Trade Integration and Business Cycle Convergence: Is the Relation Robust Across Time and Space?

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TRADE INTEGRATION AND BUSINESS CYCLE CONVERGENCE: IS THE RELATION ROBUST ACROSS TIME AND SPACE?

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Abstract

This thesis investigates the relationship between business cycle correlation and trade intensity for a group of 24 countries over the period 1959 to 2003. Previous studies have not accounted for the possibility that the business cycle correlation may be influenced by unobservable country pair specific effects. Our estimates are produced using both fixed and random effects procedures and allow for the possibility that trade intensity could be endogenous. Both methodologies suggest that the greater economic convergence is strongly influenced by rises in bilateral trade intensity. A couple of sensitivity analyses prove that the relationship is robust, such as sub-period analysis or adding potential omitted variables.

However, the magnitude and significance of the estimated relationship is not the same for all countries. Our evidence indicates that trade amongst the European countries has had the most beneficial effect on business cycle co-movements which, from optimum currency area (OCA) theory, would support the decision of most of these economies to join European Monetary Union (EMU). But all non-European countries (except China) have not shown positive or significant relationships.

In addition, the determinants of business cycle co-movements are extended to trade intensity, industry specialisation and financial integration for a sample of 15 OECD countries from 1984 to 2003. We still find the positive and statistically significant impact from trade intensity on business cycle synchronisation. Moreover, economic regions with strong financial links are significantly less synchronised and more similar industry structure results in highly correlated business cycle.[1]

[1] The paper was published in Scandinavian Journal of Economics and was presented at: European Trade Study Group (ETSG) 9th Annual Conference; International Network for Economic Research (INFER) 9th Annual Conference; Scottish Economic Society 2006 Annual Conference; VIth Doctoral Meetings in International Trade and International Finance (CEPII); and ESDS International Annual Conference.

Chapter 1 Introduction

1.1 Introduction

On 1st January 1999 when eleven European Union (EU) countries completed the final stage of European Monetary unification (Greece became the 12th member of the Euro zone in 2001) irrevocably fixed exchange rate established the conversion rates between the respective national currencies and the Euro, after which a full monetary union was established, when individual national currencies were replaced with a single currency, giving birth to the Euro. Euro banknotes and coins have been in circulation since 1st January 2002. Now member countries are Belgium, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal, Slovenia and Finland.

With the expansion of the European Union to include 12 more countries,[1] other member countries will have to decide whether they abolish national currencies and adopt the Euro in a few years like the 13 European Monetary Union (EMU) countries or still keep the national currencies like Denmark, Sweden and the United Kingdom.[2] Thus this is becoming a hot topic: should one currency only for just 13 counties of the present EMU or for the EU as a whole, or for the whole of Europe, or maybe for the whole world? In

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[1] Ten countries joined the EU in 2004: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia; and two more joined in 2007: Bulgaria and Romania.

[2] Denmark, Sweden and the United Kingdom were the only old EU member states outside the monetary union. The situation for the three older member states also looks different from that of the newer EU members. Demark is a member of ERM II. On September 25-27, 1998 the ministers of economic affairs and finance and the central-bank governors of the EU member states concluded an agreement concerning Danish and Greek participation in the new exchange-rate mechanism, ERM II, as from January 1, 1999. Furthermore, in September 1998 an agreement was concluded between the central banks of the EU member states not participating in the third stage of EMU, and the ECB, on the technical guidelines and procedures for ERM II (Demarks Nationalbank, 1998). Sweden had a referendum. In Sweden, the parliamentary parties agreed that EMU participation would not be possible without the broad approval of the Swedish people. In March 2003, following talks between the party leaders, the Riksdag decided that a national referendum was to be held on Swedish participation in EMU, on 14 September 2003. At the referendum, the Swedish people rejected participation, with 56 per cent voting against and 42 per cent for (Government Offices of Sweden, 2006). The United Kingdom has an opt-out clause. When the Maastricht Treaty was concluded in 1992, the United Kingdom was granted an opt-out clause, meaning that it was not required to participate in the third stage of EMU and consequently introduce the Euro. The United Kingdom is still in the second stage of EMU. The opt-out clause was a condition for the United Kingdom to approve the Treaty as a whole. (EUROPA, 2006)

deciding whether to join a currency union policy makers need to compare the benefits and costs of membership (Mundell, 1961; McKinnon, 1963; Kenen, 1969).

The aim of this chapter is to highlight the motivation for this thesis through reviewing existing research on optimum currency area theory and the relationship between the trade intensity and the business cycle correlation. This chapter also lists the main contributions of this thesis. The last part outlines the structure of following chapters.

1.2 Background and Theory

Considering the optimum currency area (OCA) theory, the main advantage of a single currency is the potential gains to trade and international investment that could arise from eliminating currency conversion costs and removing the uncertainty arising from unexpected exchange rate movements. However, in a currency union, countries lose monetary independence thus limiting their ability to stabilise the business cycle. Therefore the costs depend upon the degree of the business cycle synchronization between member countries. The gains from monetary autonomy are minimized if member countries are exposed to symmetric shocks or if asymmetric shocks can be absorbed for example, by having flexible labour markets.

Since Mundell (1961) first developed the concept of an optimum currency area, a vast literature has developed, including classic contributions by McKinnon (1963) and Kenen (1969). Recent surveys are available in Tavlas (1992) Bayoumi and Eichengreen (1996) and De Grauwe (2005). Mundell (1961) focussed on the cost side of cost-benefit analysis of monetary integration. From Mundell’s theory we find that if wages are rigid and if labour mobility is limited, countries that form a monetary union will find it harder to adjust to demand shifts than countries that have maintained their own national monies, who can devalue (revalue) their currency when participating in a fixed exchange rate agreement. McKinnon (1963) adds the degree of openness to trade (the ratio of tradable to non-tradable goods) to be taken into account. Economists typically cite four criteria, often called the OCA criteria, to evaluate the value of switching to a single currency. There are three economic criteria: the degree of trade between countries who adopt a common currency; the extent to which different countries experience similar shocks and the degree of labour market mobility in each region. One political criterion is the amount of fiscal transfers between regions. These four characteristics measure the ability of the economy to smooth local economic movements in the absence of monetary policy. They are all analysed empirically by lots of papers, such as Chow and Kim (2003) for East Asia countries, Karras (2005) for Asia and Pacific countries, Sorensen (2005) for OECD countries and so on.

Frankel and Rose (1998) argue that the optimum currency criteria are endogenous; in particular the level of economic integration depends upon the trade intensity between two countries. Using pooled instrumental variable estimation they identify a positive relationship between cross-country correlations of de-trended output and the level of bi-lateral trade intensity, for a group of 21 industrialised countries from 1959 to 1993. They explain this result by a larger amount of intra-industry bi-lateral trade, so as both countries trade more within the same industries the pattern of the business cycles becomes more similar. Greater economic integration from trade could also arise from demand spillovers, in that a demand shock in one country leads to a rise in imports from one or more other economies (Shin and Wang, 2005). Also, as two economies become more economically dependent upon one another, higher trade intensity may create the need for more coordinated fiscal and monetary policy, leading to synchronization of policy shocks. We would expect a negative relationship if there is a greater degree of greater specialization in those goods and services, for which a country has a comparative advantage (Eichengreen, 1992; Krugman, 1993). This leads both countries to be more exposed to industry specific shocks generating more idiosyncratic business cycles.

Kose and Yi (2002) report similar empirical estimates to Frankel and Rose (1998) using the same group of countries but a sample period of 1970 to 2000. However, they question the magnitude of their estimates since they cannot be replicated using a standard international business cycle model. A positive estimate is also provided by Otto *et al.* (2001). Imbs (2004) finds that a doubling of trade intensity would increase the business cycle correlation by 0.048 using cross-section data for 24 OECD countries.[3] While most of the literature has focused on developed countries, Baxter and Kourparitsas (2005) also find the Optimum Currency Area (OCA) criteria are endogenous for 100 developing and industrialised countries from 1970 to 1992. Calderòn *et al* (2007) find a rise in trade intensity to have a larger impact on the output correlation for developed countries than for less developed country pairs. Further support for the Frankel and Rose hypothesis is provided by Babetskii (2005), who investigated the determinants of economic integration for ten Central and Eastern European countries.

The literature (such as Shin and Wang, 2005 and Calderón *et al.*, 2007) also points out that other variables result in the cross-country synchronisation of the business cycle. In theory trade both in goods and in financial assets may affect the business cycle correlation. Moreover, closer industrial specialisation is also likely to result in synchronised business cycle cross countries and trade intensity possibly affects the business cycle through specialisation. Imbs (2004, 2006) estimates the effects of trade in goods and in financial assets as well as specialisation on the business cycle synchronisation for a group of 24 industrialised countries. However, the interactions between the trade in goods, financial integration, specialisation and the business cycle synchronisation are complex and they impact each other.[4] Three-stage least squares estimation is used for this system of simultaneous equations. He explains the same result that more bilateral trade results in closer business cycle correlation. In addition, a variety of measures of financial integration suggest that economic regions with strong financial links are significantly more synchronised; and specialisation have a sizable effect on the business cycles.

[3] See also Imbs (2006) for similar findings.
[4] Otto et al. (2001) and Kalemli-Ozcan et al. (2001) present the effect of specialisation on cycle correlation. Keheo and Perri (2002) and Kalemli-Ozcan et al. (2001) find the effect of financial integration on business cycle correlation. Also Baxter and Crucini (1995) and Harrigan (2001) present the indirect effects between trade, finance and specialisation.

1.3 Trade Intensity and the Business Cycle Correlation

In theory, closer international trade could result in either tighter or looser correlations of the business cycles. Closer bilateral trade could result in countries becoming more specialised in the goods in which they have comparative advantage. The countries might then be more sensitive to industry-specific shocks, resulting in more idiosyncratic business cycles. However, if intra-industry trade accounts for most trade, then the business cycles may become more similar across countries when countries trade more. Therefore, this relationship is ambiguous in theory.

Our evidence shows that economic convergence has increased among the world's major economies and the volume of international trade has risen. Particularly, European countries trade with each other obviously more than in the past, and this trend may continue. It is driven in part by regional trade policy, such as the completion of the single market in 1992, free trade agreements in Europe and expansion of the EU from 6 founding members in 1957 to 15 in 1995 and to 27 in 2007. EMU itself may promote intra-European trade, if the effects of the exchange rate risk and transactions are important, as EMU proponents claim. Thus the business cycle is endogenous with respect to the trade integration, while the trade integration is also affected by policy.

If the intra-industry trade accounts for a large proportion of bilateral trade then increased the intra-industry trade results in less specialisation which results in a positive cross-industry correlation. Our hypothesis is that more international trade will result in more highly correlated business cycles. Although many papers have produced estimation results stating a positive relationship between trade intensity and the business cycle correlation empirically, it is not universally accepted from theory and empirical analysis.[5] We would like to extend the period and select different countries to investigate this relationship by a developed model.

[5] Authors such as Eichengreen (1992), Kenen (1969) and Krugman (1993) have pointed out from theory that as trade becomes more highly integrated, countries specialise more in production then reduce the business cycle co-movement since greater trade intensity could reflect a larger amount of inter-industry trade and thus, higher risks of idiosyncratic shocks. Trade integration which occurs as a result of economies of scale also leads to regional concentration of industrial activities. Kose and Yi (2001, 2006) did not find any positive relationship empirically.

This thesis estimates the relationship between the business cycle correlation and trade intensity empirically. A panel data set consist of 24 countries: Australia, Austria, Belgium-Luxembourg, Canada, China, Denmark, Finland, France, Germany, Greece, Hong Kong, Republic of Ireland, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the UK and the USA across 40 years from 1959 to 2003 which is split into 5 periods. Bilateral trade intensity is measured using total bilateral trade divided by joint nominal GDP or total trade. The business cycle correlations are measured using real GDP data (expressed in US dollars), converted to natural logarithms and de-trended with a Hodrick-Prescott filter.

As theory indicates trade intensity affects industry structure which in turn can change the business cycle co-movement. And also both trade in goods and financial assets may affect the cross-country synchronisation of the business cycles. We would like to bring two additional variables, specialisation and financial integration, into the investigation and estimate their direct and indirect impacts on the business cycle correlation simultaneously. Our further hypothesis is that the total impact from trade on the business cycle correlation remains significant and both specialisation and financial integration affects the business cycle correlation significantly as well.

1.4 Contributions of the Study

We add to the previous literature in three respects. Firstly, we estimate our model using both fixed effects (FE) and random effects (RE) models. In doing so we can account for differences in the business cycle correlation across country pairs through the level of trade intensity and potentially important unobservable factors. For example, similar industrial structures or a high degree of financial integration could explain a rise in the level of bi-lateral economic integration. Proxies can be used to measure these factors but they are likely to be measured with error. Fixed effects can control for all of the country pair specific effects even if they are correlated with trade intensity. The random effects approach treats the unobservable individual effects as randomly distributed although, unlike fixed effects, they are assumed to be independent of trade intensity. Previous literature has typically used either pooled data (Frankel and Rose, 1998; Kose and Yi, 2002) or cross-section observations based on a mean of times series observations (Baxter and Kouparitsas, 2005; Imbs, 2004, 2006). Shin and Wang (2005) use only fixed effects estimation but unlike this study, they do not control for the possibility that trade intensity is endogenous. As noted earlier, there is a tendency for countries to peg the value of their currency to the currencies of their most important trading partners (Devereux and Lane, 2002; Frankel and Rose, 1998). This could result in greater monetary policy co-ordination, which in itself maybe a determinant of the business cycle correlation. Therefore any relationship identified between trade intensity and the correlation of two countries business cycles could be spurious without instrumenting for trade intensity. The instruments chosen for this study are taken from the gravity model of trade and we test for the endogeneity of trade intensity. The main finding of this analysis is that trade intensity and the business cycle comovement are positively related to one another.

Our second contribution is to estimate separate panel regressions for each country. We test whether the positive relationship between trade intensity and the correlation of de-trended output found from our aggregate dataset exists for each country. Our results suggest that trade is an important factor determining the economic convergence of the 17 European countries in the sample but not for the remaining countries. We offer two explanations for this result. Firstly, institutional arrangements such as EU membership or joining a fixed exchange rate agreement will facilitate trade, which indirectly raises the level of economic convergence.[6] Estimates from the instrumented equation suggest that free trade agreements and fixed exchange rate agreements are important determinants of trade intensity and therefore of the business cycle correlation indirectly since most European countries have free trade agreements and fixed exchange rate agreements with each other. Secondly, third country effects become more important for the European economies due to similarities in trade patterns. Thus the EU country pairs are more likely to be affected by regional effects. Due to geographical proximity the business cycle

[6] Most of the European countries are members of the EU, Norway is within the European Economic Area and Switzerland has a free trade agreement with the EU. Also many of the European economies joined the European Exchange Rate Mechanism prior to adopting the Euro as their national currency.

correlation of an EU country pair is more likely to be affected by a demand shock from a third country that is an important trading partner for both countries.

Trade intensity, specialisation, financial integration and the business cycle correlation impact simultaneously, papers such as Imbs (2004) estimate their relationship by three-stage least-squares. Again, he did not account for differences in the business cycle correlation across country pairs through the level of three determinants, and those unobservable factors could be important as we explained above. Following by Imbs (2004, 2006), we adopt a new methodology panel 3SLS estimation, which not only considers the potentially important unobservable country pair specific effects, but also disentangles the direct and indirect impact between them, through the estimation of a system of equations. Also different instrumental variables are used for three determinants to eliminate the endogenous problem.

One more contribution is that bilateral foreign direct investment (FDI) position is selected as a proxy for financial integration. In the literature, gross capital flows or portfolio stocks are usually selected to measure financial integration. We find movements in the bilateral foreign direct investment position data are very close to gross capital flows, gross capital stock and portfolio investment. Furthermore, the main advantage of FDI data is that we can access bilateral FDI data cross most OECD countries over more than 20 years, and these data can be consistent with our other variables.

1.5 Chapter Outline

Next chapter presents the OCA theory and literature reviews on analysis of the relationship between the trade intensity and the business cycle. In deciding whether to join the currency union, a country would compare the benefits and costs of membership suggested by OCA theory. The major benefit of joining a currency union is that irrevocably fixed exchange rate reduces the risk of foreign trade and investment, as well as reduces international transactions costs, improving market transparency and greater liquidity of financial markets. However, joining a currency union also brings costs. The costs are mainly from the giving up monetary independence thus limiting their ability to stabilise the business cycle. Much of this literature focuses on four OCA criteria to evaluate the value of switching to a single currency: the extent of trade; the similarity of the business cycles; the degree of labour mobility and the system of risk-sharing. Frankel and Rose (1998) argue that the costs of currency union membership depend upon the benefits i.e. the optimum currency criteria are endogenous. After the work of Frankel and Rose (1998), numerous papers have investigated the relationship between the trade intensity and the business cycle in various sample groups. Baxter and Kourparitsas (2005), Calderòn *et al* (2007) and Babetskii (2005) all find a positive relationship between the trade intensity and the business cycle correlation in different sample countries.

We focus on two important variables, the bilateral trade intensity and the business cycle correlation. Chapter 3 describes the data and variables' measurement. The business cycle correlations are measured using real GDP data, converted to natural logarithms and de-trended with a Hodrick-Prescott filter. The bilateral trade intensity is measured using total bilateral trade divided by either joint nominal GDP or total trade with the world. It is apparent that convergence has increased over time, particularly for the European countries, a factor that could potentially be explained by higher trade intensity between two countries. We also find the trade intensity increase over time.

We estimate relationship between trade intensity and the business cycle correlation using a panel data set consisting of 24 countries and 5 sub-periods observations. Chapter 4 presents the econometric models begin by a simple OLS estimation. However, the pooled OLS is not feasible for two reasons. Firstly, there are strong arguments for instrumenting trade intensity, since a large body of literature shows that bilateral trade flows are endogenous.[7] We therefore instrument trade intensity using 6 instrumental variables: language, distance, adjacency, free trade agreement, product of GDP per capita and fixed exchange rate. Secondly, pooled OLS also ignores potential unobservable country-pair

[7] See Frankel and Rose (1998), Frankel and Romer (1999), Clark and van Wincoop (2001), Calderon *et al.* (2007) and so on.

specific effects. We therefore use both a fixed and random effects estimators that allow for endogenous regressors.

The empirical results are presented in chapter 5. The OLS, fixed and random effects estimation show a significant and positive relationship between trade intensity and the business cycle correlation. Each of the slope estimates has a magnitude around 0.10, (the variety of magnitude changes by de-trending methods and normalisation) suggesting that the business cycle correlation would rise by 0.069 following a doubling of trade intensity for all de-trending methods and normalisations. The overall significance of the model is established by the F- or Wald-statistics and the country pair specific effects are statistically significant, thus justifying the use of panel methods. In a two-stage panel data model, the first step identifies that all instruments are important determinants of trade intensity. All six estimates are correctly signed and have reasonable magnitudes, though there is some variation across trade normalisation for the variables of fixed exchange rate and free trade agreement. The second step results show a positive and statistically significant relationship between trade intensity and the real GDP correlation for all de-trending methods and trade normalisations. The fixed effects estimates present higher magnitude than random effects estimates. Hausman specification test compare the fixed effects estimates with the random effects estimates using only time-variant instruments to select an 'optimal' estimator.

A couple of sensitivity analyses are implemented here to prove the robustness of the relationship. We use industrial production, total employment and unemployment rate instead of real GDP to measure the business cycle correlations and find very consistent results. In sub-period analysis we find that the β estimate is not statistically significant for the first time period, but the magnitude increases progressively over time up until the 1986-94 period, when the maximum marginal effect occurs. We also include time dummies in our 2-stage fixed effects estimation, split the sample into 2 periods, and add control variables in the business cycle equation, such as financial integration, specification, time trend and dummy variable of third trade partners. None of these change our main result and trade intensity remains statistically significant and positive effects on the business cycles.

Variation in the sign and magnitude of relationship could also take place across countries or geographical regions, particularly given the importance of gravity variables in the determination of trade intensity. Chapter 6 presents individual country regressions using both fixed and random effects. In line with the aggregate results nearly all of the slope estimates are positive and statistically significant. To enable us to choose between fixed or random effects estimates for inferences, a Hausman test was computed to compare the fixed effects estimates with the random effects estimates (using only time-variant instruments). For 15 countries random effects was found to be the “optimal” estimator. In all but 4 cases the slope estimate was found to be positive however, it is only statistically significant for the 17 European countries in the sample plus China, where the t-ratio for the slope estimate just exceeds the 5% critical value. The average slope estimate for the European countries is 0.495, with a standard deviation of 0.34. Seven of the estimates are in the range 0.15 to 0.30.

