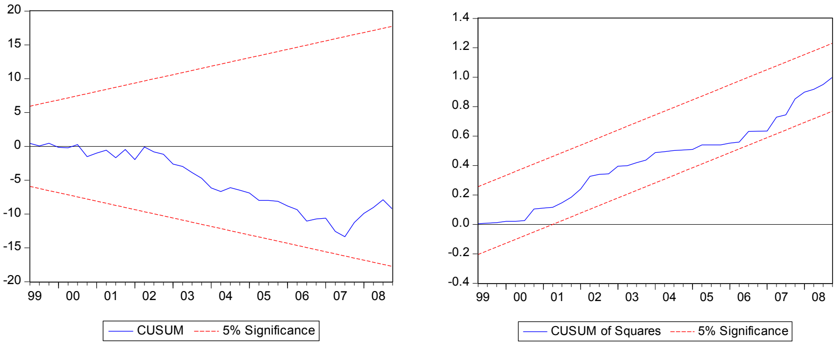
FA8.1: Stability test for the estimated ECM-ARDL for the export to China with *CV* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.



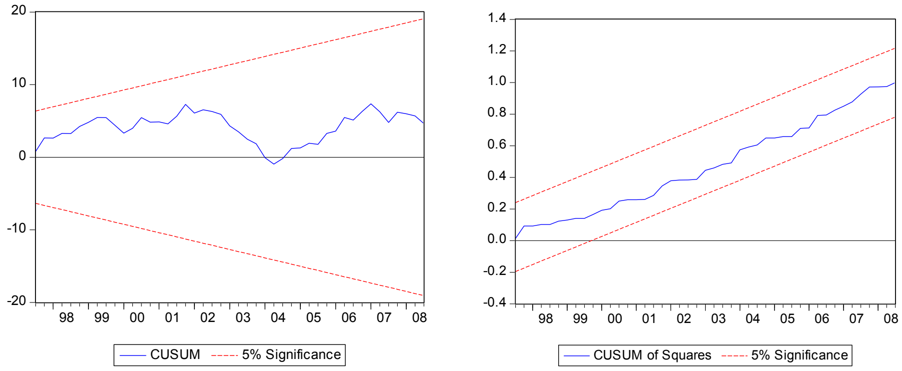
FA8.2: Stability test for the estimated ECM-ARDL for the export to China with *MSD* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.



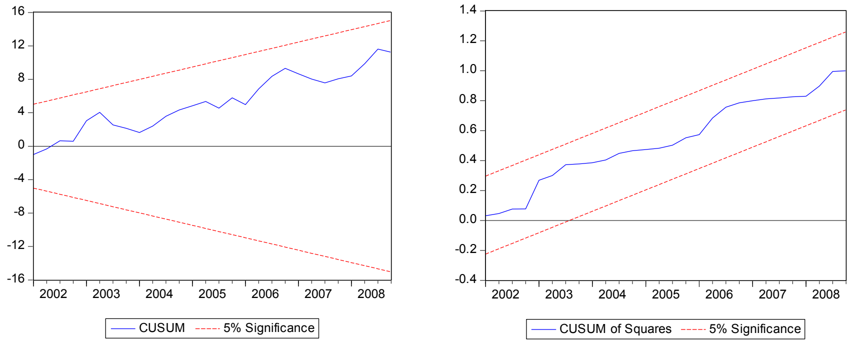
FA8.3: Stability test for the estimated ECM-ARDL for the import from China with *CV* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.



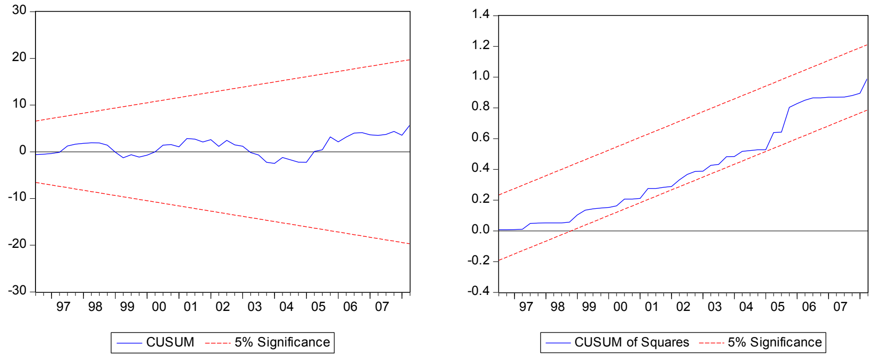
FA8.4: **Stability test for the estimated ECM-ARDL for the import from China with *MSD* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