Chapter 7 extends the determinants of the business cycles to trade intensity, specialisation and financial integration and estimate a system of simultaneous equations to disentangle the complex interactions between these variables and the business cycle synchronisation. The sample countries decrease to 15 from 1984 to 2003 since the data limitation. To consider both the unobservable country-pair specific effects and the simultaneous equations, three-stage panel data estimation is implemented. We find that the overall effect of trade on the business cycle synchronisation remains strong. Patterns of industry specialisation have a sizeable direct effect on the business cycle correlation and the business cycles in financial integrated economies are significantly more asymmetric. In individual countries analysis, most countries indicate the consistent results with aggregate results, particular for European countries, however, a few of them, such as non-European countries, change the magnitude and significant of coefficients.

The last chapter provides concluding remarks and further researches.

Chapter 2 Optimum Currency Area Theory: A Review of the Literature

2.1 Introduction

This chapter compares the costs and benefits of having one currency based on the Optimum Currency Areas theory. A single currency eliminates the costs from currency conversion and exchange rate uncertainty thus facilitating cross-border trade and investment. However, in a currency union countries lose monetary independence thus limiting their ability to stabilise the business cycle. According to the classical Optimum Currency Area criteria, two countries or regions would benefit from forming a monetary union if they are characterized by high similarity of business cycles, have strong trade links, and if they possess an efficient adjustment mechanism that can mitigate the adverse effects of asymmetric shocks.

While these OCA criteria are endogenous, in particular the level of economic integration depends upon the trade intensity between two countries. Frankel and Rose (1998) opened a large debate on the endogeneity of OCA criteria fulfilment. They argue that closer trade links could lead to business cycle synchronisation or, equivalently increase the symmetry of shocks.[8] However, this relationship is ambiguous from Optimum Currency Area (OCA) theory. According to the alternative viewpoint e.g., Krugman (1993), the opposite effect should prevail: closer trade ties could result in countries becoming more specialised in the goods in which they have comparative advantage. The countries might then be more sensitive to industry-specific shocks resulting in more idiosyncratic business cycles. Moreover, trade intensity can also be endogenous as it is explained by geographical variables, country size and currency union which are from the gravity model.

Section 2.2 discusses the theory of Optimum Currency Areas; Section 2.3 review the of definition and measurement of the business cycles following by literature review; section

[8] Also see Kose *et al* (2003), Babetskii (2005) and Calderòn *et al* (2007).

2.4 discusses the literature review of the relationship between the trade intensity and the business cycle theoretically and empirically; Section 2.5 presents the gravity model for trade intensity. The final section provides concluding remarks.

2.2 The Theory of Optimum Currency Area

2.2.1 Defining a Monetary Union?

A Monetary Union is different from a fixed exchange rate, a currency board and all the other exchange rate regimes. Fixed exchange rate is a type of exchange rate regime where in a currency's value is matched to the value of another single currency or to a basket of other currencies, or to another measure of value, such as gold. As the reference value rises and falls, so does the currency pegged to it. A currency board is a monetary authority which is required to maintain an exchange rate with a foreign currency. This policy objective requires the conventional objectives of a central bank to be subordinated to the exchange rate target. Some other exchange rate regimes will be discussed in the following chapters.

In economics, a monetary union is a situation where several countries have agreed to share a single currency (or common currency) among them, for example, the East Caribbean dollar. A fixed exchange rate is different with Monetary Union. Gros and Thygesen (1998) define a monetary union as ‘the complete liberalisation of capital transactions and full integration of banking and other financial markets together with the elimination of margins of currency fluctuation and the irrevocable locking of exchange rate parities.’

European Monetary Union (EMU) is the best example for a monetary union which has been widely researched and involving issues that are largely familiar. The Treaty of Maastricht made provision for the single currency to be introduced in the European Union in three stages. (Bordo and Jonung, 2000) The first stage, starting on 1st July 1990, entailed the liberalisation of capital movements and the beginning of the convergence process. Then from 1st January 1994 to 31st December 1998, European Council implements all secondary legislation on EMU for the Member States and on the introduction of Euro bank notes and coins. Finally, the currency was introduced in non-physical form (travellers' cheques, electronic transfers, banking, etc.) at midnight on 1st January 1999 when the national currencies of the initial eleven participating countries[9] ceased to exist independently in that their exchange rates were locked at fixed rates against each other, effectively making them mere non-decimal subdivisions of the Euro. The Euro thus became the successor to the European Currency Unit (ECU). The notes and coins for the old currencies, however, continued to be used as legal tender until new notes and coins were introduced on 1st January 2002. Greece joined the Euro zone in 2001 and on 1st January 2007, Slovenia joined Euro zone as well. After 1st January 2002, EMU lead to a full monetary union.

During the intermediate phase between 1999 and 2002, the Euro was mainly used among banks and for marketable government debt held in financial markets but national currencies and Euro were perfect substitutes at the wholesale level, since banks redenominated accounts and made transfers at 'par' (without any bid-ask spreads for non-cash transactions). The key to this is that the Euro and other national currencies were declared 'legally equivalent' at the conversion rates fixed on 1st January, 1999. Therefore, Gros and Thygesen (1998) argue that the period between 1999 and 2002 is more than just an irrevocable fixing of exchange rates, but it represents a full monetary union yet.

There are also a number of other monetary unions that have been established in the 20th century and are still in operation today. One example is the CFA Franc Zone, formed in 1959 by former French colonies in west and central Africa. The members of the CFA Franc Zone are listed in Table 2-1. The East Caribbean Currency Area formed in 1965 which comprises several small countries in the Caribbean Ocean that were previously British colonies. In the 19th century, a lot of monetary unions were created in many

[9] The Euro countries are Belgium, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal and Finland. Greece joined the EMU in 2001. Denmark, Sweden and the United Kingdom decide to stay out for the time being.

colonies, in particular in British colonies. However, they were destroyed a couple of years later or in the 20th century for different reasons such as political developments.

For example the Scandinavian Monetary Union was created in 1873 between Sweden and

Table 2-1

Existing Monetary Unions

Currency	Members	Issued by
the CFA franc BEAC	Cameroon, the Central African Republic, Chad, the Republic of the Congo, Equatorial Guinea and Gabon	Communauté Économique et Monétaire de l'Afrique Centrale (CEMAC) (the Economic and Monetary Community of Central Africa)
the CFA franc BCEAO	Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo	the Union Économique et Monétaire Ouest Africaine (UEMOA) (the West African Economic and Monetary Union)
the CFP franc	French Polynesia, New Caledonia, and Wallis and Futuna	the Institut d'émission d'outre-mer (IEOM), (the Overseas Issuing Institute)
the East Caribbean dollar	Anguilla, Antigua and Barbuda, Dominica, Grenada, Montserrat, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines	the Eastern Caribbean Currency Union of the Organisation of Eastern Caribbean States (OECS)
the Euro	thirteen European Union member states: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Slovenia and Spain and is also used in Monaco, San Marino, and the Vatican City which are licensed to issue and use the Euro. Two other countries and a subnational entity use the Euro but are not licensed to issue any Euro coins or notes, montenegro and kosovo.	Economic and Monetary Union of the European Union

Notes: The CFA franc is a currency used in 12 formerly French-ruled African countries, as well as in Guinea-Bissau and in Equatorial Guinea.

Denmark and Norway joined the union in 1875. After the First World War the monetary union was terminated in 1914.

De facto monetary unions are not listed in this table. For example the United States dollar is used by the United States and its possessions, Palau, Micronesia, the Marshall Islands, Panama, Ecuador, El Salvador, East Timor, the British Virgin Islands and the Turks and Caicos Islands.

2.2.2 Optimum Currency Area Theory

The articles by Mundell (1961) and McKinnon (1963) are two of the early but seminal contributions on monetary unions and OCA theory. They provide a highly perceptive analysis of the factors that could make a currency area optimum. Mundell emphasises the significance of convergence between the economic structures of the regions or countries within a currency area. Given that a currency area involves relinquishing the exchange rate as an instrument that can be used for correcting external imbalances, an OCA requires structural convergence so that the risk of asymmetric shocks is minimised. McKinnon does not question the relevance of the convergence requirement, but adds another factor to be taken into account: the degree of openness to trade (the ratio of tradable to non-tradable goods). Greater trade leads to greater savings in the transactions costs and risks associated with different currencies. A higher the degree of openness leads to lower cost of establishing a currency area because devaluations in highly open economies would be quickly translated into higher domestic prices and would consequently lead to an upward revision in nominal wages. Therefore, devaluations are less likely to be effective in securing improvement in competitiveness and correcting external imbalances.

The convergence and openness criteria together with factor mobility between OCA members have constituted the core of the debate in the OCA literature. Yet, there are two further points that Mundell and McKinnon raised. The one raised by Mundell is that currency unions within single countries do not necessarily constitute OCAs. Regional divergence within one country may well expose the regions in that country to asymmetric shocks. Therefore, there is no guarantee that national monetary unions are necessarily optimal. This conclusion suggests that the choice between national and multinational OCAs is essentially a choice between two second-best arrangements rather than between first-best and second-best options. The other point raised by McKinnon and relates to destabilising effects of the flexible exchange rate regime as the alternative to monetary unions. In small open economies, flexible exchange rates may generate excessive demand for foreign currency as a substitute for domestic currency. This would be the case when the usefulness of domestic currency as a unit of account and medium of exchange is impaired by inflationary tendencies. Then, flexible exchange rates can be a source of external imbalance rather than a mechanism ensuring external balance.

In deciding how large of an OCA or whether to join an OCA policy makers need to compare the benefits and costs of membership. A single currency eliminates the costs from currency conversion and exchange rate uncertainty thus facilitating cross border trade and investment. However, in a currency union countries lose monetary independence thus limiting their ability to stabilise the business cycle.

The costs of a monetary union derive from the fact that when a country relinquishes its national currency it also relinquishes an instrument of economic policy i.e. it loses the ability to conduct a national monetary policy. Mundell (1961) first developed the theory of OCA and focussed on the cost side of cost-benefit analysis of monetary integration. From Mundell's theory we find that if wages are rigid and if labour mobility is limited, countries that form a monetary union will find it harder to adjust to demand shifts than countries that have maintained their own national monies, who can devalue (revalue) their currency when participating in a fixed exchange rate agreement.

Whereas the costs of a common currency have much to do with the macroeconomic management of the economy, the benefits are mostly situated at the microeconomic level. The most visible gain from a monetary union is the potential gains to trade and international investment that could arise from eliminating currency conversion costs. These costs disappear when countries move to a common currency, such as Euro zone.

The EC Commission has estimated these gains, and arrives at a number between 13 and 20 billion ECUs per year. (De Grauwe, 2005) This represents one-quarter to one-half of one per cent of EU GDP. Therefore countries with close international trade links would benefit from a common currency and are more like to be members of an OCA. For example, Norway might approach the decision of whether to join the Euro zone. The gain will be higher if Norway trades a lot with the Euro zone countries since it avoids the exchange rate risk after joining the Euro zone and has no transaction costs. If Norway's trade with the Euro zone amounts to 60 percent of its GNP while its trade with the United States amounts to only 5 percent of GNP, then other things equal, joining Euro zone clearly yields a greater monetary efficiency gain to Norway traders than joining the Dollar zone. The elimination of transaction costs will also have an indirect gain. It will reduce the scope for price discrimination between national markets.

Another main advantage of a common currency is removing the uncertainty arising from unexpected exchange rate movements. Firstly, the uncertainty about future exchange rate changes introduces uncertainty about future revenues of firms which leads to a loss of welfare in countries. Most trade contracts are not for immediate delivery of goods; and since they are denominated in terms of the currency of either the importer or the exporter, unanticipated fluctuations in exchange rate affect realized profits and hence the volume of trade. Risk-averse individuals always prefer a future return that is more certain than one that is less so, at least if the expected value of these returns is the same. Hence removing the uncertainty of exchange rate raises economic welfare. Also exchange rate uncertainty reduces uncertainty about the future prices of goods and services. Individuals and economic agents base their decisions concerning production, investment and consumption on the information that the price system provides for them. If these prices become more uncertain the quality of these decisions will decline. Therefore adopting a common currency will eliminate nominal exchange rate risk, and thereby will lead to a more efficient working of price mechanism.

Hooper and Kohlhagen (1978) is the first study to analyze systematically the effects of exchange rate uncertainty on trade flows in the context of the theory of the firm under risk. They conclude that if traders are generally risk averse, an increase in exchange risk will unambiguously reduce the value of trade. Doroodian (1999) applies the GARCH technique for three developing countries India, South Korea, and Malaysia and find that exchange rate uncertainty has a negative and significant effect on trade flows. However, McKenzie (1999) supports that exchange rate volatility may exert a positive or negative impact on trade.

There are some other benefits to form a monetary union. For example the new currency that comes out of a monetary union is likely to weigh more in international monetary relations than the sum of the individual currencies prior to the union. As a result, the new common currency can create additional benefits of the monetary union.

2.2.3 Comparing Costs and Benefits

Combining benefits and costs above, the theory of OCA can be summarized using Figure 2-1. The diagram illustrates a country's total costs and benefits relative to GDP of moving from a flexible to a common currency with its major trading partners. The horizontal axis measures the ratio of international trade and to GDP. The 'Benefits' curve indicates the benefits from exchange rate stability. As we know the greater the volume of international trade relative to the size of the economy, the larger are the benefits from a stable exchange rate or a common currency relative to GDP. Several of the benefits mentions above can be reaped by adopting a common currency, the position and positive slope of the 'Benefit' curve will be higher when the fixed exchange rate is achieved by entering a monetary union.

The 'Costs' curve in Figure 2-1 indicates the costs of switching from a flexible to a fully fixed exchange rate, measured as a percentage of GDP. The fact that this curve lies above the horizontal axis reflects the assumption of OCA theory that the short-run volatility of output and inflation will tend to be lower under flexible than under fixed exchange rates. The assumption of positive costs of fixing the exchange rate is based on the idea that the ability to pursue an independent monetary policy under flexible exchange rates makes it easier to stabilize the economy. But as indicated in the diagram, these costs will be smaller relative to GDP the more the domestic economy is integrated with the economies of its trading partners. The reason for the negative slop of the 'Cost' curve is that a country with flexible exchange rate requires a significant adjustment of its real exchange rate to reach symmetric shocks. As Sorensen (2005) explained that when a shock hits the domestic country and its trading partners symmetrically, there is no need for a real exchange rate adjustment. Moreover, in the case of symmetric shocks a common interest rate policy will be equally appropriate for the domestic and for foreign economy if we assume that the two countries have roughly the same social preferences for output stability relative to inflation stability, so there is no need for nominal exchange rate flexibility to allow for different national monetary policies. As the domestic and foreign economies become more integrated, it is more likely that they will be exposed to the same type of shocks. Hence they have less need for exchange rate flexibility as the degree of international economic integration increases. For this reason the costs of moving to a fixed exchange rate will fall as we move to the right along the horizontal axis in this figure.

If the domestic country allows its nominal exchange rate to depreciate in order to absorb a negative asymmetric shock to its export demand, the increase in import prices stemming from the depreciation will be transmitted more quickly to the domestic wage and price level the larger the ratio of imports to GDP. The gain in competitiveness obtained through a flexible exchange rate will, therefore, be more short-lived and consequently the cost of giving up exchange rate flexibility will be smaller the more the domestic economy depends on international trade. Also, as the domestic and foreign economies become more integrated in terms of trade and investment, the international mobility of labour is also likely to increase, since cross-border economic transactions tend to reduce the information barriers and cultural barriers to migration. If a country is hit by a negative asymmetric shock which creates unemployment, some domestic workers will emigrate to look for jobs abroad. Therefore it is unnecessary to deal with the unemployment problem through a depreciation of the domestic currency immediately. Then the cost of giving up exchange rate flexibility falls to the extent that increased economic integration implies increased labour mobility.

At the intersection point A of the benefit and cost lines in Figure 2-1, the benefits from a fixed exchange rate or common currency are just offset by the costs. At a higher degree of trade integration, the domestic country would benefit in economic terms from entering a currency union with its trading partners since the position of the benefits curve will be higher and its slope steeper in the latter case. At lower degrees of integration, the costs of exchange rate fixity exceed the benefits. OCA theory does not offer a quantitative method for estimating whether a particular country is to the right or to the left of the critical point A in Figure 2-1. But the theory does help us to focus on the factors which are important for evaluating whether fixing the exchange rate or joining a currency union is a good or bad idea. The theory also explains that if international trade integration continues to deepen in currency area, then we will find that more countries are willing to form or join a currency union with their most important trading partners. Thus the theory suggests that more European countries will want to adopt the Euro as time goes by.

The cost-benefit of a monetary union is also very much influenced by the degree of wage

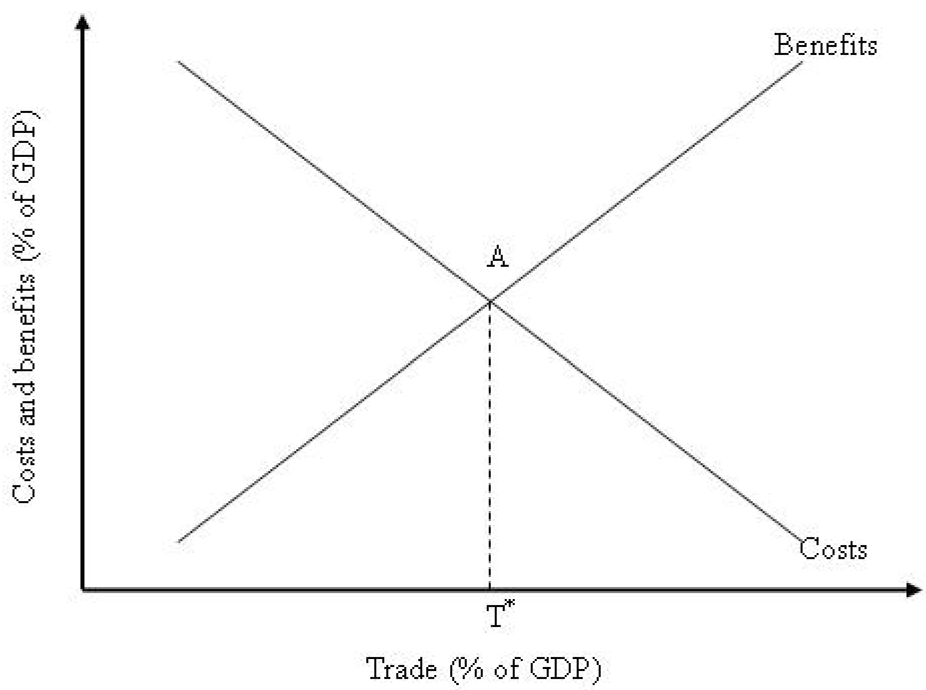

Figure 2-1. *Costs and Benefits of a Monetary Union*

rigidities and the mobility of labour. A decline in wage rigidities has the effect of shifting the cost line in Figure 2-1 downwards. As a result, the critical point at which it becomes advantageous for a country to relinquish its national currency is lowered. More countries become candidates for a monetary union. In a similar way, an increase in the degree of mobility of labour shifts the cost curve to the left and makes a monetary union more attractive. In other words, if labour mobility increases, the single market will make monetary union more attractive for members. Also the size and the frequency of asymmetric shocks determine whether a monetary union will be attractive to countries. Countries that experience very different demand and supply shocks will find it more costly to form a monetary union. In Figure 2-1, the cost line shifts to the right.

The analysis in Figure 2-1 is static and we also add some dynamics to this analysis so as to obtain a better insight into the question of how these costs and benefits of monetary union may evolve over time. Figure 2-2 discusses the relationship between the degree of trade integration among members of a potential common currency and the correlation of the business cycle.

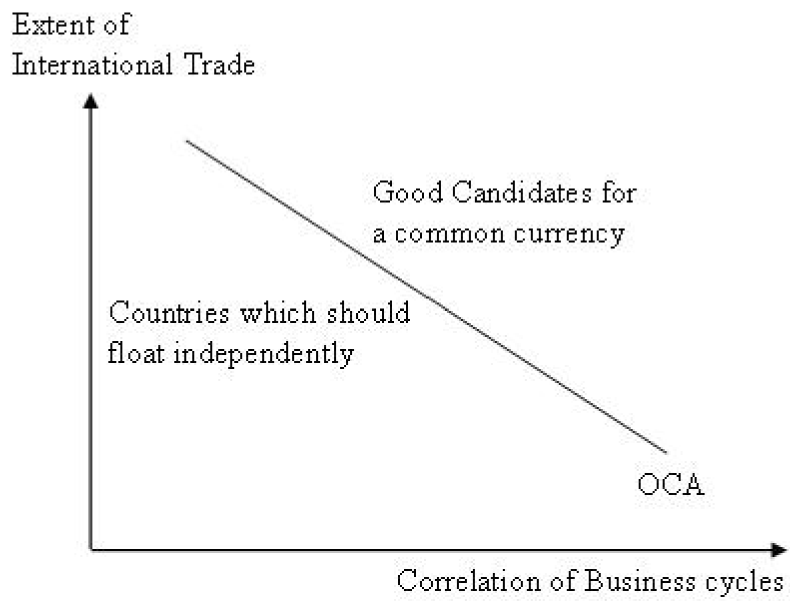

Figure 2-2. *Business Cycle Symmetry, Trade Integration and the Monetary Regime*

In long-run period, from the above discussion, we know that as trade integration increases, the net gains of a monetary union increase. At the same time, when economic divergence increases, i.e. low correlation of the business cycles, the costs of a monetary union increase. The 'OCA' curve combines the two phenomena together: the higher trade integration and closer business cycles, the more benefits and the less costs forming a monetary union. All points on the OCA line are then combinations of the business cycle correlations and integration for which the monetary union has a zero net gain. Points high up and to the right represent groupings of countries that should share a common currency; the benefits outweigh the costs of lost monetary independence.

Drawing from costs and benefits discussions, particularly with respect to the costs effects highlighted by Mundell (1961), much of literature concludes four OCA criteria:

- The degree of trade between countries who adopt a common currency
- The extent to which different countries experience similar shocks
- The degree of labour market mobility in each region
- The amount of fiscal transfers between regions

As we mentioned that the higher degree of trade between countries, the more gains these countries achieve and the more suitable to be members in OCA. A single currency requires a one size fits all monetary policy and if the loss of an independent monetary policy is not to be costly, countries must experience similar shocks. High labour mobility between the countries can overcome the problem from a single interest rate. For example, in the same currency area, one economy, A, is expanding and another, B, is contracting, but both have the same interest rate. If the labour is mobile and market flexible, economy B with high unemployment rate will seek employment in the economy A to eliminate the unemployment pressure. However, if fiscal transfers exist, income differences also can be reduced. The extending economy A can pay higher taxes that are transferred to the contracting economy B. Therefore the greater any of the four criteria between the countries, the more suitable a common currency.

2.2.4 *Empirical Evidence on OCA*

The theory of OCA and four criteria have been applied extensively in lots of empirical analysis, such as Frankel and Rose (1998), De Grauwe (2005) and Baxter and Kouparitsas (2005). They examine the four criteria or some subset using Asia and European countries data, frequently using the USA as a benchmark for comparison. A couple of papers discuss the feasibility of creating a currency union in Asia or East Asia. Some of them have a negative attitude since the lack of political commitment and experience with political cooperation results in asymmetric shocks. Chow and Kim (2003) apply the OCA criteria to investigate whether pegging to a common currency is a desirable option in East Asia including nine countries and the estimates of the EU are used as a benchmark. They find that East Asian countries are structurally different from each other and more likely to be subject to asymmetric shocks. Based on the second criteria, the less similarity of the business cycles, the more cost for a common currency peg in East Asia and it is difficult to sustain a common currency. Zhang *et al.* (2004) do very similar empirical analysis for East Asia economies. They compare the size of underlying shocks and the speed of adjustment to shocks in East Asia with the EU and the result is also similar with Chow and Kim (2003). Empirical results do not display strong support for forming an OCA in the East Asia region. However, some small sub-regions are potential candidates for OCAs, such as the Asian NIEs and the ASEAN.[10] Recently Tang (2006) examines the possibility of forming an Asian Monetary Union (AMU) for a group of 12 Asian countries again based on the OCA criteria.[11] He does not find any support for the formation of a full-fledged AMU either. Karras (2005) extend the sample countries to 18 Asian and Pacific countries across 40 years to examine a Yen OCA.[12] He compares the cost which is asymmetric business cycles and benefits which is price stability for those countries. His empirical results indicate that the estimated cost

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[10] Zhang *et al.* (2004) selected 10 East Asia countries: Japan, Korea, Taiwan, Hong Kong, Singapore, Malaysia, Indonesia, Thailand, Philippines and China, in which Asian NIEs are Hong Kong, Singapore and Taiwan, and ASEAN, are Indonesia, Malaysia, Philippines, Singapore and Thailand.

[11] Countries are Australia, China, Hong Kong, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, Thailand and Tai Wan.

[12] 18 Asian and Pacific countries are Australia, Bangladesh, China, Hong-Kong, Indonesia, India, Japan, Korea, Sri Lanka, Malaysia, Nepal, New Zealand, Pakistan, the Philippines, Papua New Guinea, Singapore, Thailand, and Taiwan.

and benefit measures exhibit substantial variability across the countries and are positively correlated. This makes the evaluation of net benefits particularly difficult because countries for which the costs are likely to be high are also those countries for which the member will be particularly beneficial and only net benefit can be compared for individual countries, for example Korea is a better candidate for adopting the Yen than Pakistan or Malaysia.

However, some papers support that forming a single currency region in East Asia is desirable. Cheung and Yuen (2004) use China, Japan and Korea's output to evaluate the prospect of creating a currency union between them. Followed by the OCA theory, they find that the three countries have synchronous output movements at both long-run and short run horizons and have considerably intensified their trade and investment interactions since 1990s. Furthermore, the estimated output loss is likely to be less than the potential benefit from forming a currency union. Therefore, their conclusion is that "China, Japan and Korea should form a currency union and promote their common economic interests" (p.24). Huang and Guo (2006) examine nine East Asia countries, with nine EMU countries adopted as benchmarks. They only find a part of countries can join in a common currency zone.

As mentioned, the creation of a common currency area may be expected to stimulate trade among the members of the currency union because the adoption of a common currency reduces the transaction costs and riskiness of international trade. Thus we would expect that, after the introduction of the Euro, trade within the Euro area has increased by more than trade between EMU and non-EMU countries. Sorensen (2005) finds that the bilateral trade between EMU countries are more than that between Demark, Sweden and the UK with EMU countries. Hence the potential benefits from EMU membership for three outsider countries appear to be less than the benefits for those EU countries which have already adopted the Euro. Sorensen also finds that the Euro (and the greater exchange rate stability in the few years before the adoption of Euro from the start of 1999) has tended to boost trade among EMU countries compared to the trade among non-EMU countries from 1993 to 2002, which is the period before and after European Monetary Unions. The Euro may so far have increased bilateral trade within the EMU by between 9 per cent and 37 per cent, depending on the estimation method used. All of these confirm that the benefits from a common currency are significant. With regard to the costs of monetary union Sorensen finds that all of the three outsider countries (Demark, Sweden and UK) have lower output co-movement[13] with the EMU area that output co-movement within the EMU, suggesting that Demark, Sweden and the UK have tended to be more exposed to asymmetric shocks than the countries in the EMU. Therefore the three outsider countries would tend to face higher costs of giving up their national currencies according to OCA theory.

Furceri and Karras (2006) compare the 10 new EU member countries with older members from the costs and benefits to decide whether they are suit to join Euro zone. The results show that the position of benefits which is price stability of the new members is overall better than some EMU countries; however, countries with high benefit also have high costs. Therefore the net benefits can be compared for them and some of them are more suitable to adopt Euro such as Poland.

2.2.5 The Endogeneity of the OCA Criteria

Figure 2-2 indicates that higher bilateral trade integration or closer business cycles represent groupings of countries that should share a common currency. Nevertheless, the degree of integration between potential members of a common currency area cannot be considered independently of income correlation since the correlation of the business cycles across countries depends on trade integration. For example, European countries trade with each other more than in the past and this trend may continue. It depends partly on regional trade policy: such initiatives as the completion of the single market in 1992 and the expansion of the EU to 15 members. EMU itself may promote bilateral trade, if the effects of the exchange rate risk and transactions costs are important, as EMU proponents claim. Thus cyclic correlation is endogenous with respect to trade integration,

[13] Lower degree of output co-movement indicates a lower degree of synchronization of national business cycles.

while integration is also affected by policy. Frankel and Rose (1998) open a large debate that OCA criteria are jointly endogenous, in particular the level of economic integration depends upon the trade intensity between two countries.

As such, the endogeneity of the OCA criteria is an application of the Lucas critique: currency union affects the underlying OCA criteria in such a way that they are more likely to be satisfied ex post, as both monetary and trade integration deepen.

2.3 The Business Cycle

2.3.1 Defining and Measuring the Business Cycle

Parkin (2005) defines that "a business cycle is the periodic but irregular up-and-down movement in production" (p.741). It is measured by fluctuations in real GDP around potential GDP.[14] When real GDP is less than potential GDP some resources are underused. For example, firms can always produce less output if they do not work at full capacity utilisation or if they do not work their labour force at full efficiency during its working shift. When real GDP is greater than potential GDP, resources are being overused. Many people work longer hours than they are willing to put up with in the long run, or machines can be utilised at more than full capacity during intense periods of production and capital is worked so intensively.

Business cycles are not regular, predictable, or repeating. Their timing changes unpredictably, but they have the same characteristics. Every business cycle has two phases: a recession and an expansion; and two tuning points: a peak and a trough. A recession is a period during which real GDP decreases (its growth rate is negative) for at least two successive quarters. An expansion is a period during which real GDP increases. (Parkin, 2005) When an expansion ends and a recession begins, the turning point is called a peak. When a recession ends and a recovery begins, the turning point is called a through.

[14] When all the economy's labour, capital, land and entrepreneurial ability are fully employed, the value of production is called potential GDP. (Parkin, 2005)

Therefore, business cycles are only temporary, whether in an expansion or in a recession, output is eventually expected to return to its trend level. The economy can remain above or below its trend level for several years. In other words, expansions last for several years and then are replaced by recessions which are also persistent. The business cycle involves shifts over time between periods of relatively rapid growth of output (recovery and prosperity), alternating with periods of relative stagnation or decline (contraction or recession) and then again experiencing these oscillations, also tries to document how persistent each stage of the business cycle is.

All countries experience economic growth, but the growth rate varies both over time and across countries. The fluctuations in economic growth rates over time tend to be correlated across countries. The literature indicates that the world economy has become more closely integrated in recent years due to many reasons such as globalisation, bilateral trade and financial flows across countries. The co-movement of macroeconomic aggregates across different countries has become a topic of increasing interest in both academic and policy circles. A number of studies focus on measuring the degree of shock asymmetry across countries.

Economic indicators are economic statistics reflecting the general direction of the economy. Some indicators are termed leading indicators because they tend to lead or forecast the direction of the economy or the business cycle; real GDP is known as a leading indicator. Other examples include industrial production, total employment, unemployment rate, balance of trade and interest rates.

It is essential for applied business cycle researchers to identify the business cycle component of macroeconomic time series since macroeconomic time series could be better characterised by stochastic trends rather than by linear trends and methods for stochastic detrending have been developed. (Nelson and Plosser, 1982) There are many different methods that can be used to decompose time series into their trend and cyclical components. Canova (1998) provides a good discussion of the many aspects of the detrending debate and finds that both quantitatively and qualitatively stylised facts of US business cycles vary widely across detrending methods and alternative detrending filters extract different types of information from the data. The most popular filter-based method is probably that proposed by Hodrick and Prescott (1980) and it is widely used in empirical work.[15] The use of the HP filter has already been criticized. King and Rebelo (1993) provide examples of how it alters measures of persistence, variability, and comovement when it is applied to observed time series and series simulated with real business-cycle models. Harvey and Jaeger (1993) and Cogley and Nason (1995) show that spurious cyclicality is induced when the HP filter is applied to the level of a random walk process. More recently, Baxter and King (1999) propose a finite moving average approximation of an ideal band-pass filter based on Burns and Mitchell's (1946) definition of the business cycle, the BP filter is designed to pass through components of time series with fluctuations between 6 and 32 quarters while removing higher and lower frequencies. It has been used in empirical studies as well.[16] There are also other methods used in empirically work, such as first order differencing (or fourth order differencing for quarterly data), Kalman filter (Kalman 1960), Beveridge and Nelson's procedure (1981) and so on.

2.3.2 Literature Review on the Business Cycle Co-movement

In early research, the judgement about shocks was based on cross-country correlation of real output, industrial production, or real exchange rate cycles, such as Cohen and Wyplosz (1989) and De Grauwe and Vanhaverbeke (1993). Backus *et al.* (1995) report that business cycles measured by pair-wise correlations in the major industrialised economies are similar. Highly synchronized European business cycles are found by Bergman (2004). Artis and Zhang (1997) find that the world business cycle became more group specific after 1979, with the German business cycle linking countries participating in the Exchange Rate Mechanism (ERM) group and these countries' business cycles became more synchronized to the German and less synchronized with the USA business cycle. Artis *et al.* (1997) find a strong business cycle association between the USA and

[15] See Frankel and Rose (1998), Crosby (2003), Clark and van Wincoop (2001) and Calderon et al. (2007).
[16] For example Baxter (1994), and King et al. (1995). Other types of band-pass filters have also been proposed. For example, see Hasler et al. (1994).

Canada and also identify a group of core European countries with highly synchronized business cycles. Rose and Engel (2002) report that members of currency unions tend to have more highly synchronized business cycles compared to countries with national monies.

Blanchard and Quah (1989) propose a bi-variate vector autoregressive (VAR) procedure in order to separate shocks from responses. Moreover, this method makes it possible to identify the origins of shocks, for example, supply and demand. They define shocks as linear combinations of the residuals from a bi-variate VAR representation of real output growth and inflation. By construction, one type shock, demand, has only a transitory impact on the level of output, while another type of shock, supply, might have a long-term impact on the level of output. Babetskii (2005) adopts the structural VAR identification methodology developed by Blanchard and Quah (1989) and finds a synchronized business cycle in ten Central and Eastern European Countries (CEECs). And furthermore they find that an increase in trade intensity leads to higher symmetry of demand shocks and a decrease in exchange rate volatility has a positive effect on demand shock convergence.

Gregory *et al.* (1997) use time-series analysis and adopt Kalman filtering and dynamic factor analysis to find the common fluctuations across macroeconomic aggregates in G7 countries. Clark and Shin (1998) focus on European countries and study the effect of country-specific shocks in industrial production by a VAR factor model. They find synchronized business cycles in European countries as well. Recently, Lumsdaine and Prasad (2003) developed a weighted aggregation procedure and provided evidence to prove a world business cycle and a European business cycle by the output correlations for 17 OECD countries.

Kose, Otrok, and Whiteman (2003) extend the sample of countries to sixty and employ a Bayesian dynamic latent factor model to study the dynamic co-movement of the business cycles. They also find a statistically significant common world business cycle in almost all sixty countries. In addition, world factor explains most economic fluctuations in developed countries, while the country-specific factor accounts for more volatility in developing countries.

A couple of studies analyse the business cycle correlations of European countries compared with the business cycle of the USA. Clark and van Wincoop (2001) compare the business cycles in 9 US census regions and 14 European Union countries and find that correlations among US regions are significantly higher than among European countries. These differences can be related to the border effect which can be explained by the lower trade among European countries compared to the trade between US Census regions. Wynne and Koo (2000) study all 15 EU countries and the 12 Federal Reserve districts in the US. They also report much higher correlations between the US districts than those between the European countries. While the long-standing members of the EU have highly synchronized cycles and large EU countries' business cycles tend to be more correlated to the US in particular the business cycle in the UK.

However, some empirical evidence does not support this point of view. Massmann and Mitchell (2003) propose that the synchronization of European business cycles is not clear and switched between convergence and divergence over the last 40 years. Using monthly data on industrial production, they find an upward trend in synchronization until the mid 1970s, a period of divergence until the mid to later 1980s, a short-lived period of convergence until the German unification in the early 1990s where synchronization fell sharply and finally a period of convergence. These results suggest that the degree of synchronization is not constant over time and that the particular sub-periods used in the analysis can affect the results. Kose, Prasad and Terrones (2003) focus on the comparison of developing countries and developed countries and find little evidence that business cycle co-movements on average become more synchronized at global level during the most recent period of globalization. The statistic of the correlations of output indicate that on average, developed countries have stronger correlations with world output than do developing countries. Industrialised countries increase their correlations sharply in the 1970's and further rise in the 1990's, however, developing countries' correlations are much lower than industrialised countries and there is a decline in the 1990's. Heathcote and Perri (2003) measure the change in the business cycle correlation between two regions, the United States and the rest of the world and find that over the last 40 years the U.S. business cycle has become less synchronized with the cycle in the rest of the world because U.S. change the nature of real shocks and increase the financial integration with others.

Studies of the business cycle have flourished and we have discussed a lot of different approaches to measure the business cycles. Some of them focus on main economic indicators correlations such as real GDP, industrial production or unemployment by different filters. Some of them use different methods to measure, such as VAR model and Bayesian dynamic latent factor model. Most studies find evidence that the business cycle co-movement becomes more synchronised across countries. What determines this closer business cycle across countries? Trade is the leading potential explanation.

2.4 The Relationship between Trade Intensity and Business Cycles

Fluctuations in export demand might cause cycles. One country's exports are another country's imports, and these imports will fluctuate only if foreign income fluctuates. International trade helps explain how cycles get transmitted from one country to another, and lots of studies have been done from theory and empirical analysis to investigate the relationship between bilateral trade intensity and the business cycle correlation.

2.4.1 The European Commission View versus the Krugman View

There are two opposite views on the relationship between trade integration and shock asymmetry, 'The European Commission View' and the 'Krugman View'. According to the European Commission (1990), closer integration leads to less frequent asymmetric shocks and to more synchronised business cycles between countries. They support the view that bilateral trade between countries is to a large degree intra-industry trade. The trade is based on the existence of economies of scale and imperfect competition (product differentiation). It leads to a structure of trade in which countries buy and sell to each other the same categories of products. Thus, France sells cars to and buys cars from UK, and vice versa. This structure of trade leads to a situation where most demand shocks will affect these countries in a similar way. For example, when consumers reduce their demand for cars, they will buy fewer French and UK cars. Thus, both countries' aggregate demand will be affected in similar ways. The removal of barriers with the completion of the single market will reinforce these tendencies. As a result, most demand shocks will tend to have similar effects. Instead of being asymmetric, these shocks will tend to be more symmetric.

On the other hand, for Krugman (1993), closer integration implies higher specialization since greater trade intensity could reflect a larger amount of inter-industry trade (trade which involves exports and imports of different goods, for example one country exports cotton and imports wines) and thus, higher risks of idiosyncratic shocks. Trade integration which occurs as a result of economies of scale also leads to regional concentration of industrial activities. The basic argument here is that when impediments to trade decline this has two opposing effects on the localisation of industries. It makes it possible to produce closer to the final markets, but it also makes it possible to concentrate production so as to profit from economies of scale (both static and dynamic). This explains why trade integration in fact may lead to more concentration of regional activities rather than less.

2.4.2 Review of the Empirical Literature on the Relationship between the Trade Integration and the Business Cycles

Frankel and Rose (1998) opened a large debate on the endogeneity of OCA criteria fulfilment. In the spirit of the European Commission (1990), Frankel and Rose (1998) put forward an argument that closer trade links could lead to the business cycle synchronization or, equivalently, increase the symmetry of shocks. 21 industrialised countries are selected and the sample period is quarterly from 1959 to 1993 which is split into four periods: 1959Q1 to 1967Q3; 1967Q4 to 1976Q2; 1976Q3 to 1985Q1 and 1985Q2 to 1993Q4. Only two variables are involved in regressions, bilateral trade intensity and the business cycle correlation. The trade intensity is measured by the log of bilateral trade between countries *i* and *j* over time period t divided either by total trade of countries *i* and *j* or nominal GDP of country *i* and country *j* for the same period. The quarterly data on real GDP, an index of industrialised production, total employment, and the unemployment rate are used as a proxy for the business cycle. As mentioned earlier, to decompose time series into a business cycle trend and cyclical components Frankel and Rose use four alternative de-trended filters to approximate the cyclical part of output after taking the natural logarithms (except for the unemployment rate): 1.) Fourth differences since most variables are in logs, this corresponds to the four-quarter growth rate; 2.) the residual from the regression of the original series on a linear time trend, a quadratic time trend, and three quarterly dummies; 3.) the original series minus the Hodrick-Precott (HP) filter; 4.) the residuals from a regression of the original series on a constant and three quarterly dummies, minus the HP trend of the residuals. Totally, they have 16 versions of correlations (four variables and four measures of the business cycle per variable) for each country pair. A positive and statistically significant relationship is found between trade intensity and the business cycle correlation.