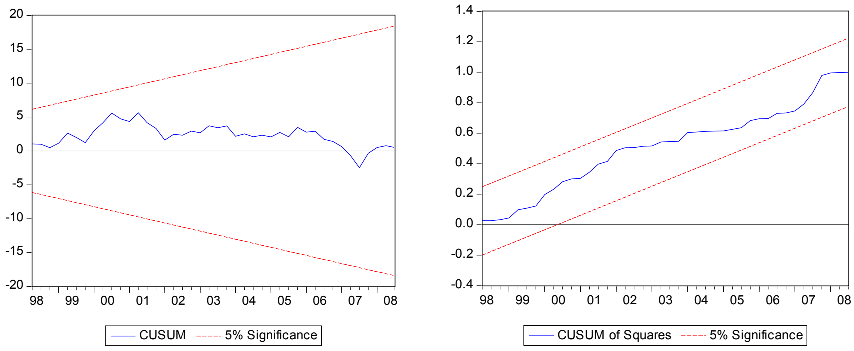
FA8.5: **Stability test for the estimated ECM-ARDL for the export to Japan with *CV* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



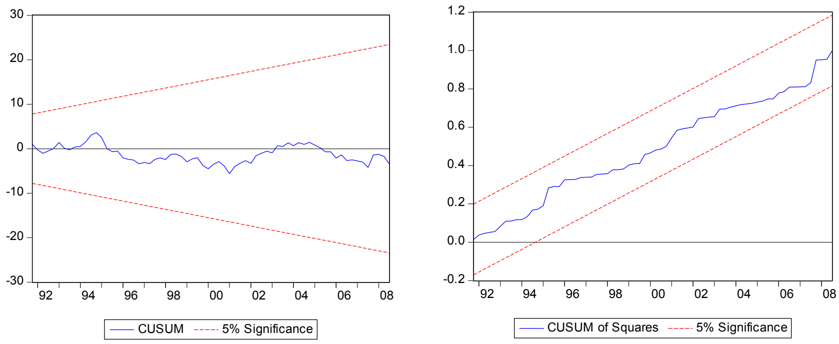
FA8.6: **Stability test for the estimated ECM-ARDL for the export to Japan with *MSD* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



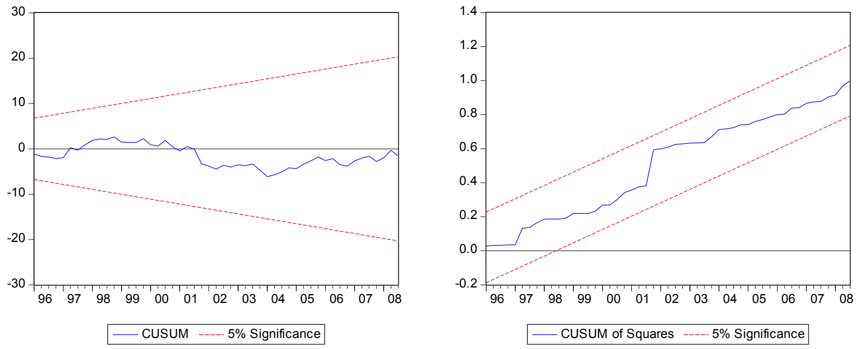
FA8.7: Stability test for the estimated ECM-ARDL for the import from Japan with *CV* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.