While both of these variables could be jointly endogenous making OLS inappropriate, monetary coordination with large trade partners may generate a spurious correlation between trade and the business cycle correlation and trade could be correlated with the error term. Instrumental Variable (IV) techniques are used here to solve the endogeneity problem. Taken from the gravity model of trade, the log of distance; adjacency and language dummies are used as instruments since they can explain bilateral trade very well and also are uncorrelated with the business cycle correlations. Again they identify a positive and significant relationship between the level of bilateral trade intensity and the cross-country correlation. When the business cycle correlation is measured by real GDP increasing trade intensity (normalised by total trade) by one standard deviation increased bilateral business cycle correlation by 0.35 from a pre-trade increase level of 0.22. In addition, a series of tests are used for the robustness, such as changing the instrumental variables, adding period-specific or country-specific fixed effect, splitting the sample into two periods and so on. The results do not appear to be very sensitive to these changes. This result is confirmed by Otto *et al.* (2001) and Gruben *et al.* (2002) by the same methods and similar sample.

Followed by Frankel and Rose (1998), this relationship is estimated by a couple of other papers by extending the sample countries, period or developing methodology. Clark and van Wincoop (2001) select 14 European Union countries and 9 U.S. census regions to investigate the effect of bilateral trade on the business cycles. The business cycles are measured by annual data of both employment and real GDP. Firstly they find that the U.S. regions business cycle correlations are significantly higher than among the European countries since the European national border decreases the bilateral trade and then impact the business cycle correlations. Using pooled instrumental variable estimation they identify a positive relationship between the business cycle correlations and the bilateral trade for both EU countries and US. They also find that the effect of common border on business cycles is destroyed by including trade in regression, i.e. the common border explains the business cycles via trade as an instrumental variable. Rose and Engel (2002) extend the sample to over 150 countries. The trade intensity firstly estimated by gravity model to solve the endogeneity problem and include more instruments such as, the product of GDP per capita, trade agreement and so on. They find a consistent result with Frankel and Rose that increased international trade induces more tightly synchronized business cycles and the trade intensity does not destroy the significance of currency union in the business cycle regression.

Kose, Prasad and Torrones (2003) find an important role for trade in explaining GDP correlations alongside financial integration.[17] Using a large sample of 21 industrialised and 55 developing countries from 1960 to 1999 they find that trade and financial integration enhance global spillovers of macroeconomic fluctuations. They also compare

[17] Financial integration is also another important determinant of business cycle correlations. It affects business cycle directly or indirectly through trade intensity. Therefore we include it into our research in chapter 7.

industrialised and developing countries and find that the results are not materially affected and the effects of the trade and financial linkages on output correlations appeared to be stronger for industrialised counties than for the developing countries. Imbs (2004, 2006) and Hethcote and Perri (2004) also find a positive relationship between the trade intensity and the business cycle alongside with financial integration.

Fidrmuc (2004) questions the magnitude of the Frankel and Rose (1998) estimates and argues that "*indeed, Frankel and Rose's hypothesis underlines that bilateral trade is mainly intra-industry trade, although this indicator does not directly enter their analyses*" Fidrmuc (2004, page 5). He uses both bilateral trade and intra-industry trade which focus on the differences between import and export for the same industry to analyze the degree of the business cycles synchronization across OECD countries. He confirms that the endogeneity hypothesis of the OCA criteria and both trade intensity and intra-industry trade induce the convergence of the business cycles. Shin and Wang (2004, 2005) find the same results with Fidrmuc (2004) for a group of Asian and European countries. Shin and Wang (2004) find that intra-industry trade is the major channel through which the business cycle of Korea becomes synchronized with that of other Asian economies using data for 12 Asian countries from 1976 to 1997. They argue that increasing trade itself does not necessarily lead to more synchronization of the business cycles in Korea case. Business cycle comovements are strengthened only when increased trade is accompanied by more intra-industry trade. Shin and Wang (2005) extend the research on East Asia countries to European countries from 1977 to 1999. Again, they find that intra-industry trade is the major channel by which the European countries business cycles become synchronised which is consistent with the case of Korea and Frankel and Rose's results.

Babetskii (2005) reports similar empirical estimates to Frankel and Rose and investigates the determinants of economic integration for ten Central and Eastern European countries from 1990 to 2002 by estimated time-varying coefficients of supply and demand shock asymmetry with indicators of trade intensity and exchange rates. His result indicates that an increase in trade intensity leads to higher symmetry of demand shocks and the effect of integration on supply shock asymmetry varies from country to country. Also he finds that a decrease in exchange rate volatility has a positive effect on demand shock convergence.

Baxter and Kourparitsas (2005) focus on the large sample of 100 developing and industrialised countries from 1970 to 1992. They investigate the determinants of business cycle co-movement, using the approach of Leamer (1983) and potential candidate explanations are (i) bilateral trade between countries; (ii) total trade in each country; (iii) sectoral structure; (iv) similarity in export and import baskets; (v) factor endowments; and (vi) gravity variables. They find a consistent result with literature that higher bilateral trade between two countries is robustly correlated with a higher business cycle correlation between the countries both with and without the gravity variables. While they do not find a robust correlation between similarity in industrial structure and the business cycle correlation; countries belonging to a currency union do not have significantly more highly correlated business cycles than countries that do not share a common currency; total trade, factor endowments are also found not to be robust. Only one ‘‘gravity’’ variable, distance between the two countries, is found to be robust and it is negatively related to the business cycle correlation. Böwer and Guillemineau (2006) also confirm the bilateral trade as a key determinant of business cycle synchronisation in the context of the Euro area.

Recently, further support for the Frankel and Rose hypothesis is provided by Calderòn *et al.* (2007), who find a rise in trade intensity to have a larger impact on the output correlation for developed countries than for less developed countries pairs. They extend the sample to 147 industrialised and developing countries over 40 years (from 1960 to 1999) and estimate the relationship between trade intensity and business cycle by a two-stage fixed effects model which considers the trade endogeneity and accounts for county pair specific effects. They adopt standard measurements for both variables: the degree of business cycle synchronization between the country pair is measured by real GDP de-trended by the quadratic trend model; first difference using annual data; Hodrick-Prescott filter; and Band-pass filter; and the bilateral trade is measured by bilateral inter-industry trade and intra-industry trade. They identify a positive and statistically significant relationship in full sample, industrialised countries sample, developing countries sample and mixed sample. In full sample, an increasing in one standard deviation of bilateral trade intensity, the business cycle correlations increase from 0.05 to 0.085 which is much less than Frankel and Rose. The impact of trade intensity on the business cycle correlations among industrialised countries is higher than the impact among developing countries and the impact for industrialised-developing country pairs.[18]

The opposite view has been defended by Paul Krugman. As theory describes that trade intensity affects the business cycle correlations in two ways and Krugman (1993) argues that if inter-industry trade which is caused by greater specialization in goods and services for which a country has a comparative advantage account for a major share of international trade, the business cycle correlations will be more idiosyncratic. This view is also supported by Eichengreen (1992). Moreover, Kenen (2000) shows in a framework of the Keynesian model that the correlation between two countries' output changes increases unambiguously with the intensity of trade links between these countries. But this does not necessarily mean that asymmetric shocks are reduced as well. Kose and Yi (2001, 2006) also do not find any positive relationship between the trade intensity and the business cycles.

Kose and Yi (2001, 2006) use the same group of countries as Frankel and Rose (1998) but a different sample period (1970 to 2000). However, they question the magnitude of their estimates since they cannot be replicated using a standard international business cycle model. Kose and Yi update the model of Backus *et al.* (1994) and employ a three-country real business cycle model. The transportation costs are considered as way of introducing variation in trade since different levels of transportation costs will translate into different levels of trade with consequent effects on GDP co-movement. They simulate the effects of increased goods market integration under two asset market structures, complete markets and international financial autarky. The empirical results from the real business cycle model under both asset market structures are far away the

[18] Calderon et al (2007) report that a one standard deviation increase in bilateral trade intensity normalised by total GDP raises correlations from 0.25 to 0.33 for industrial countries which is the same order of magnitude as that reported by Frankel and Rose (1998), but the same increase in trade would lead to a negligible increase in correlations from 0.075 to 0.077 for industrial and developing countries and from 0.031 to 0.052 for developing country pairs.

magnitude from the empirical results. They explain two reasons for the model's failure: 1) observations that bilateral trade between countries is typically quite small as a share of GDP and relative to a country's total trade will affects the relationship; 2) the feedback effects from the country-pair to the world economy and then back also will result in model's failure. Even country-pairs with large absolute changes in their bilateral trade share of GDP will not generate large feedback effects if the pair constitutes a small share of world GDP.

Lots of studies analyse OECD countries while a number of studies focus on Asia or Asia-Pacific economies. Choe (2001) focuses on 10 East Asian countries to discuss economic integration through trade. His results are not very consistent with results of OECD countries and the significant level of the relationship depends on sample period and a key country, Japan. The effect of bilateral trade dependence is weakly significant for the period 1981-1990, however, in the period 1986-1995, the effect is more robust. The reason to explain it is that the change of the intraregional production structure, beginning in the late 1980s, led to the strong relationships between co-movement of business cycles and bilateral trade, through the deepened intraregional economic linkages in the early 1990s. When they only consider the developing East Asian countries (exclude Japan) the statistical robustness of trade significantly declined in both periods. This implies that Japan is a very important part in the synchronization of business cycles in this region, but the role of the developing East Asian countries themselves became important after the late 1980s.

In contrast, Crosby (2003) examines the evidence on GDP correlations in 13 Asia-Pacific countries and does not find high correlations between these countries, and does not find a significant relationship between trade and GDP correlations either. His sample includes countries that are very open to trade, such as Hong Kong, Singapore and Malaysia who all have trade-to-GDP ratios of over 100 percent and countries that are very closely synchronised with the USA such as Australia and Singapore. Recently Kumakura (2006) also selects very similar 13 Asia-Pacific countries to examine the empirical relationship between the trade and the business cycle correlations. Again, he does not find a statistically significant relationship either; instead, the economies relying on the electronics industry appear to be the key determinant of international income correlations.

2.5 The Gravity Model of Trade

There are strong arguments for instrumenting trade intensity, since a large body of literature shows that bi-lateral trade flows are endogenous. From theory, as Frankel and Rose (1998) suggested, the OCA criteria are endogenous. To capture gains from exchange rate stability countries are willing to link their currencies deliberately to those of their most important trading partners. Therefore they lose an important stability tool, monetary policy, and their monetary policy will be closely tied to that of their neighbours. This monetary policy coordination could result in an observed positive association between trade links and income links. That means exchange rate stability causes high trade and close business cycles, rather than high trade result in close business cycle. Therefore to identify the effect of bilateral trade patterns on income correlations, exogenous determinants of bilateral trade patterns need to be used as instruments. However, it is hard to find good instrumental variables which are correlated with bilateral trade intensity but uncorrelated with the residuals of the business cycle correlation equation. Fortunately, the gravity model provides a very good solution. This model is one of the most empirically successful in economics (Anderson and van Wincoop, 2003). The Gravity model is a popular formulation for statistical analysis of bilateral trade flows between different geographical entities. The regressors in the model can explain trade very well but are not correlated with the business cycle correlation. In the next section we review the model.

2.5.1 The Gravity Model of Trade Theory

The gravity model of trade in international economics predicts bilateral trade flows based on economic mass, the economic sizes calculated from GDP and distance between two units. The model was first used by Jan Tinbergen in 1962. The basic theoretical model for trade between two countries *i* and *j* takes the form of:

$$T_{ij} = G \times \frac{M_i \times M_j}{DIS_{ij}} \tag{2-1}$$

where T_{ij} is the bilateral trade flow from origin *i* to destination *j*, *M* is the economic size of each country, *DIS* is the distance and *G* is a constant. Using logarithms, the equation can be converted to a linear form for econometric analysis and constant *G* becomes part of α. The economic sizes of the exporting and importing countries, *Mi* and *Mj*, are usually measured with gross domestic product. The basic model for such a test results in the following equation:

$$ln(T_{ij}) = \alpha + \beta_1 ln(GDP_i) + \beta_2 ln(GDP_j) - \beta_3 ln(DIS_{ij}) + \varepsilon_{ij} \tag{2-2}$$

The model often includes variables to account for income level (GDP), language relationships, contiguity, and colonial history (whether Country1 ever colonized Country2 or vice versa). The model has also been used in international relations to evaluate the impact of treaties and alliances on trade, and it has been used to test the effectiveness of trade agreements and organizations such as NAFTA and the WTO.

The basic Gravity model does a pretty good job at explaining trade with just the size of the economies and their distances. However, there is a huge amount of variation in trade they cannot explain. Most authors, such as Anderson (1979) add other variables with less theoretical justification, usually because empirical analysis has shown that they “work.” We discuss the most commonly included variables as follows.

Many studies estimate the gravity model with the log of per-capita income (*ln(GDP/POP)*) of the exporting and importing countries included as well as the log of aggregate incomes (lnGDP). The idea behind this appears to be that higher income countries trade more in general. One cause might be superior transportation infrastructure (roads to the interior, container ports, airports, etc.). High income countries probably have lower tariffs as well.

One explanation for the trade impeding effects of distance was transaction costs caused by inability to communicate and cultural differences. Therefore countries that speak the same language would trade more. Part of the reason for this common language effect is probably the shared history that caused the two countries to share a language. Indeed, measures of colonial links also are positively correlated with trade. Adjacent countries that share a border are also proved to trade more.

There are numerous studies that have tested the gravity model. Deardorff (1998), Evenett and Keller (1998) and Feenstra *et al.* (1998) provide the theoretical model which best underpins the empirical findings of the gravity model. Versions of the gravity model also have been used to investigate the bilateral trade empirically, such as Frankel and Romer (1999) Frankel and Rose (2002) and Rose (2000, 2001).

2.5.2 Review of the Empirical Literature on the Gravity Model for Trade Endogeneity

McCallun (1995) and Clark and van Wincoop (2001) prove empirically that common border affects bilateral trade very much and affects the business cycle indirectly through bilateral trade intensity. McCallum's examination of the trade patterns of Canadian provinces counter that borders must matter very much because the typical Canadian province trades 20 times more with other provinces than with American states of a given size and distance.

Clark and van Wincoop (2001) argue that Europe countries are gradually becoming more integrated as barriers to cross-border flows of goods, capital and labour are being removed. Particularly, after the adoption of a single currency, their monetary and fiscal policies are becoming more coordinated. They investigate the importance of European national borders from a direct comparison of U.S. and European business cycle synchronization using 14 European Union countries and 9 U.S. Census regions. Firstly, they measure the business cycle correlation by employment and GDP data and compare correlations between 9 U.S. regions with cross European Union countries and also compare regions within France and Germany with regions between these countries. They find that the average within country business cycle correlation is larger than the cross country correlation and the difference is statistically significant that prove that the national border does play an important role. Does the border effect explain the business cycle correlation directly or via some explanations? Clark and van Wincoop add some potential explanations into the business cycle regression. From the empirical result they find that adding trade to the correlation regression causes the border effect to fall by an amount approximately equal to the coefficient on trade times the corresponding border effect for trade which is from the gravity model. In addition, the large coefficients on trade are not the result of collinearity between trade and the common border since they are identical when omitting the common border. Therefore they conclude that the trade can account for most of the observed border effect on correlations and the variable of common border is an important variable in gravity model.

Recently, Anderson and van Wincoop (2003) developed a consistent and efficient theoretical gravity model to solve the border puzzle and implement the theory in a two-country model which consist of the United States and Canada and a multi-country model that includes 22 industrialised countries. They focus on the effect of border on bilateral trade intensity and find that borders reduce trade between industrialised countries by moderate amounts of 20-50 percent which confirm Clark and van Wincoop's conclusion form empirical analysis.

These geographic characteristics are not affected by the income correlations or by government policies and we can believe that countries' geographic characteristics have no effects on their business cycle except through their impact on trade. Therefore, it is a good instrumental variable of trade on correlations. Frankel and Romer (1999) create a gravity equation as instrumental variables for bilateral trade which consider both the geography factors and other potential variables.

$$\ln(T_{ij}/GDP_i) = \alpha_0 + \alpha_1 \ln D_{ij} + \alpha_2 \ln N_i + \alpha_3 \ln A_i + \alpha_4 \ln N_j + \alpha_5 \ln A_j$$
$$+ \alpha_6 (L_i + L_j) + \alpha_7 B_{ij} + \alpha_8 B_{ij} \ln D_{ij} + \alpha_9 B_{ij} \ln N_i + \alpha_{10} B_{ij} \ln A_i \qquad (2\text{-}3)$$
$$+ \alpha_{11} B_{ij} \ln N_j + \alpha_{12} B_{ij} \ln A_j + \alpha_{12} B_{ij} (L_i + L_j) + e_{ij}$$

where bilateral trade ($\ln(T_{ij}/GDP_i)$) measured by log of the ratio of bilateral trade between country *i* and county *j* to country *i*'s GDP. D_{ij} is the distance between the country pair; *N* is population; *A* is area; *L* is a dummy for landlocked countries, and *B* is a dummy for common border between two countries. The empirical results from 63 countries across 10 years are generally as expected and confirm that geographic variables are major determinants of bilateral trade. Distance has a large and significant negative impact on bilateral trade; country *j*'s size is positive correlated with bilateral trade; the common border has a considerable effect on trade; if the country-pair share the same language, the bilateral trade is higher; and if one of the countries is landlocked, trade falls by about a third. The fitness of the regression also is quite high which is 0.36. One more question may appear that all variables used in finding the geographic component of countries' trade might have some endogenous component that is correlated with the error term in the income equation. To check that no single variable that could be endogenous is driving the results, Frankel and Romer omit each variable every time but none of these changes has a major effect on the results and all IV results remains much larger than the OLS estimates.

Most studies show a similar format of the gravity model with that of Frankel and Romer (1999) and include both basic and other potential variables. Nevertheless, there are another two important variables which should be considered regarding to evaluating trade-creating policies: free trade agreements (FTA) and monetary union.

Regional trade liberalizing agreements like Europe's common market and North America's free trade agreements have proliferated in the last 20 years and one of the primary uses of gravity model has been to evaluate them. A study by Frankel and Rose (2002) finds that FTAs lead to a tripling of trade between partners.

Another important variable for trade is monetary union. Twelve European countries have formally abandoned their national currencies and adopted a new currency, the Euro. In 2000 Ecuador abandoned its national currency as well and dollarised. A number of countries also adopted monetary regimes without abandoning the domestic currencies. In 1984 Hong Kong peg its currency with US dollar through currency board schemes and in 1991 Argentina did the same. From these evidences, lots of studies find that the effect of a common currency on international trade is large. As Rose (2000) noted that two countries with the same currency trade more than comparable countries with their own currencies, perhaps over three times as much. Substituting a single currency for several national currencies reduces the transactions costs of trade within that group of countries and also eliminates the exchange rate risk then promotes trade. Therefore, the currency union play an important role in gravity model. Frankel and Rose (2002), Rose (2000, 2001) and Rose and Engel (2002) all investigate the effect of currency union in promoting trade empirically.

Frankel and Rose (2002) use over 180 countries, almost 8000 country-pair observations, at five years intervals to investigate the implications of common currencies for trade and income. Firstly they investigate the effect of common currency on trade by gravity model. Compared with Frankel and Romer (1999), Frankel and Rose (2002) include not only the standard gravity regressors, but also other controls to demonstrate the robustness of the results. The geographic characteristics are the log of distance, a dummy for common border, common language dummy and a dummy for landlocked countries. They use log of product real GDP and log of product of land area instead of area and population for both country i and j to measure the size. The other controls include log of product real GDP per capita, common colonizer dummy, political union dummy and common free trade agreement dummy. The 'Currency Union' variable is unity if the two countries belonged to a common currency area, such as Panama and the United States, and zero otherwise. 'Currency Board' is unity if one of the countries uses the currency of the other in a currency board arrangement, such as Hong Kong and the United States. The regressions are estimated by ordinary least square and they find gravity model fits well, explaining over 60 percent of the variation in the data. The coefficients for the traditional gravity determinants are highly significant statistically and economically sensible. The negative coefficient of distance indicates the falling trade between county pairs when increase the distance. Trade rises with size (log of real GDP) and large countries are more self-sufficient. The positive coefficient of income per capita show that rich countries trade more than poor. Two countries that speak the same language trade more, as do countries that share a common land border. Belonging to a regional, common colonial heritage and a historical link to a mother country, areas in political union all have positive effects to trade. Then they focus on the currency union and currency board coefficients and the coefficients for each are positive, significant and large. Their coefficients are also similar in size and statistically significant no different. And also the coefficient of currency union are not affect by country size since after drop very small countries and the small product of sizes observations, the currency union coefficient remained highly significant and positive.

Secondly, to prove the relationship between currency union and income, Frankel and Rose (2002) estimate a regression of trade and income by two-step least square. Here trade is estimated by 6 instrumental variables: log distance, log population of county j, common language dummy, common border dummy, log product of area and landlocked which should follow the IV estimation assumption that they are correlated with trade but uncorrelated with income. The positive and significant coefficient of trade indicates that the currency union effect on income is through effect on trade. To prove this effect does only come from trade, they did some robust tests. They look for possible non trade effects by including measures of currency union directly in the income equation but they fail to find significant evidences. Then they put the effect of currency union on trade and the effect of trade on income together and find the effect of currency union on income comes through the trade route. After dropping small and poor countries or considering the time lags, the results are still significant. Another question will be asked that the common currency could be endogenous and the currency union and trade could be determined by some third factor. Hence a couple of potential third factors are included in the first step, trade equation, such as common language, colonial history, political union and so on. The currency union effect remains almost as strong as ever. Therefore the variable of currency union can be viewed as good instrumental variable from literature.

The significant effect from currency union on trade also is achieved by Rose (2000) and Rose (2001). Again using larger observations (33,903 bilateral observations spanning five years), Rose (2000) adopts the gravity model to estimate the relationship between currency union and bilateral trade. The determinants of bilateral trade include log of product of GDP; log of product of GDP per capita; log of distance; contiguity dummy; common language dummy; regional trade agreement dummy; common border dummy; colonies dummy; common currency dummy and volatility of bilateral exchange rate. All the coefficients seem reasonable and are statistically significant. These traditional gravity effects are intuitively reasonable, and have the similar magnitude with literature and the t-statistics often exceed 50 in absolute value. Both higher income per capita and larger country size increase trade. The greater the distance between two countries, the lower their trade. Sharing a land border, a language or a regional trade agreement also increases trade by economically and statistically significant amounts. Ex-colonies and their colonizers, countries with the same colonizer, and geographically disparate areas of the same state all have more intense trade. All equations fit the data relatively well, explaining over half of the variation in bilateral trade. Coefficients of currency union are all positive and significant in equations and the effect is economically large even holding all other factors constant. Rose's point estimate is that 'countries with the same currency trade over three times as much with each other as countries with different currencies.' Again, like other literatures, Rose (2000) also did a couple of sensitivity analyses: he drops the developing country pair observations to test the effect of purely developing country phenomenon; changes the measurement of monetary regime and the distance; searches for omitted variables that may be responsible for the results; adds to the default specification eleven different sets of additional regressors and also he adopts different estimation techniques, Tobit, to estimate the gravity equation. The key results do not appear sensitive either to the exact specification of the gravity equation, or to the particular estimation technique. Rose (2001) did the similar analysis for gravity model but considers the county-pair specific effects. He finds that currency union has an economically and statistically significant positive effect on trade in the large data set.

Although lower inflation has many benefits, these regimes also have their costs in terms of macroeconomic stability. These costs may be large if a country is poorly correlated with other countries that are in the same currency union. Rose and Engel (2002) follow the Rose's (2000) gravity model of international trade and find a strong and significant effect of currency union on trade again. However, they also find that the business cycles are more tightly synchronized for members of a currency union. Even they change a couple of control variables the results do not change much. When the natural of log of bilateral trade between country *i* and country *j* is used as the sole control regressor, which is estimated by gravity model IV estimation, increased international trade induces more tightly synchronized business cycles and controlling for trade does not destroy the significant of currency union. It is important test since Clark and van Wincoop (2001) find that inclusion of trade as a control destroys the border effect. Therefore members of international currency unions tend to experience more trade and at the same time more synchronized business cycles than do countries with their own currencies. Based on their empirically, the variable of currency union can not be an instrumental variable in bilateral trade equation since it is correlated with both the trade and the business cycle correlations.

From these empirical studies we find that currency union does play an important role in gravity model and the effect on trade is large. However, whether this effect of currency union on the business cycles is directly or via trade is not clear. Papers such as Frankel and Rose (2002) and Shambaugh (2004) support that the effects of currency union on income come through the promotion of trade. However papers such as those by Rose (2001) and Baxter and Kouparitsas (2005) support that the effect of a currency union to business cycle is direct. One of this thesis's tasks is test whether the currency union affect business cycle correlations directly or this effect comes through trade and currency union should be an instrumental variable for bilateral trade.

2.6 Conclusions

The theory of optimum currency areas sees the choice of exchange rate regime as a trade-off between the benefits and costs of joining a monetary union. One major benefit is that credibly fixed exchange rate reduces the risk of foreign trade and investment. Further benefits are gained if exchange rate stability is achieved by entering a currency union where adoption of a common currency reduces international transactions costs, improves market transparency and increases the liquidity of financial markets. The costs arise from the fact that a fixed exchange rate or common currency excludes the possibility of an independent national monetary policy to stabilize the domestic economy (Mundell, 1961). The benefits of common currency increase with the degree of international economic integration whereas the costs decrease with economic integration. When integration proceeds beyond a certain point, it therefore becomes optimal to switch from a flexible exchange rate to a common currency.

OCA theory suggests that the costs of giving up exchange rate flexibility within a group of trading partners will be relative small if there is a low frequency of asymmetric shocks, a high degree of labour mobility across countries, and an international transfer mechanism securing a transfer of resources from countries hit by positive shocks to those hit by negative shocks. OCA theory also implies that the benefits of a common currency will be greater the greater the volume of trade and investment across borders. The literature indicates that those EU countries which have so far chosen to opt out of the EMU do indeed tend to be more exposed to asymmetric shocks and to trade less with EU partners than those countries which have already joined the EMU.

The world economy has become more closely integrated in recent years due to many different reasons and bilateral trade intensity is a very important determination. From a theoretical viewpoint, closer international trade could result in either tighter or looser correlations of national business cycles. As Krugman points out (1993), closer bilateral trade could result in countries becoming more specialised in the goods in which they have comparative advantage if inter-industry trade accounts for major share of international trade. The countries might then be more sensitive to industry-specific shocks, resulting in more idiosyncratic business cycles. However, if intra-industry trade accounts for most trade, then the business cycles may become more similar across countries when countries trade more. Nevertheless, it is reasonable to claim that a presumption exist in favour of the latter view. A lot of studies prove this point of view empirically by different data or different models, for instance Frankel and Rose (1998), Kose *et al* (2003), Babetskii (2005), Baxter and Kourparitsas(2005), Calderòn et al (2007) and so on.

When estimating the relationship between trade intensity and the business cycle, trade intensity could be endogenous. The gravity model provides a good solution for the endogeneity problem. Lots of studies have proved that variables from the gravity model, such as common border, distance, country size, common official language and country size, are good instrumental variables since they explain bilateral trade intensity very well but are uncorrelated with the business cycle correlation. While whether the variable of currency union which explains the countries' exchange rate floating level is a good instrumental variable or not is unclear as the effect from it on the business cycle could be either direct or indirect via trade intensity.

Chapter 3 Measurement of Variables and Data Descriptions

3.1 Introduction

In theory, closer international trade could result in either tighter or looser correlations of the business cycles. Closer bilateral trade could result in countries becoming more specialised in the goods for which they have a comparative advantage. The countries might then be more sensitive to industry-specific shocks, resulting in more idiosyncratic business cycles. However, if intra-industry trade accounts for most trade, then the business cycles may become more similar across countries when countries trade more. Following the literature we focus on these two variables: the bilateral trade intensity and the business cycle correlation to do empirical analysis. Actual data on both of these variables are not available, therefore we must rely on constructed proxies. This chapter introduces definitions for these two variables and investigates them over time and across country pairs.

We follow Frankel and Rose (1998) to select 21 OECD countries plus China, Hong Kong and Mexico since those three countries are important trade partners to the 21 OECD countries. The sample period is from 1959 to 2003 and is split equally into five periods[20]. Our sample length is the same with Frankel and Rose's (1998) but extend one extra period. The business cycles are widely known to be irregular, varying in frequency, magnitude and duration. Baxter and King (1999) propose a Band-Pass filter that isolates the components of the time series with fluctuations between six and 32 quarters. Vallee (2002) finds the duration of the business cycle is about 9.25 years. Joseph Schumpeter thought there were three cycles within the economy: a long, 60-year cycle, a moderately

[20] Australia; Austria; Belgium-Luxembourg; Canada; China; Denmark; Finland; France; Germany; Greece; Hong Kong; Ireland; Italy; Japan; Mexico; Netherlands; New Zealand; Norway; Portugal; Spain; Sweden; Switzerland; United Kingdom and United States. Five periods are: 1959-67, 1968-76, 1977-85, 1986-94, and 1995-2003.

long, 10-year cycle, and a short, 40-month cycle. Therefore we believe that nine years is a good length for the cyclical period.

The reminder of this chapter is as follows: section 3.2 presents the sample selection; section 3.3 defines the measurements of the bilateral trade intensity and the business cycle correlation; section 3.4 and 3.5 presents a statistical analysis of the both variables over time and across country pairs, respectively. The summary of this chapter is presented in section 3.6.

3.2 Sample Selection

Not only developed countries but also developing countries or both developed and developing countries have been selected to investigate the relationship between the trade intensity and the business cycles empirically.[21] In this thesis, we focus on industrialised countries and follow the Frankel and Rose (1998) to select the 21 OECD countries: Australia; Austria; Belgium-Luxembourg[22]; Canada; Denmark; Finland; France; Germany; Greece; Ireland; Italy; Japan; Netherlands; New Zealand; Norway; Portugal; Spain; Sweden; Switzerland; United Kingdom and United States. Most European countries' important trading partners have been included since the bilateral trade of European countries mostly is from European countries. However, a couple of countries trade not only with European countries, but also with some countries which are in their own regions. For example the U.S.A. has a high trade volume with Germany and the U.K. and also trades a lot with Mexico and China. Japan also has a lot of trade with Asian countries. Therefore it is necessary to check whether our 21 OECD countries' most important trading partners are included in our sample.

The top twenty trading partners for each of the 21 OECD countries are shown in appendix I. All countries' top 3 trading partners are included in our sample except Japan

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[21] See Frankel and Rose (1998), Babetskii (2004), Clark and van Wincoop (2001), Haan *et al.* (2002), Calderon *et al.* (2007), Baxter and Kouparitsas (2005)

[22] We view Belgium and Luxembourg as one economic country.

and the USA.[23] Most of the European countries' important trading partners are themselves already included in our sample. Nevertheless, we find that there is a significant amount of trade between China, Hong Kong and the 21 OECD countries[24], particularly for the Asia-Pacific economies, i.e. Australia, Japan and New Zealand. Mexico is also an important trading partner to U.S.A. and Canada. The trade expenditure between the U.S.A. and Mexico represents 9.21% of the USA total trade with the rest of the world. The bilateral trade between Canada and Mexico is 2.08% of Canada's total trade. Hence, China, Hong Kong and Mexico should be included in our sample to cover most countries' important trading partners.

The first column of Table 3-1 is the percentage of total trade accounted for by the top 23 trading partners, while the second column shows how much trade occurs between each country and the 23 countries in our sample. The average percentage of total trade accounted for by the 23 sample countries is 77% and some of them are close to or exceed 90%. The last column reports the difference between the two percentages. Most countries show a slight difference with average of 8% except Japan. From appendix I, we find that the major trading partners of Japan are the Asian countries such as Korea, Indonesia, Singapore, Malaysia and Thailand. We will not include these countries in our sample as they are not that important to other European counties. We will test the robustness by using these countries later. Therefore our sample has included most important trade partners for nearly all of the sample countries.

In addition, in the second column, percentages increase at least 2-3% after adding China, Hong Kong and Mexico into our sample, particularly for Australia, Japan, New Zealand and the USA.[25] Therefore our sample of countries is 22 OECD countries plus China and Hong Kong.

The time period of observations covers 45 years from 1959 to 2003. It is probable that the degree of synchronization has changed over time and these changes are related to other

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[23] China and Korea are Japan's second and third important trade partners and Mexico is USA's third important partner.
[24] 19 of the 21 OECD countries indicate that China is in their top 20 trade partner lists and Hong Kong appears in 8 of the 21 OECD countries' top 20 trade partner lists.
[25] We didn't report percentages of twenty sample partners in Table 3-1.

Table 3-1

Bilateral Trade Percentage

Sample Countries	Top 23 (%)	23-country from our sample (%)	Differences (%)
Australia	85	69	15
Austria	87	79	8
Belgium & Luxembourg	88	86	3
Canada	93	90	3
China	81	67	14
Denmark	87	85	3
Finland	81	74	7
France	79	74	5
Germany	81	76	5
Greece	82	70	11
Hong Kong	88	77	11
Ireland	89	85	4
Italy	78	73	5
Japan	81	41	40
Mexico	95	91	4
Netherlands	83	79	5
New Zealand	85	76	8
Norway	91	88	3
Portugal	88	83	5
Spain	82	77	5
Sweden	85	83	2
Switzerland	87	84	2
UK	81	77	4
USA	81	70	11
Average	85	77	8

Source: Trade data come from IMF, Direction of Trade data set denominated by US dollars.
Notes: The percentage of top 23 is calculated by ($Trade_{i,top23}$)/($Trade_{i,world}$) and the second column is calculated by ($Trade_{i,sample}$)/($Trade_{i,world}$).

developments than the timing of EU membership, for example the exchange rate regime. Therefore we divide our sample into five periods, and each period is 9 years in length, i.e. 1959-1967, 1968-1976, 1977-1985, 1986-1994 and 1995-2003. The sub-periods can reflect different monetary regimes and different degrees of economic integration and also we can calculate the correlations based on 9 years data.

Our first period is in the Bretton Woods System (1944-68) which is the fixed exchange rate period. In 1944 the British and American governments established the International Monetary Fund (IMF), which was intended to police a system of fixed exchange known universally as the Bretton Woods system. The Bretton Woods system worked on a principle known as the Gold Standard. Under this arrangement the USA pledged to keep the dollar price of gold fixed irrevocably at the price of $35 per ounce. Other countries then fixed their currencies in terms of dollars, devaluing or revaluing as necessary in order to counteract disequilibrium. While the Bretton Woods System broke down in 1968-73, this is in our second period. On 15 August 1971, the USA announced the closing of the Gold Window because of the upward pressure on the deutschmark. After 6 months, they increased the price of gold from $35 to $38, named Smithsonian Agreement. But the Smithsonian System broke down in under 12 months. In the late 1960s, as national inflation rates began to diverge and inconsistencies in Bretton Woods became increasingly obvious, floating appeared more and more attractive as a possible solution to the problems. The period since the beginning of 1973 is the floating rate era and the major rates have floated to a more or less managed degree for the whole period, which covers our last three periods. From 1979, twelve European countries organized European Monetary System (EMS). In this era, from 1987 to 1992 it is the period of implementation of single European act period and our fourth period is in this period. The years between 1993 and 1998 are the common market and preparations for monetary union. In 1999, European Monetary Union (EMU) is organized and many of our sample countries adopt Euro after 2002 which covers our last period.

3.3 Measuring the Bilateral Trade Intensity and the Business Cycle Correlation

As we noted in chapter 2, countries with close international trade links would benefit from a common currency and are more likely to be members of an optimum currency area. If countries join a currency union, they give up a potentially important stabilising tool and countries with close business cycles would benefit from a common currency and are more likely join the OCA as well. Therefore, the bilateral trade intensity and the business cycle correlation are two criteria for OCA and also are two key variables we focus on.

3.3.1 *Bilateral Trade Intensity*

We are interested in the bilateral intensity of international trade between two countries, *i* and *j* at time *t*. Following previous literature, we use two different proxies for bilateral trade intensity.[26] Firstly, we use total bilateral trade divided by joint nominal GDP ($Y_{it}+Y_{jt}$):

$$TI^{1}_{ij,t} = \ln\left[\frac{1}{t}\sum_{t=1}^{\tau}\left(\frac{X_{ij,t}+M_{ij,t}}{Y_{i,t}+Y_{j,t}}\right)\right] \tag{3-1}$$

where $X_{ij,t}$ denotes total export (f.o.b.) from country *i* to country *j* during period *t*; $M_{ij,t}$ denotes total import (c.i.f.) from country *i* to country *j* during period *t* and $Y_{i,t}$ and $Y_{j,t}$ are level of nominal GDP in country *i* and *j* at period *t*, respectively. $TI^{1}_{ij,t}$ is the bilateral trade intensity between country *i* and country *j* at period *t* normalised by total GDP.

Secondly, total bilateral trade between country *i* and *j* divided by the aggregate trade of both countries:

$$TI^{2}_{ij,t} = \ln\left[\frac{1}{t}\sum_{t=1}^{\tau}\left(\frac{X_{ij,t}+M_{ij,t}}{X_{i,t}+X_{j,t}+M_{i,t}+M_{j,t}}\right)\right] \tag{3-2}$$

where $X_{i,t}$ denotes total global exports from country *i*, and $M_{i,t}$ denotes total imports from the world. Both of the intensities take the natural log.

The two normalisations are highly correlated (92%). We implement the t test for means and F-test for variances to examine the similarity between the two normalisations. The

[26] Frankel and Rose (1998); Clark and van Wincoop (2001); Calderón *et al*. (2007); Gruben et al., (2002); Fidrmuc (2004); and Imbs (2004 and 2006) all adopt one method or both methods to measure the trade intensity.

Table 3-2

Normalisations of Trade Intensity

	Mean t-test (H_0: $Mean(TI^1_{ij,t})$-$Mean(TI^2_{ij,t})$=0)	Variance F-test (H_0: $Var(TI^1_{ij,t})/Var(TI^2_{ij,t})$=1)
Test-value	-64.97	1.13
p-value	(0.00)	(0.02)

Notes: $TI^1_{ij,t}$ is trade intensity normalised by GDP and $TI^2_{ij,t}$ is trade intensity normalised by total trade.

Table 3-3

Correlations between Trade Intensities

	$TI^1_{ij,t}$	$TI^1_{ji,t}$	$TI^2_{ij,t}$	$TI^2_{ji,t}$
$TI^1_{ij,t}$	1.00			
$TI^1_{ji,t}$	0.93	1.00		
$TI^2_{ij,t}$	0.92	0.84	1.00	
$TI^2_{ji,t}$	0.86	0.91	0.94	1.00

Notes: $TI^1_{ij,t}$ ($TI^1_{ji,t}$) is the trade intensity from country *i* (*j*) to country *j* (*i*) normalised by GDP and $TI^2_{ij,t}$ ($TI^2_{ji,t}$) is the trade intensity from country *i* (*j*) to country *j* (*i*) normalised by total trade.

null hypothesis of the tests is trade intensity normalised by GDP, which is statistically the same with trade intensity normalised by total trade against the alternative hypotheses that they are not equally. The p-values reported in Table 3-2 reject both null hypotheses at the 5 percent significance level and indicate that the trade intensity normalised by GDP and the trade intensity normalised by total trade are not equally both from mean and variance. The difference between both measures will arise when at least one of the economies has a low level of openness. As Frankel and Rose (1998) and other papers mentioned that it is difficult to say whether normalising by total trade or total output is more appropriate from theory therefore we conduct our regressions with both trade intensities.

The trade data are taken from the *International Monetary Fund's Direction of Trade* data set, whereas nominal GDP data are taken from *SourceOECD, Economic Outlook*.[27] All data are annual frequency and cover 24 countries from 1959 to 2003. They are all expressed by US dollars. As Frankel and Rose (1998) referred, a problem which is typical

Table 3-4

Comparisons of Bilateral Trade Intensity from i to j and from j to i

		$TI^1_{ij,t}$	$TI^2_{ij,t}$
Mean (t-test)	t-value	2.76	1.28
H0: $Mean(TI_{ij,t})$-$(Mean\,TI_{ji,t})=0$	p-value	(0.01)	(0.20)
Variance (F-test)	f-value	0.92	0.94
H0: $Var(TI_{ij,t})/Var(TI_{ji,t})=1$	p-value	(0.12)	(0.26)

Notes: $TI^1_{ij,t}$ is trade intensity normalised by GDP and $TI^2_{ij,t}$ is trade intensity normalised by total trade.

of bilateral trade data is that export flows from country *i* to country *j* are not necessarily equal to import flows of country *j* from country *i*. We did a couple of following tests to compare the bilateral trade flows from country *i* to *j* and *j* to *i*.

Firstly, we find high correlations between trade intensity from country *i* to *j* and that from *j* to *i*. When the trade intensity normalised by GDP the correlation is 93% and when the trade intensity normalised by total trade the correlation is 94% (Table 3-3). Also we find that the correlations are consistent over time. Using the same tests, we compare the trade intensity from country *i* to country *j* with that from country *j* to country *i* by mean and variance in Table 3-4 and we find that the bilateral trade from *i* to *j* is the same as bilateral trade from *j* to *i* only except the mean of trade intensity when it is normalised by GDP. Therefore we would like to follow the literature to drop the repeated observations and only consider half of our observations. When we analyze the country *i* we use bilateral trade data from country *i* to country *j*. Hence 24 sample countries and 5 periods will create 1380 observations including 276 country pairs times 5 periods.

[27] Nominal GDP of China, Hong Kong and Mexico are from *World Bank World Development Indicators*, since there are no data in OECD database.