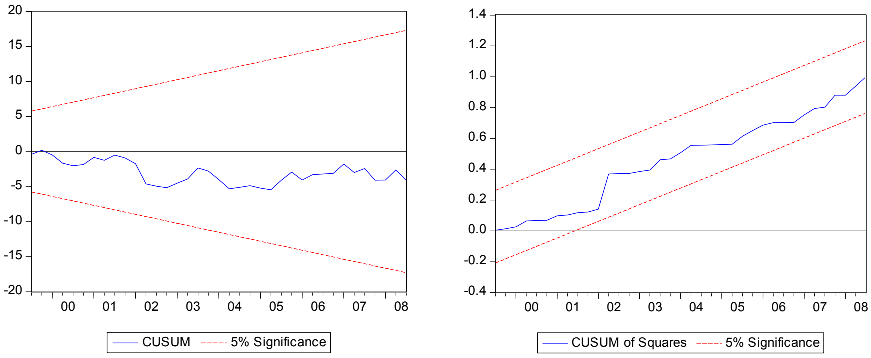
FA8.8: Stability test for the estimated ECM-ARDL for the import from Japan with *MSD* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.



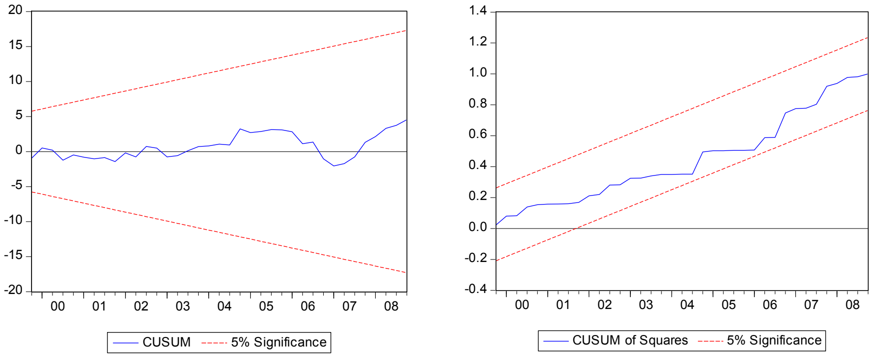
FA8.9: Stability test for the estimated ECM-ARDL for the export to New Zealand with *CV* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.



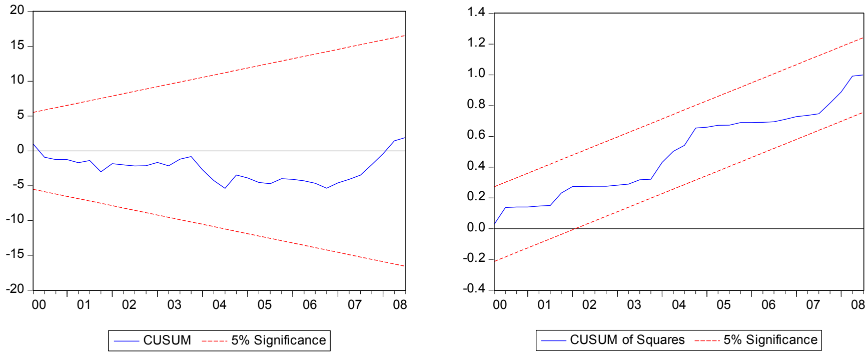
FA8.10: **Stability test for the estimated ECM-ARDL for the export to New Zealand with *MSD* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



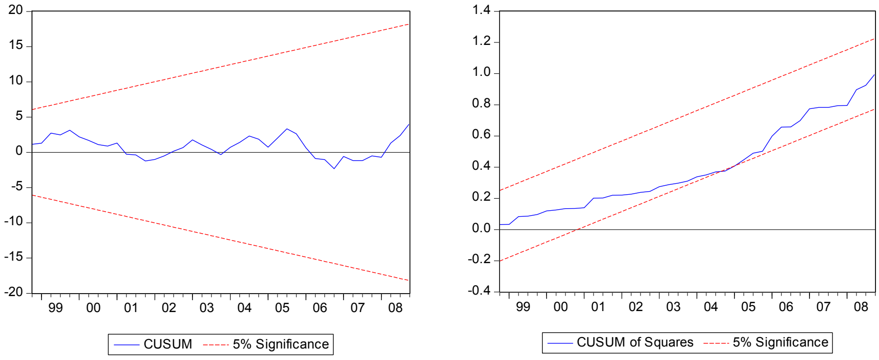
FA8.11: **Stability test for the estimated ECM-ARDL for the import from New Zealand with *CV* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