3.3.2 *The Business Cycle Correlation*

The other key variable in our study is the degree of the business cycle synchronisation between countries *i* and *j*. Choosing a proxy for the business cycle is a difficult issue, which was addressed in a long series of papers and not yet resolved. Frankel and Rose (1998) use simple de-trended and differenced indicators of economic activity. Following this literature, we use real GDP to measure the business cycle first:

$$Corr_{ij,t} = \frac{Cov(Y_{it}, Y_{jt})}{\sigma_{Y_{it}} \times \sigma_{Y_{jt}}} \qquad (3\text{-}3)$$

where *Y* is real GDP expressed in US dollars, which are from SourceOECD Economic Outlook.[28] $Corr_{ij,t}$ is the correlation of Y_{it} and Y_{jt} during period t.

Before estimating correlations, we would like to transform the variables in two different ways. Firstly, we take natural logarithms of real GDP and then de-trend it so as to isolate cyclical components of economic time series conforming to a certain definition of the business cycle. Given the importance of different de-trending procedures, and the lack of consensus about optimal de-trending techniques, we employ two difference procedures. Firstly we de-trend the variables using the well-known Hodrick-Prescott filter (Hodrick-Prescott, 1980)[29] with a $\lambda = 7$[30]. Secondly, we take simple first-differences of logs of the

[28] *SourceOECD Economics Outlook* does not report the real GDP in Dollars, so we use the GDP deflator and exchange rate from SourceOECD Economics to calculate the annual real GDP in US Dollars, covering the same sample of countries (24 countries) and years (1959-2003) as the trade data.

$$Real\ GDP = \frac{Nominal\ GDP}{GDP\ Deflator} \times \frac{US\$}{National\ Currency}$$

Real GDP data of China, Hong Kong and Mexico are from World Bank, World Development Indicators, since there are no data available in *OECD* database for those countries.

[29] According to the HP-filter, trends are retrieved by fitting a smooth line to the data points for each individual series. This smooth line is derived from minimizing the following loss function, which penalizes lack of fit and lack of smoothness:

$$\min_{\{Y_t^{Trend}\}_{t=1}^{T}} \sum_{t=1}^{T}\left(Y_t - Y_t^{Trend}\right)^2 + \lambda \sum_{t=2}^{T-1}\left[\left(Y_{t+1}^{Trend} - Y_t^{Trend}\right) - \left(Y_t^{Trend} - Y_{t-1}^{Trend}\right)\right]^2$$

The first term in the objection function is a measure of the goodness of fit. The second term is variations in the growth rate of the trend component. The parameter λ is key since it determines the trade-off between goodness-of-fit and the smoothness of the trend component. In the limit as $\lambda \to \infty$ the trend becomes linear thereby

Table 3-5

Comparison of de-trending Methods

	Mean t-test (H_0: $Mean_{Corr-HP}$-$Mean_{Corr-DI}$=0)	Variance F-test (H_0: $Var_{Corr-HP}/Var_{Corr-DI}$=1)
Test-value	6.28	0.94
p-value	(0.00)	(0.22)

Note: the subscript Corr-HP is the real GDP correlation de-trended by HP filter, and Corr-DI is the real GDP correlation de-trended by first differences.

Table 3-6

Comparison of Business Cycle Correlation Proxies

	HP-filter				Difference			
	Mean		Variance		Mean		Variance	
	t-test	p-value	F-test	p-value	t-test	p-value	F-test	p-value
GDP vs. IP	11.36	(0.00)	1.77	(0.00)	8.33	(0.00)	2.02	(0.00)
GDP vs. EM	22.13	(0.00)	1.07	(0.23)	21.86	(0.00)	1.23	(0.00)
GDP vs. UN	15.99	(0.00)	1.21	(0.00)	14.87	(0.00)	1.41	(0.00)
IP vs. EM	12.63	(0.00)	0.60	(0.00)	14.98	(0.00)	0.61	(0.00)
IP vs. UN	4.54	(0.00)	0.68	(0.00)	6.18	(0.00)	0.70	(0.00)
EM vs. UN	-8.16	(0.00)	1.13	(0.05)	-9.76	(0.00)	1.14	(0.03)

Note: GDP is real GDP correlations, IP is industrial production correlations, EM is total employment correlations, and UN is unemployment rate correlations. Both t-test and f-test are the same with Table 3-2.

real GDP, multiplying by 100, so that the resulting variable can be interpreted as a growth rate.

These correlations are estimated between two countries over a given span of time. The sample contains 1380 observations $[(1+23)\times 23 \div 2 \times 5]$ as well, 276 country pairs time 5 periods. Again, we compare the different de-trending methods by correlations' mean and variance. Table 3-5 reports comparison results of t-test for the mean and f-test for the

allowing for large fluctuations in the cyclical component. When $\lambda \to 0$ the trend component instead becomes equal to the data series Y_t, and the cyclical component approaches zero.

[30] As Harvey and Jaeger's (1993) show that the use of HP-filter can generate spurious cyclical patterns. Hodrick and Prescott take λ as a fixed parameter, which they set λ equal to 1600 for US quarterly data. Their choice of this value was based upon a prior about the variability of the cyclical part relative to the variability of the change in the trend component. In our case we will use the value of $\lambda = 7$ for annual real GDP

Table 3-7

Correlations for Different Measures of the Business Cycle

	GDP-HP	GDP-DI	IP-HP	IP-DI	EM-HP	EM-DI	UN-HP
GDP-DI	0.88						
IP-HP	0.23	0.23					
IP-DI	0.17	0.18	0.91				
EM-HP	0.22	0.21	0.39	0.35			
EM-DI	0.22	0.23	0.42	0.38	0.68		
UN-HP	0.26	0.23	0.43	0.37	0.46	0.44	
UN-DI	0.24	0.25	0.45	0.43	0.42	0.46	0.89

Note: GDP is real GDP correlations, IP is industrial production correlations, EM is total employment correlations, and UN is unemployment rate correlations.

variance. We find the real GDP correlations de-trended by HP-filter and first differences to have a different mean but the same variance.

Real GDP is not the only measure of economic achieving that can be used to measure the business cycle and from theory we also adopt industrial production, total employment and the unemployment rate as good proxies.[31] Table 3-6 presents the results of economic activities comparisons. Based on p-values, it is very clear that all of the means of four economic activities, real GDP, industrial production, total employment and unemployment rate, are significantly different, and also nearly all of them have different variances. In Table 3-7 we find high correlations between de-trending methods but the correlations between different economic activities are much lower. For example, the correlation coefficient of different de-trending methods of real GDP is 88%, but real GDP correlations have low correlations with industrial production, employment and unemployment. It is necessary to select different economic activities to measure the business cycle but we do not show all estimation results together. We report results when the business cycle is measured by industrial production, total employment and unemployment rate in the robustness test section.

[31] Davidas and Szapary (2004) discuss various measures of business cycles also from the perspective of the acceding countries. Anderson, Kwark and Vahid (1999) use the quarterly indices of industrial production to measure the business cycles since GDP data for their countries is only available at an annual frequency and Bergman (2004), Fidrmuc (2004) use the industrial production as well. Bayoumi and Eichengreen (1994), Crosby (2003) and Calderon et al. (2007) use annual data on GDP to measure the correlations of business cycle. Clark and Van Wincoop (2001) adopt both Employment and GDP.

3.4 Bilateral Trade Intensity Analysis – Across Countries and Periods

The bilateral trade intensities are panel data containing 276 country pairs across five periods, from 1959 to 2003. Hence we would like to compare them across country pairs and over time.

In Table 3-8 we present the average bilateral trade intensity normalised by nominal GDP for each individual countries across five sub-periods and the whole period. The average value is calculated from each individual country with its 23 partners. The first five columns report the average bilateral trade intensities for each period. It is clear that nearly all countries increase their trade intensities over time. The average trade intensities of 24 counties show a clear upward trend from 0.27% in the first period to 0.56% in the last period. The column of ‘change’ shows the difference between the first period (1959 to 1967) and the last period (1995 to 2003) which is calculated by $[(TI_{Period5}-TI_{Period1})/TI_{Period1}]\times 100$. As we expect that all 24 countries report positive values indicating all countries have more bilateral trade over time. Some countries such as China, Hong Kong and Mexico have large increases since they become more open to the world recently and bilateral trade has increased at a faster rate than GDP. A couple of European countries also increase their intensities much, such as Spain, Ireland and Portugal. The last column presents the bilateral trade intensity for whole period. Germany, Belgium & Luxembourg and the Netherlands report the highest trade intensity and Mexico, New Zealand and Greece report the lowest trade intensity. This finding is consistent with the gravity model theory and literature. How far a country is from other countries provides considerable information about the amount that it trades. New Zealand is far from most other countries which reduce its trade, and Greece also is relatively far from other European countries. However, Belgium, the Netherlands and Germany are close to European countries and many of the world’s most populous countries.

Table 3-8

Average Trade Intensity normalised by Nominal GDP

Periods / Countries	1959-67	1968-76	1977-85	1986-94	1995-03	Change (%)	1959-03
Australia	0.0022	0.0021	0.0021	0.0021	0.0025	14	0.0022
Austria	0.0018	0.0027	0.0030	0.0033	0.0039	117	0.0029
Belgium & Luxembourg	0.0065	0.0082	0.0097	0.0097	0.0107	65	0.0090
Canada	0.0024	0.0027	0.0028	0.0029	0.0037	52	0.0029
China	0.0004	-	0.0025	0.0050	0.0053	1230	0.0033
Denmark	0.0035	0.0041	0.0043	0.0041	0.0049	42	0.0042
Finland	0.0019	0.0027	0.0029	0.0029	0.0038	102	0.0028
France	0.0029	0.0055	0.0067	0.0072	0.0082	179	0.0061
Germany	0.0065	0.0086	0.0108	0.0106	0.0134	107	0.0100
Greece	0.0008	0.0010	0.0011	0.0012	0.0014	83	0.0011
Hong Kong	0.0012	0.0019	0.0030	0.0088	0.0102	762	0.0050
Ireland	0.0009	0.0013	0.0020	0.0025	0.0038	337	0.0021
Italy	0.0030	0.0044	0.0055	0.0058	0.0076	148	0.0053
Japan	0.0015	0.0024	0.0028	0.0026	0.0029	90	0.0025
Mexico	0.0004	0.0005	0.0008	0.0011	0.0022	480	0.0010
Netherlands	0.0068	0.0083	0.0097	0.0095	0.0100	47	0.0088
New Zealand	0.0011	0.0011	0.0011	0.0010	0.0011	4	0.0011
Norway	0.0029	0.0038	0.0042	0.0039	0.0044	54	0.0038
Portugal	0.0008	0.0012	0.0013	0.0023	0.0027	228	0.0017
Spain	0.0012	0.0018	0.0023	0.0038	0.0057	376	0.0029
Sweden	0.0046	0.0062	0.0062	0.0052	0.0071	55	0.0059
Switzerland	0.0036	0.0042	0.0046	0.0047	0.0066	85	0.0047
UK	0.0055	0.0070	0.0083	0.0079	0.0080	44	0.0074
USA	0.0019	0.0028	0.0037	0.0041	0.0053	184	0.0035
Average	0.0027	0.0037	0.0042	0.0047	0.0056	204	0.0042
Regions							
European	0.0032	0.0043	0.0049	0.0051	0.0063	98	0.0048
Asia-Pacific	0.0013	0.0019	0.0023	0.0039	0.0044	243	0.0028
NAFTA	0.0015	0.0020	0.0024	0.0027	0.0037	140	0.0025

Source: Trade data are taken from the International Monetary Fund's Direction of Trade data set, nominal GDP data are taken from SourceOECD, Economic Outlook. China, Hong Kong and Mexico's GDP are from World Bank. We have no trade data for China from 1968 to 1976.

Notes: Trade intensity is measured by $TI^{1}_{ij,t} = \ln\left[\frac{1}{t}\sum_{t=1}^{\tau}\left(\frac{X_{ij,t}+M_{ij,t}}{Y_{i,t}+Y_{j,t}}\right)\right]$ and an average value obtained using the values from the country pairs. % of changes is calculated by $[(TI_{Period5} - TI_{Period1}) / TI_{Period1}]*100$.
Asia-Pacific region includes Australia, China, Hong Kong, Japan, and New Zealand; NAFTA includes Canada, Mexico and USA; all other 16 European countries are in the European region. All data reported in this table are without natural log.

In the second panel of Table 3-8 we show the average regions' trade intensities across periods. The Asia-Pacific region includes Australia, China, Hong Kong, Japan, and New Zealand; NAFTA includes Canada, Mexico and the USA; all other 16 countries are in the European region. All these regions and the average 24 countries bilateral trade intensities are draw in Figure 3-1. It is clear that the European countries have the highest trade intensities across five periods. We also find that European countries increased their trade intensity in the last period more than other periods, which probably can be explained by the introduction of the Euro in 1999. In the first two periods, Asia pacific and the NAFTA regions have similar level of trade intensities, then Asia Pacific region increase much faster than NAFTA. Generally, the trade intensity of European countries is nearly twice that of the other two regions.

We report the trade intensity normalised by total trade in Table 3-9. 19 of 24 countries have stable or a little decreasing trade intensities in the first three periods and only five of them have a clear upward trend, which is a bit different with the trade intensity normalised by GDP. Average values of 24 countries indicate that average trade intensities

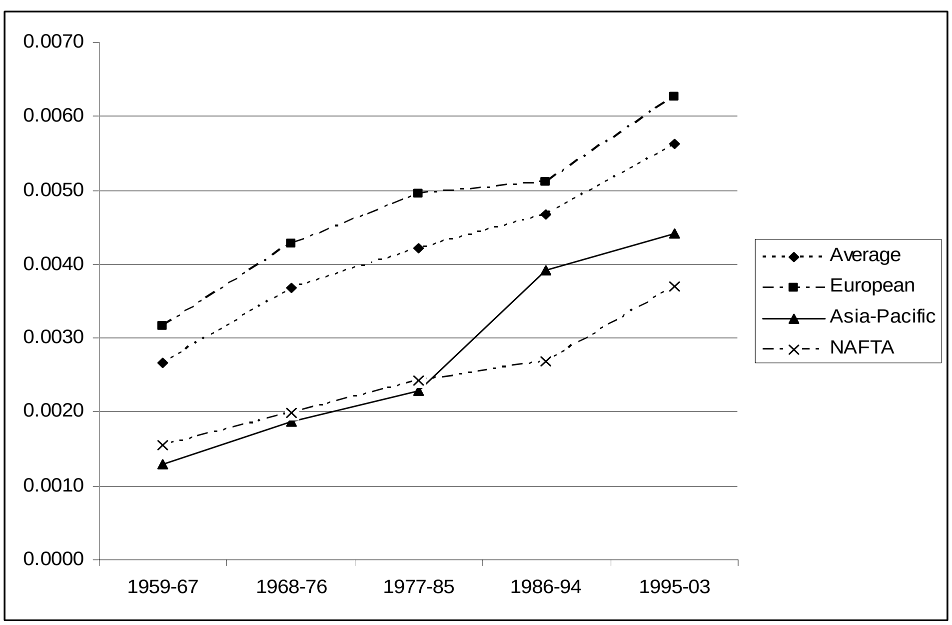

Figure 3-1. *Average and Regions Bilateral Trade Intensity normalised by GDP*

Source: Table 3-8.

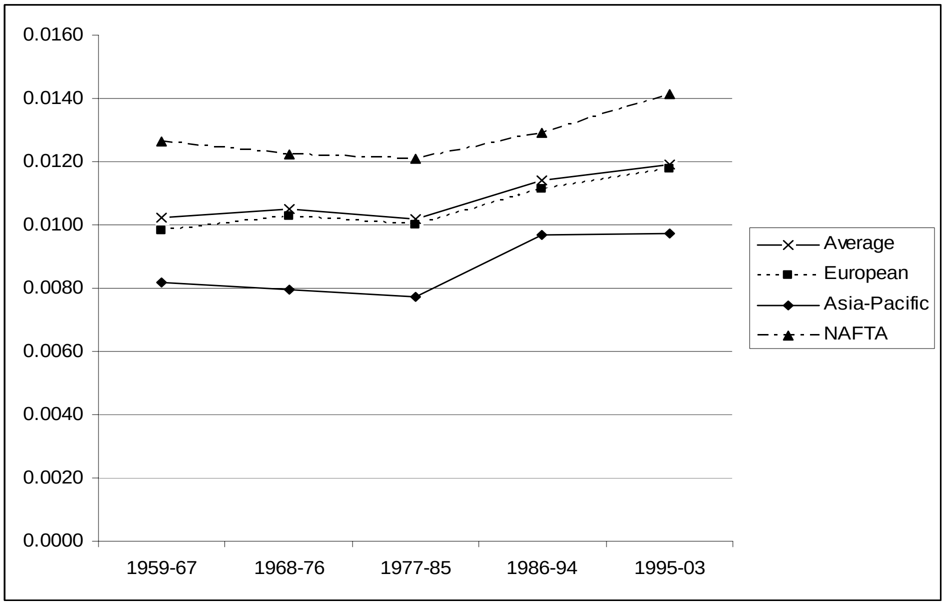

Figure 3-2. *Average and Regions Bilateral Trade Intensity normalised by Total Trade*

Source: Table 3-9

are the same in the first and the third periods which are 1.02% and a little bit higher in the second period, 1.05%. In the last two periods, their average trade intensities increase to 1.14% and 1.19%. We also find that seven countries have negative change percent between first and last period.

Germany, Belgium-Luxembourg and the Netherland still have very high trade intensities when they are measured by total trade. The USA and the UK report very high trade intensity as well and they are only a little less than Germany. This result can be explained by the USA and the UK have large bilateral trade volumes with these industrial countries, however, the bilateral trade are relatively low to their GDP. The regions trade intensities are reported in the bottom panel in Table 3-9 and Figure 3-2. We find that the European countries are not the highest intensity regions any more and they are even lower than the average values. While NAFTA presents high trade intensities mainly because of the high value from the USA and there are only three members in NAFTA. All three regions have stable trade intensities in the first three periods and increase from 1986. Compare with trade intensity normalised by GDP, trade intensity normalised by total trade have relative high values.

Table 3-9

Average Trade Intensity normalised by Total Trade

Periods / Countries	1959-67	1968-76	1977-85	1986-94	1995-03	Change (%)	1959-03
Australia	0.0098	0.0083	0.0069	0.0068	0.0067	-32	0.0077
Austria	0.0058	0.0065	0.0061	0.0070	0.0070	21	0.0065
Belgium & Luxembourg	0.0144	0.0147	0.0142	0.0148	0.0152	5	0.0147
Canada	0.0123	0.0121	0.0107	0.0108	0.0108	-13	0.0113
China	0.0076		0.0084	0.0101	0.0116	52	0.0094
Denmark	0.0093	0.0092	0.0085	0.0087	0.0088	-5	0.0089
Finland	0.0055	0.0062	0.0059	0.0065	0.0066	20	0.0062
France	0.0152	0.0172	0.0169	0.0192	0.0187	23	0.0175
Germany	0.0234	0.0234	0.0235	0.0255	0.0282	20	0.0248
Greece	0.0027	0.0029	0.0025	0.0029	0.0029	9	0.0027
Hong Kong	0.0092	0.0081	0.0081	0.0137	0.0139	51	0.0106
Ireland	0.0026	0.0031	0.0039	0.0049	0.0064	143	0.0042
Italy	0.0133	0.0133	0.0136	0.0165	0.0177	33	0.0149
Japan	0.0103	0.0119	0.0123	0.0148	0.0136	32	0.0126
Mexico	0.0031	0.0026	0.0040	0.0044	0.0070	127	0.0042
Netherlands	0.0149	0.0151	0.0148	0.0153	0.0147	-1	0.0150
New Zealand	0.0040	0.0035	0.0029	0.0029	0.0028	-31	0.0032
Norway	0.0079	0.0087	0.0084	0.0082	0.0080	1	0.0082
Portugal	0.0026	0.0031	0.0029	0.0051	0.0054	106	0.0038
Spain	0.0053	0.0063	0.0068	0.0108	0.0128	142	0.0084
Sweden	0.0136	0.0144	0.0128	0.0117	0.0123	-9	0.0130
Switzerland	0.0107	0.0102	0.0094	0.0100	0.0117	9	0.0104
UK	0.0198	0.0187	0.0194	0.0198	0.0183	-8	0.0192
USA	0.0225	0.0219	0.0215	0.0235	0.0247	10	0.0228
Average	0.0102	0.0105	0.0102	0.0114	0.0119	29	0.0108
Regions							
European	0.0098	0.0103	0.0100	0.0111	0.0118	20	0.0106
Asia-Pacific	0.0082	0.0080	0.0077	0.0097	0.0097	18	0.0087
NAFTA	0.0126	0.0122	0.0121	0.0129	0.0141	12	0.0128

Source: Trade data are taken from the International Monetary Fund's Direction of Trade data set. We have no data for China from 1968 to 1976.