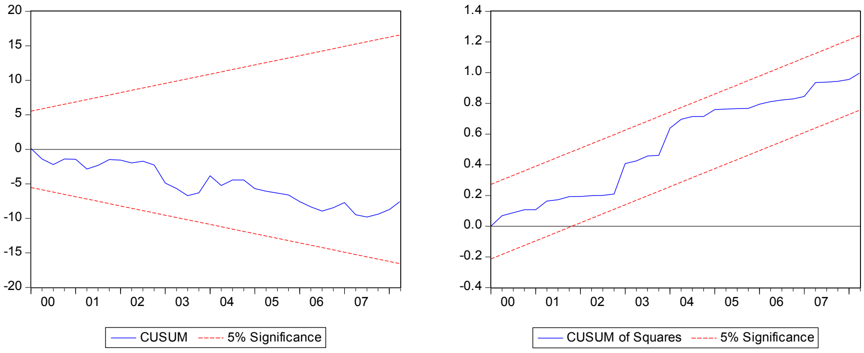
FA8.12: **Stability test for the estimated ECM-ARDL for the import from New Zealand with *MSD* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



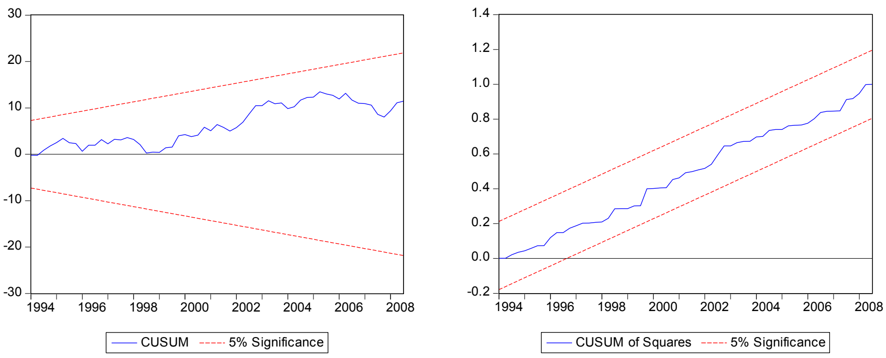
FA8.13: **Stability test for the estimated ECM-ARDL for the export to South Korea with *CV* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



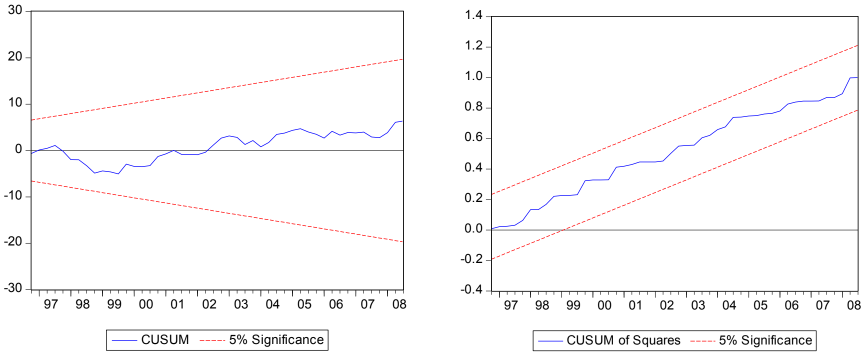
FA8.14: **Stability test for the estimated ECM-ARDL for the export to South Korea with *MSD* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



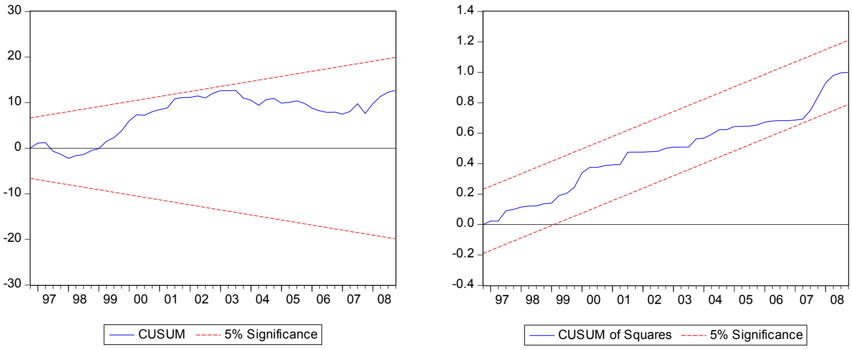
FA8.15: **Stability test for the estimated ECM-ARDL for the import from Singapore with *CV* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