Notes: Trade intensity is measured by $TI^{2}_{ij,t} = \ln\left[\frac{1}{t}\sum_{t=1}^{\tau}\left(\frac{X_{ij,t}+M_{ij,t}}{X_{i,t}+X_{j,t}+M_{i,t}+M_{j,t}}\right)\right]$ and an average value obtained using the values from the country pairs. % of changes is calculated by $(TI_{Period5} - TI_{Period1}) / TI_{Period1} * 100$. Asia-Pacific region includes Australia, China, Hong Kong, Japan, and New Zealand; NAFTA includes Canada, Mexico and USA; all other 16 European countries are in European region. All data reported in this table are without natural log.

Table 3-10

Bilateral Trade Intensity normalised by GDP across Country Pairs

	Australia	Austria	Belgium & Luxembourg	Canada	China	Denmark	Finland	France	Germany	Greece	Hong Kong	Ireland	Italy	Japan	Mexico	Netherlands	New Zealand	Norway	Portugal	Spain	Sweden	Switzerland	UK	USA
Australia																								
Austria	0.04																							
Belgium & Luxembourg	0.16	0.40																						
Canada	0.21	0.06	0.16																					
China	0.34	0.07	0.11	0.28																				
Denmark	0.05	0.26	0.50	0.06	0.06																			
Finland	0.08	0.20	0.46	0.04	0.08	0.75																		
France	0.14	0.23	2.68	0.17	0.14	0.24	0.16																	
Germany	0.21	1.59	2.56	0.25	0.32	0.77	0.38	2.41																
Greece	0.03	0.15	0.26	0.02	0.02	0.12	0.11	0.16	0.31															
Hong Kong	0.46	0.11	0.31	0.19	4.02	0.16	0.11	0.11	0.22	0.03														
Ireland	0.06	0.09	0.38	0.07	0.02	0.19	0.16	0.19	0.24	0.07	0.09													
Italy	0.18	0.63	0.88	0.18	0.17	0.25	0.14	1.77	2.10	0.30	0.17	0.12												
Japan	0.66	0.04	0.10	0.42	0.74	0.06	0.04	0.18	0.39	0.05	0.52	0.04	0.12											
Mexico	0.03	0.02	0.08	0.30	0.06	0.02	0.02	0.09	0.14	0.00	0.07	0.03	0.09	0.14										
Netherlands	0.18	0.49	6.80	0.22	0.23	0.75	0.46	1.33	3.26	0.31	0.41	0.52	1.02	0.19	0.06									
New Zealand	1.07	0.02	0.10	0.07	0.07	0.04	0.03	0.04	0.05	0.05	0.27	0.05	0.04	0.12	0.02	0.06								
Norway	0.05	0.15	0.42	0.20	0.04	1.44	0.65	0.24	0.54	0.06	0.11	0.19	0.12	0.07	0.01	0.64	0.02							
Portugal	0.02	0.14	0.35	0.03	0.01	0.19	0.14	0.28	0.28	0.05	0.04	0.11	0.19	0.02	0.02	0.31	0.02	0.19						
Spain	0.06	0.15	0.49	0.07	0.11	0.14	0.12	1.07	0.76	0.09	0.10	0.13	0.63	0.07	0.19	0.55	0.01	0.11	0.70					
Sweden	0.16	0.38	0.90	0.13	0.10	2.29	1.76	0.39	0.97	0.13	0.20	0.22	0.33	0.09	0.06	1.00	0.05	2.33	0.24	0.24				
Switzerland	0.13	1.21	0.99	0.13	0.11	0.39	0.25	0.89	1.64	0.12	0.54	0.20	1.00	0.15	0.11	0.75	0.04	0.21	0.23	0.29	0.49			
UK	0.63	0.25	1.35	0.72	0.19	0.73	0.47	1.24	1.58	0.14	0.48	1.51	0.83	0.32	0.07	1.59	0.37	0.93	0.29	0.57	0.99	0.59		
USA	0.19	0.04	0.17	2.58	0.28	0.06	0.04	0.34	0.61	0.02	0.31	0.07	0.28	1.20	0.84	0.22	0.04	0.05	0.03	0.13	0.12	0.12	0.57	
Average	0.22	0.29	0.90	0.29	0.33	0.42	0.28	0.61	1.00	0.11	0.50	0.21	0.53	0.25	0.10	0.88	0.11	0.38	0.17	0.29	0.60	0.47	0.74	0.35
S.D.	0.26	0.39	1.47	0.52	0.82	0.54	0.38	0.68	1.00	0.09	1.23	0.30	0.57	0.29	0.17	1.24	0.21	0.54	0.16	0.27	0.70	0.51	0.49	0.55

Notes: All the data source and measurement are the same with Table 3-8 and they are present as %.

Table 3-11

Bilateral Trade Intensity normalised by Total Trade across Country Pairs

	Australia	Austria	Belgium & Luxembourg	Canada	China	Denmark	Finland	France	Germany	Greece	Hong Kong	Ireland	Italy	Japan	Mexico	Netherlands	New Zealand	Norway	Portugal	Spain	Sweden	Switzerland	UK	USA
Australia																								
Austria	0.12																							
Belgium & Luxembourg	0.29	0.50																						
Canada	0.54	0.12	0.29																					
China	1.59	0.25	0.25	0.73																				
Denmark	0.15	0.52	0.62	0.12	0.20																			
Finland	0.24	0.41	0.54	0.09	0.27	1.54																		
France	0.45	0.61	6.12	0.44	0.41	0.67	0.47																	
Germany	0.55	3.75	5.42	0.60	0.75	1.89	0.94	6.61																
Greece	0.11	0.38	0.33	0.05	0.07	0.28	0.29	0.51	0.78															
Hong Kong	0.92	0.13	0.26	0.30	8.66	0.18	0.10	0.23	0.46	0.03														
Ireland	0.15	0.13	0.37	0.12	0.06	0.29	0.27	0.49	0.52	0.12	0.06													
Italy	0.59	1.81	1.91	0.48	0.51	0.73	0.40	5.41	5.56	0.90	0.35	0.31												
Japan	3.33	0.22	0.42	1.73	3.58	0.30	0.21	0.77	1.47	0.27	2.36	0.21	0.56											
Mexico	0.13	0.08	0.13	0.64	0.17	0.06	0.06	0.29	0.38	0.01	0.11	0.07	0.29	0.74										
Netherlands	0.34	0.68	7.89	0.40	0.43	1.03	0.64	3.13	6.93	0.44	0.38	0.59	2.23	0.76	0.13									
New Zealand	3.58	0.04	0.12	0.16	0.27	0.07	0.06	0.15	0.12	0.16	0.27	0.09	0.14	0.59	0.07	0.09								
Norway	0.14	0.32	0.52	0.42	0.16	2.87	1.33	0.67	1.32	0.15	0.11	0.29	0.37	0.36	0.03	0.87	0.04							
Portugal	0.08	0.31	0.40	0.07	0.04	0.38	0.30	0.78	0.65	0.14	0.04	0.17	0.55	0.11	0.07	0.40	0.05	0.39						
Spain	0.21	0.43	0.91	0.18	0.31	0.43	0.37	3.14	1.93	0.31	0.16	0.35	1.91	0.35	0.77	1.04	0.05	0.37	2.03					
Sweden	0.46	0.80	1.26	0.29	0.28	4.80	3.76	1.16	2.43	0.32	0.25	0.39	0.95	0.41	0.19	1.54	0.12	4.99	0.53	0.71				
Switzerland	0.36	2.39	1.30	0.28	0.32	0.79	0.50	2.62	3.91	0.28	0.67	0.31	2.75	0.70	0.34	1.10	0.09	0.41	0.48	0.85	1.03			
UK	1.90	0.61	2.71	1.85	0.53	1.89	1.21	3.38	3.79	0.37	1.00	3.64	2.27	1.31	0.22	3.21	1.08	2.28	0.75	1.58	2.52	1.42		
USA	1.46	0.27	1.17	16.09	1.45	0.46	0.28	2.13	3.42	0.17	1.81	0.46	1.91	8.30	5.21	1.40	0.34	0.41	0.21	0.96	0.86	0.88	3.55	
Average	0.77	0.65	1.47	1.13	0.93	0.89	0.62	1.75	2.48	0.27	1.06	0.42	1.49	1.26	0.42	1.50	0.32	0.82	0.38	0.84	1.33	1.04	1.92	2.28
S.D.	0.98	0.87	2.11	3.29	1.85	1.11	0.79	1.85	2.32	0.21	2.84	0.72	1.54	1.82	1.06	1.90	0.69	1.13	0.42	0.74	1.46	1.06	1.13	3.47

Notes: All the data source and measurement are the same with Table 3-9 and they are present as %.

Bilateral trade intensities also vary across countries and we would like to identify the different effects from their partners. Table 3-10 shows the bilateral trade intensity normalised by nominal GDP for the whole period (1959-2003).

The results confirm the gravity model theory again that closer countries or countries within the same region have more bilateral trade. We find that Australia and New Zealand have 1.07% bilateral trade intensity, 2.58% for US and Canada, 1.51% for the UK and Ireland and their intensities are much higher than the average value, 0.42%. The Nordic region has high intra bilateral trade intensity. Most of their bilateral values are greater than one and some even are greater than two. China and Hong Kong are very close and part of China's import and export are through Hong Kong, therefore their bilateral trade intensity (4.02%) is very high. Another finding from Table 3-10 is that the bilateral trade intensity between core European countries which include 6 initial European Community (EC) members Belgium-Luxembourg, Germany, France, Italy and the Netherlands plus UK are very high and most of them are greater than one. This also proved that currency union do have an important effect on trade and improve the bilateral trade intensity.

The bilateral trade intensity normalised by total trade in Table 3-11 shows a more significant result that closer country-pairs or country pairs in the same region present higher values. We find the USA has extremely high trade intensities with Canada, Mexico, Japan, which are 16.09%, 5.21%, 8.3% respectively. Amongst the Asia-Pacific regions, Australia – New Zealand, Australia – Japan, Japan-China, Japan-Hong Kong and China-Hong Kong all have high intensities. The Nordic region, including Denmark, Finland, Norway, and Sweden and Core European countries, have high bilateral trade intensities as well. However the country pairs that are far from each other or not are in the same region, such as Portugal - Greece and Norway and Mexico show very low intensities.

As we said, difference between both bilateral trade measures will arise when at least one of the economies has a low level of openness. Therefore we would like to have a look at the openness for each individual country across five periods. If traded goods and services

Table 3-12

Average Trade Openness

Periods / Countries	1959-67	1968-76	1977-85	1986-94	1995-03	Change (%)	1959-03
Australia	0.24	0.24	0.27	0.28	0.34	39	0.30
Austria	0.33	0.44	0.51	0.52	0.66	102	0.57
Belgium & Luxembourg	0.66	0.91	**1.11**	**1.10**	**1.22**	84	**1.13**
Canada	0.31	0.40	0.47	0.48	0.68	120	0.55
China	0.00	0.00	0.18	0.37	0.46	26329	0.36
Denmark	0.48	0.48	0.53	0.49	0.55	15	0.52
Finland	0.35	0.44	0.51	0.43	0.58	68	0.50
France	0.17	0.29	0.37	0.35	0.43	157	0.38
Germany	0.28	0.37	0.47	0.43	0.49	73	0.46
Greece	0.21	0.27	0.31	0.32	0.32	54	0.31
Hong Kong	**1.04**	**1.35**	**1.53**	**2.23**	**2.43**	135	**2.25**
Ireland	0.55	0.72	0.93	0.97	**1.17**	113	**1.07**
Italy	0.21	0.31	0.39	0.32	0.40	95	0.36
Japan	0.15	0.22	0.23	0.15	0.17	15	0.17
Mexico	0.10	0.11	0.18	0.29	0.60	525	0.40
Netherlands	0.64	0.76	0.87	0.82	0.99	56	0.90
New Zealand	0.35	0.40	0.48	0.43	0.47	33	0.45
Norway	0.44	0.51	0.53	0.49	0.51	17	0.50
Portugal	0.30	0.35	0.47	0.52	0.54	82	0.51
Spain	0.14	0.21	0.26	0.29	0.40	186	0.33
Sweden	0.34	0.45	0.48	0.43	0.61	77	0.51
Switzerland	0.43	0.47	0.55	0.54	0.60	41	0.56
UK	0.29	0.39	0.43	0.40	0.42	43	0.41
USA	0.07	0.11	0.15	0.16	0.19	176	0.16
Average	0.34	0.42	0.51	0.53	0.63	89	0.57
Regions							
European	0.37	0.46	0.55	0.54	0.63	72.23	0.58
Asia-Pacific	0.36	0.44	0.54	0.69	0.77	117.19	0.71
NAFTA	0.16	0.21	0.27	0.31	0.49	210.81	0.37

Notes: The trade data come from IMF, Direction of Trade data set and nominal GDP come from SourceOECD, Economic Outlook. All the data are annually and denoted by US dollars. Bold mark values are high openness values which are greater than 1. The openness for each individual country is average value in periods.

constitute a large proportion of the economy, then exchange rate uncertainty is a more serious issue for the country in the aggregate. Such an economy may be too small and too open to have an independent floating currency. Table 3-12 presents average trade openness for 24 countries. The openness is measured by country's total trade with world divided by its nominal GDP as follows:

$$Openness_{i,t} = \frac{Import_{iworld,t} + Export_{iworld,t}}{Nominal\ GDP_{i,t}},\quad i = Australia, Austria, ..., US. \qquad (3\text{-}4)$$

where total trade is import plus export of country *i* with world during period *t*. Both trade and nominal GDP are annual data and expressed by US dollars.

All countries show increasing trends openness over time and foreign trade has become increasingly important for some countries, such as China, Hong Kong, Mexico and Spain. In this case, we find China's change percentage is very large if we compare the last period with the first period. Between 1960 and 1962, China suffered a serious natural disaster and a cultural revolution lasted for ten years from 1966 to 1976. Both happened in our first two periods. In these years, the international trade of China is nearly zero. After 1979, China changed policy and it became more and more open and bilateral trade with other countries increased very fast.

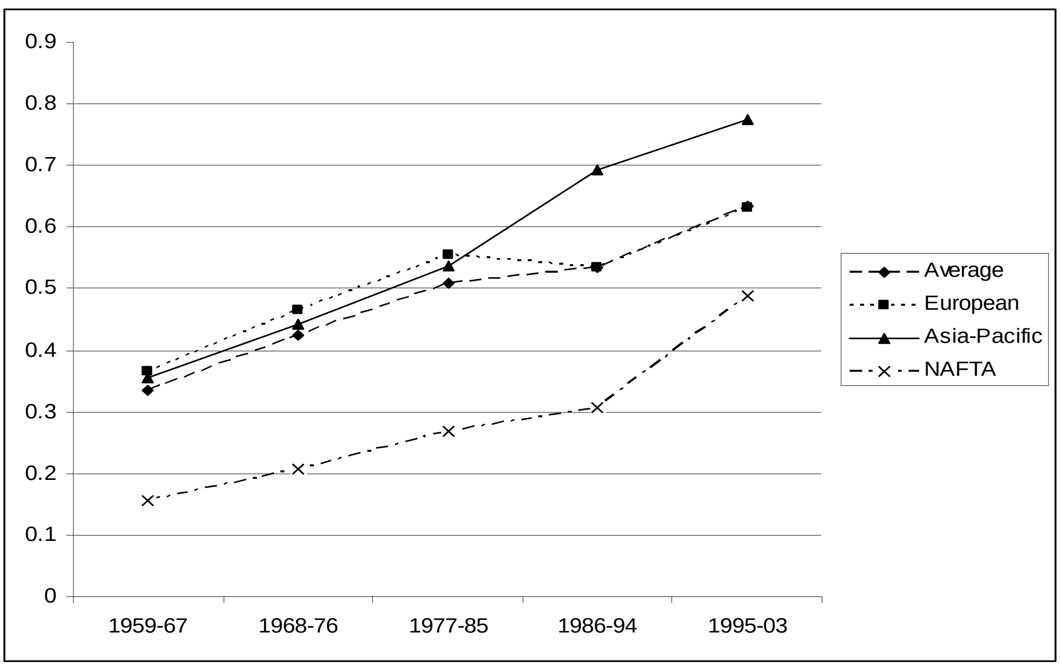

Figure 3-3. *Openness for Average values and three regions*

Source: Table 3-10

In January 1994, Canada, the United States and Mexico launched the North American Free Trade Agreement (NAFTA) and formed the world's largest free trade area. Mexico appears benefited significantly from this. During 1977 to 1985, Mexico's bilateral trade with the world is 29 billion US dollars and it increased to 77 billion US dollars in 1986-1994 and then jump to 282 billion US dollars in 1995-2003 after joining NAFTA. The percentage change increases from 1.65 for 3rd and 4th period to 2.63 for 4th and 5th period. However their GDP growth keeps constant. Therefore, Mexico appears to have had a sharp increase of its openness from 29% to 60%.

The last column is the average openness across the whole period. Based on the average openness, we divide our sample into two groups, a high openness group and a low openness group. 12 out of the 24 countries are found to have a high level of openness, defined as 50% or more of nominal GDP accounted for by international trade. We report three regions' average openness in the second panel of Table 3-10 and Figure 3-3 as well. The NAFTA has relative low openness to other regions. In the first three periods, both Asia-Pacific and European regions have similar openness with the average value. From fourth period, Asia-Pacific countries increase their openness since both China and Hong Kong increase openness rapidly; however, European countries decrease their openness a little bit in the fourth period and then increase in the last period.

3.5 The Business Cycle Correlation Analysis – Across Countries and Periods

Again we investigate the changes of real GDP correlations across time and across country pairs. Table 3-13 presents the average bilateral correlation between individual counties with their 23 partners for the five sub-periods and the full sample. As can be seen from the first five columns, the point estimates of the degree of synchronization change over time. Most countries, particularly for those from Europe, show similar trends. They synchronised business cycles in the first three periods and correlations decrease in the fourth period then increase again in the last period.

Table 3-13

Average Real GDP Correlations de-trended by HP-filter

Periods / Countries	1959-67	1968-76	1977-85	1986-94	1995-03	Change (%)	1959-03
Australia	0.00	0.63	0.42	0.25	0.65	13605	0.39
Austria	0.34	0.71	0.71	0.59	0.67	97	0.60
Belgium & Luxembourg	0.30	0.70	0.76	0.62	0.68	126	0.61
Canada	0.23	**-0.03**	0.36	0.21	0.41	80	0.24
China	0.20	0.15	0.05	0.01	0.46	128	0.18
Denmark	0.26	0.69	0.71	0.57	0.68	166	0.58
Finland	0.34	0.46	0.72	0.54	0.69	104	0.55
France	0.28	0.58	0.77	0.61	0.68	141	0.58
Germany	0.16	0.67	0.73	0.50	0.67	329	0.55
Greece	0.16	0.23	0.74	0.56	0.69	343	0.48
Hong Kong	0.24	0.30	0.55	0.19	**-0.12**	-151	0.23
Ireland	0.19	0.52	0.75	0.59	0.67	256	0.54
Italy	**-0.38**	0.62	0.76	0.58	0.61	261	0.44
Japan	**-0.21**	0.46	0.42	0.20	0.32	252	0.24
Mexico	0.24	0.42	0.27	**-0.40**	**-0.40**	-263	0.03
Netherlands	0.20	0.67	0.72	0.59	0.67	233	0.57
New Zealand	0.27	0.56	0.66	0.41	0.62	132	0.50
Norway	0.20	0.54	0.75	0.62	0.62	210	0.54
Portugal	0.06	0.59	0.60	0.53	0.69	1136	0.49
Spain	0.16	0.60	0.75	0.54	0.67	317	0.54
Sweden	0.27	0.50	0.75	0.59	0.68	153	0.56
Switzerland	0.23	0.69	0.71	0.58	0.59	156	0.56
UK	0.33	0.61	0.75	0.63	0.46	41	0.56
USA	0.16	0.37	0.15	0.16	**-0.09**	-154	0.15
Average	0.18	0.51	0.61	0.43	0.51	737	0.45
Regions							
European	0.18	0.58	0.73	0.57	0.66	261	0.55
Asia-Pacific	0.10	0.42	0.42	0.21	0.39	291	0.31
NAFTA	0.21	0.26	0.26	-0.01	-0.02	-111	0.14

Source: SourceOECD Economics Outlook.
Notes: Average real GDP correlations calculated using the individual correlations from each country vis-à-vis their 23 partners. Bold marks are the negative correlations.