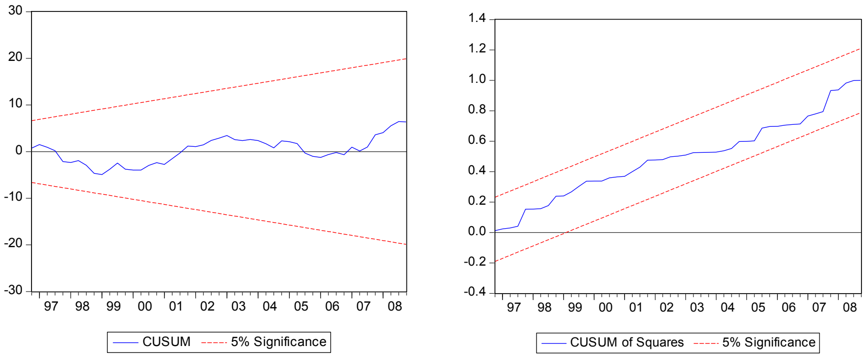
FA8.16: **Stability test for the estimated ECM-ARDL for the import from Singapore with *MSD* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



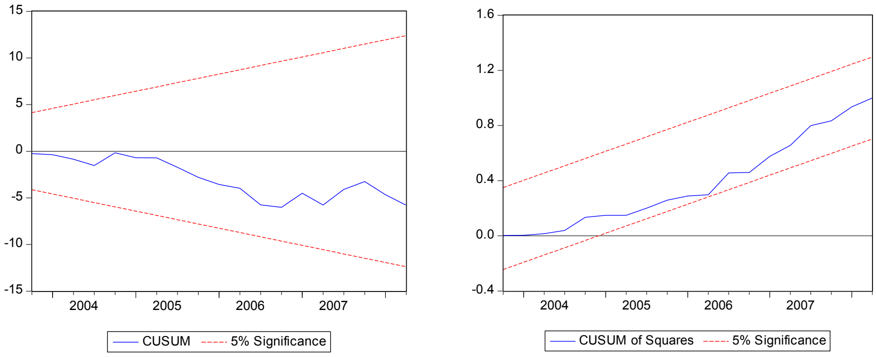
FA8.17: **Stability test for the estimated ECM-ARDL for the import from UK with *CV* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



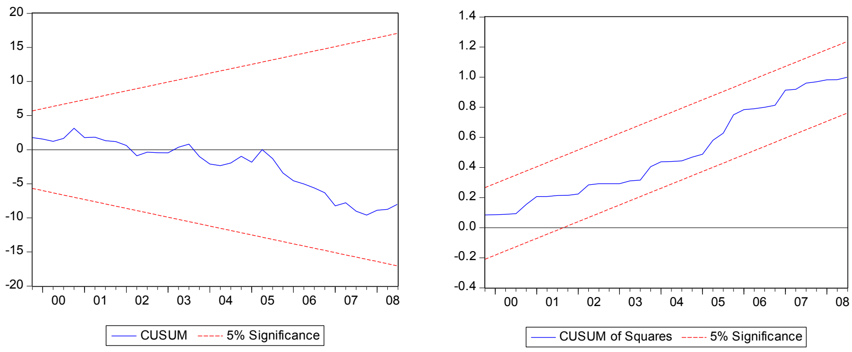
FA8.18: **Stability test for the estimated ECM-ARDL for the export to US with *CV* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



FA8.19: **Stability test for the estimated ECM-ARDL for the export to US with *MSD* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level.**



FA8.20: **Stability test for the estimated ECM-ARDL for the import from US with *MSD* as volatility measure, the straight lines represent critical bounds at the 5 per cent significance level**.



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