The sixth column reports the percentage change between last period and first period and all European countries have significant increases. Nevertheless, some non-European countries, such as Hong Kong, Mexico, and the USA see a fall in their average business cycle correlation. This result also is found by Heathcote and Perri (2003)'s that "over the

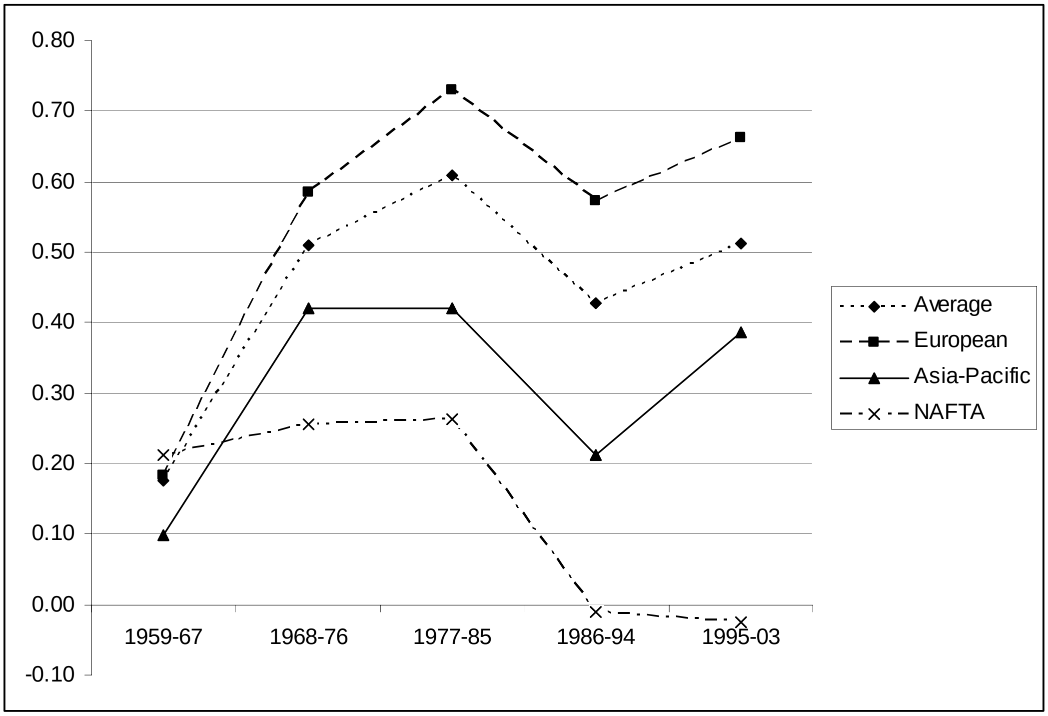

Figure 3-4. *Correlations de-trended by HP-filter for Average Values and Regions*

Source: Table 3-13

last 40 years the USA business cycle has become less synchronised with the cycle in the rest of the world since financial integration has played the major role in producing the observed changes in international co-movement" (p.63). The last column is the average GDP correlations for the whole period. All European countries present consistent and high GDP correlations that are around 50%-60%, and most non-European countries relatively low business cycle correlations.

We report the three regions average business cycle correlations in the second panel of Table 3-13 and Figure 3-4. European countries have the highest correlations which start from a low correlation, 0.18 and increase rapidly to the highest value, 0.73, in the third period then decrease to 0.57 and increase again to 0.66. Asia-Pacific countries have the similar trend to the European countries' but the values are much lower. The NAFTA countries' business cycles are different with others. They start from a high average correlation (0.21) in the first period and keep in a consistent level in the following two periods and then decrease sharply to negative correlations which mainly because Mexico

Table 3-14

Average Real GDP Correlations de-trended by First Differences

Periods / Countries	1959-67	1968-76	1977-85	1986-94	1995-03	Change (%)	1959-03
Australia	**-0.14**	0.61	0.26	0.16	0.59	515	0.30
Austria	0.29	0.65	0.60	0.63	0.64	126	0.56
Belgium & Luxembourg	0.28	0.68	0.68	0.65	0.66	134	0.59
Canada	0.17	0.05	**-0.01**	0.25	0.44	159	0.18
China	0.05	0.24	0.00	**-0.11**	0.33	583	0.10
Denmark	0.18	0.64	0.61	0.63	0.66	270	0.54
Finland	0.30	0.60	0.56	0.60	0.66	121	0.54
France	0.41	0.54	0.68	0.64	0.64	56	0.58
Germany	0.31	0.67	0.64	0.59	0.65	106	0.57
Greece	0.18	0.21	0.62	0.62	0.64	252	0.45
Hong Kong	0.24	0.17	0.32	0.37	**-0.14**	-158	0.19
Ireland	0.07	0.46	0.66	0.63	0.66	839	0.50
Italy	**-0.31**	0.50	0.66	0.64	0.59	293	0.42
Japan	**-0.01**	0.45	0.17	0.45	0.41	3188	0.29
Mexico	0.25	0.21	0.41	**-0.41**	**-0.55**	-317	-0.02
Netherlands	0.14	0.65	0.63	0.63	0.64	371	0.54
New Zealand	0.14	0.49	0.55	0.31	0.59	331	0.41
Norway	0.01	0.51	0.67	0.65	0.60	7134	0.49
Portugal	**-0.04**	0.63	0.44	0.59	0.66	1619	0.45
Spain	0.07	0.61	0.61	0.61	0.64	868	0.51
Sweden	0.31	0.57	0.64	0.64	0.66	117	0.56
Switzerland	0.09	0.62	0.59	0.63	0.58	582	0.50
UK	0.29	0.59	0.67	0.67	0.48	68	0.54
USA	0.04	0.23	0.20	0.20	**-0.13**	-452	0.11
Average	0.14	0.48	0.49	0.47	0.48	700	0.41
Regions							
European	0.15	0.57	0.62	0.63	0.64	322.15	0.52
Asia-Pacific	0.05	0.39	0.26	0.24	0.36	567.89	0.26
NAFTA	0.15	0.16	0.20	0.01	-0.08	-153.25	0.09

Source: SourceOECD Economics Outlook.

Notes: Average real GDP correlations calculated using the individual correlations from each country vis-à-vis their 23 partners. Bold marks are the negative correlations.

have -0.40 correlations in the last periods and there are only three members in NAFTA. Their average correlation (0.14) also is the lowest values in three regions.

Table 3-14 reports the real GDP correlations de-trended by first differences. Most correlations are still positive and European countries also have relative higher values. European countries have consistent and high correlations which are around 40%-60%,

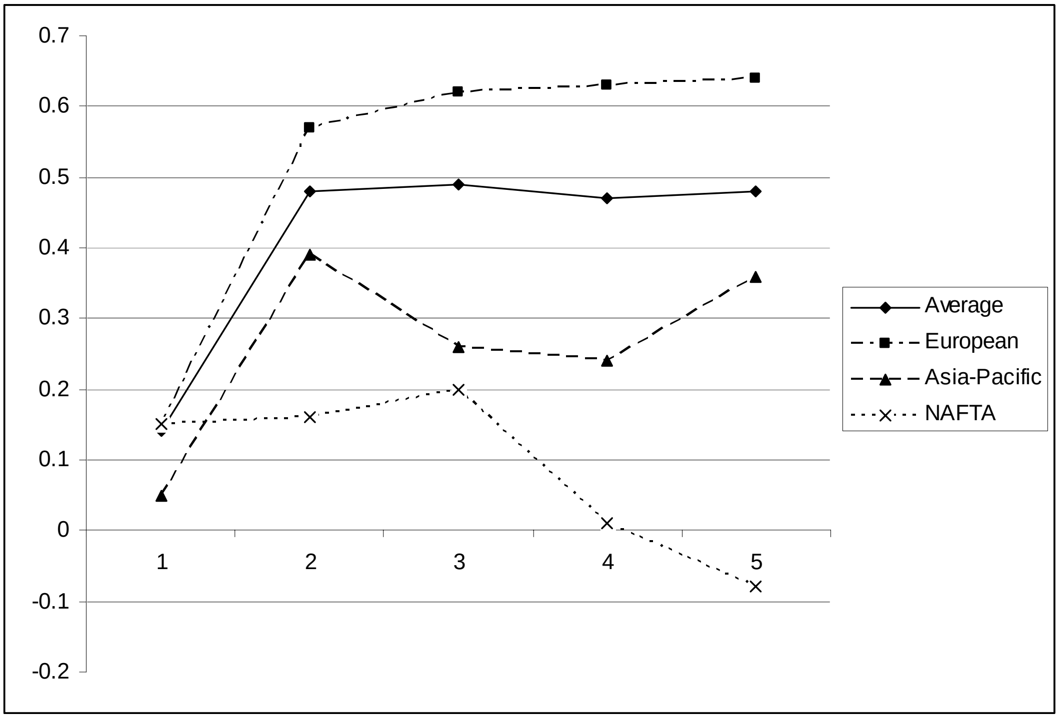

Figure 3-5. *Correlations de-trended by HP-filter for Average Values and Regions*

Source: Table 3-14.

however, non-European countries such as China, Mexico and US have very low even negative correlations. Regarding to the average countries correlations (Figure 3-5), we find that after sharply increase between the first and second period, the correlations stabilize (around 48%) for the following periods. European countries are similar with the average countries but have higher correlations. Asia-Pacific countries increase correlations in the second period and decrease in the third and fourth period, then increase again in the last period. NAFTA countries are the same with before, in the first two periods, their correlations increase a little bit and then decrease to negative.

Table 3-13 and Table 3-14 analyze the correlation variations over time, and we also should investigate differences of bilateral correlations across country-pairs. Table 3-15 reports the correlations coefficients matrix of real GDP de-trended by HP filter for our 24 sample countries over whole period. The bilateral correlations are not like bilateral trade intensity which depend on the locations and distance between countries. We find that all European countries have high correlations with European partners. Some European country pairs' correlations are even above 90%. However, non-European countries have relative low correlations with European countries and non-European countries and most of them are below 50%. For example, Belgium and Luxembourg have very high correlations with other 15 European partners and the average value is 89%, however they only have 24% correlation with other 8 non-European countries. We only find Australia – New Zealand has 76% correlation which is the only high correlation in non-European groups. It is probable can be explained by closer countries and higher bilateral trade result in closer business cycle which also is the topic we will prove in later chapters.

Table 3-16 reports the bilateral correlations of real GDP de-trended by first differences for the whole period. Their values are less than the correlations in Table 3-15 but still indicate the same phenomenon that European countries have obviously higher correlations with European countries than non-European countries with European or non-European countries.

From both Table 3-15 and Table 3-16, we find that many European country pairs' correlations are very high. "When assessing the significance of these correlations, it is desirable to exclude that part accounted for by the international business cycle, for only deviations from common movements are important in assessing the suitability of a group of countries for monetary unification" (Bayoumi and Eichengreen, 1994, p.17). Therefore, we follow Bayoumi and Eichengreen (1994) to remove the international business cycles and check whether the real business cycles are still positive or not. We select the Group of Three (G-3) countries which is the same with Bayoumi and Eichengreen (1994**)** – Germany, Japan, and the United States – as the basis for our choice of the underlying correlation. Based on the Kendall and Stuart (1967)'s method, the correlation coefficients between three countries are approximately 0.40, so 0.40 is used as the null hypothesis.

Table 3-15

Correlation Coefficient Matrix for Real GDP de-trended by HP Filter

	Australia	Austria	Belgium & Luxembourg	Canada	China	Denmark	Finland	France	Germany	Greece	Hong Kong	Ireland	Italy	Japan	Mexico	Netherlands	New Zealand	Norway	Portugal	Spain	Sweden	Switzerland	UK	USA
Australia																								
Austria	0.33																							
Belgium & Luxembourg	0.38	**0.96**																						
Canada	0.64	0.09	0.14																					
China	0.28	**0.96**	**0.95**	0.07																				
Denmark	0.61	0.72	0.74	0.48	0.71																			
Finland	0.38	**0.95**	**0.97**	0.12	**0.94**	0.73																		
France	0.28	**0.96**	**0.95**	0.03	**0.94**	0.65	**0.91**																	
Germany	0.51	**0.83**	**0.86**	0.27	0.82	0.75	**0.85**	**0.85**																
Greece	0.40	**0.86**	**0.89**	0.13	**0.84**	0.76	**0.88**	**0.86**	**0.90**															
Hong Kong	0.41	**0.88**	**0.90**	0.18	**0.84**	0.72	**0.90**	**0.87**	**0.87**	**0.94**														
Ireland	0.17	0.50	0.54	-0.09	0.54	0.18	0.49	0.54	0.45	0.34	0.32													
Italy	0.31	**0.99**	**0.98**	0.08	**0.97**	0.70	**0.95**	**0.96**	**0.84**	**0.87**	**0.88**	0.52												
Japan	0.76	0.53	0.51	0.42	0.52	0.70	0.48	0.47	0.52	0.53	0.44	0.25	0.50											
Mexico	0.46	**0.88**	**0.90**	0.16	**0.88**	0.78	**0.91**	**0.83**	0.79	**0.83**	**0.85**	0.32	**0.88**	0.58										
Netherlands	0.56	0.74	0.75	0.35	0.65	0.74	0.79	0.69	0.70	0.72	0.78	0.24	0.71	0.49	0.80									
New Zealand	0.52	**0.83**	**0.85**	0.33	0.79	**0.84**	**0.87**	0.80	**0.83**	**0.88**	**0.90**	0.22	0.82	0.57	**0.86**	**0.86**								
Norway	0.53	0.79	**0.84**	0.37	0.79	**0.84**	**0.85**	0.77	0.81	**0.83**	**0.88**	0.27	0.80	0.47	**0.89**	0.82	**0.90**							
Portugal	0.35	**0.92**	**0.92**	0.06	**0.92**	0.71	**0.90**	**0.90**	0.80	0.82	0.80	0.53	**0.93**	0.57	0.82	0.66	0.76	0.71						
Spain	0.52	0.78	**0.83**	0.29	0.75	0.77	0.82	0.77	**0.84**	**0.92**	**0.88**	0.36	0.77	0.60	0.75	0.73	**0.86**	0.78	0.75					
Sweden	0.15	0.17	0.25	0.20	0.30	0.05	0.22	0.18	0.23	0.13	0.14	0.50	0.20	0.13	0.11	-0.12	0.08	0.12	0.23	0.21				
Switzerland	-0.01	0.12	0.13	-0.06	0.22	0.20	0.07	0.20	0.14	0.16	0.01	0.16	0.11	0.35	0.05	-0.11	0.07	0.04	0.23	0.23	0.16			
UK	0.32	0.28	0.33	0.32	0.29	0.25	0.21	0.34	0.31	0.19	0.17	0.50	0.25	0.42	0.21	0.19	0.18	0.21	0.28	0.32	0.35	0.41		
USA	0.27	-0.13	-0.02	0.14	-0.17	-0.05	0.03	-0.10	-0.01	0.07	0.08	-0.09	-0.14	-0.07	-0.07	0.20	0.15	0.11	-0.13	0.24	0.11	-0.05	0.02	
Average	0.40	0.65	0.68	0.21	0.64	0.59	0.66	0.64	0.64	0.64	0.64	0.34	0.65	0.47	0.63	0.56	0.64	0.63	0.63	0.64	0.18	0.12	0.28	0.02
s.d.	0.17	0.34	0.32	0.18	0.33	0.27	0.33	0.33	0.28	0.31	0.33	0.19	0.34	0.18	0.33	0.29	0.30	0.29	0.31	0.24	0.12	0.13	0.10	0.13

Table 3-16

Correlation coefficient for real GDP de-trended by First Differences

	Australia	Austria	Belgium & Luxembourg	Canada	China	Denmark	Finland	France	Germany	Greece	Hong Kong	Ireland	Italy	Japan	Mexico	Netherlands	New Zealand	Norway	Portugal	Spain	Sweden	Switzerland	UK	USA
Australia																								
Austria	0.15																							
Belgium & Luxembourg	0.38	**0.85**																						
Canada	0.32	0.23	0.12																					
China	0.20	0.07	0.09	0.11																				
Denmark	0.20	**0.87**	**0.86**	0.15	0.11																			
Finland	0.27	0.75	0.70	0.32	0.22	0.70																		
France	0.27	**0.92**	**0.93**	0.13	0.15	**0.93**	0.71																	
Germany	0.18	**0.90**	**0.88**	0.15	0.19	**0.85**	0.78	**0.87**																
Greece	0.32	0.72	0.64	0.28	0.06	0.58	0.62	0.72	0.72															
Hong Kong	0.24	0.18	0.24	0.39	0.06	0.17	0.30	0.15	0.33	0.16														
Ireland	0.32	0.65	0.79	-0.04	0.07	0.57	0.63	0.72	0.70	0.74	0.16													
Italy	0.26	0.59	0.59	0.02	0.09	0.55	0.48	0.54	0.64	0.67	0.07	0.77												
Japan	0.16	0.49	0.51	0.07	-0.06	0.52	0.18	0.49	0.47	0.41	-0.02	0.33	0.36											
Mexico	0.27	-0.05	0.01	0.12	-0.14	-0.15	-0.14	0.10	-0.13	0.03	-0.05	-0.09	-0.17	-0.12										
Netherlands	0.39	0.76	**0.94**	0.00	-0.01	**0.83**	0.60	**0.87**	0.81	0.52	0.29	0.73	0.58	0.40	-0.12									
New Zealand	0.46	0.56	0.44	0.42	0.11	0.50	0.67	0.42	0.55	0.50	0.13	0.34	0.28	0.19	-0.09	0.38								
Norway	0.26	0.75	0.74	0.10	0.36	0.70	0.63	0.66	0.68	0.66	0.52	0.72	0.61	0.36	-0.01	0.71	0.36							
Portugal	0.52	0.52	0.72	0.11	0.01	0.54	0.52	0.61	0.62	0.58	0.09	0.67	0.59	0.22	-0.07	0.77	0.24	0.66						
Spain	0.24	0.74	0.71	0.14	0.01	0.65	0.83	0.72	0.81	0.67	0.05	0.76	0.76	0.25	0.03	0.64	0.56	0.60	0.57					
Sweden	0.42	0.74	**0.86**	0.15	-0.01	0.69	0.74	0.86	0.77	0.70	0.19	0.80	0.63	0.40	-0.16	0.76	0.37	0.75	0.69	0.74				
Switzerland	0.30	0.75	0.73	0.11	0.13	0.73	0.67	0.68	0.79	0.65	0.21	0.58	0.50	0.29	0.17	0.78	0.55	0.74	0.69	0.63	0.60			
UK	0.42	0.71	0.73	0.30	0.12	0.61	0.71	0.79	0.67	0.74	0.17	0.75	0.52	0.28	-0.15	0.62	0.59	0.55	0.55	0.67	0.74	0.56		
USA	0.28	0.06	0.11	0.37	0.30	0.22	0.02	0.16	0.04	0.03	0.22	-0.16	-0.08	0.23	0.19	0.10	0.29	-0.12	-0.06	-0.02	0.04	0.10	0.18	
Average	0.30	0.56	0.59	0.18	0.10	0.54	0.51	0.58	0.57	0.51	0.19	0.50	0.42	0.29	-0.02	0.54	0.41	0.49	0.45	0.51	0.56	0.50	0.54	0.11
S.D.	0.10	0.30	0.29	0.13	0.12	0.28	0.27	0.29	0.31	0.24	0.13	0.32	0.29	0.17	0.13	0.30	0.15	0.29	0.26	0.30	0.26	0.27	0.20	0.14

We calculated a uniform critical value of *r*=0.83 that can be employed for all country pairs [32]. In both tables, we mark bold for significantly positive correlations after considering international business cycle. It is very clear that European countries are significantly positive correlated with European partners and the correlations of non-European countries are insignificant after removing international business cycle in Table 3-15. But in Table 3-16 only part of European country pairs have significant and positive correlations after removing international effects.

We report both variables' statistical descriptions in Table 3-17. Three bilateral trade observations are missing since there is no trade data between China and Hong Kong in our second period and no trade data between China and Mexico in the first two periods. The lowest bilateral trade intensities for both normalisations are between US and China in the first period since China was really close at that time. The highest bilateral trade intensities are between Belgium-Luxembourg and the Netherlands when trade intensity normalised by GDP and between US and Canada when trade intensity normalised by total

Table 3-17

Variables Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Trade1	1377	0.0041	0.01	0.0000	0.0801
Trade2	1377	0.0107	0.02	0.0000	0.1732
GDP-HP	1380	0.45	0.43	-0.8957	0.9984
GDP-DI	1380	0.41	0.44	-0.8970	0.9987

Notes: trade1 is bilateral trade intensity normalised by nominal GDP, trade2 is bilateral trade intensity normalised by total trade. GDP-HP is real GDP correlation de-trended by HP filter and GDP-DI is de-trended by first differences. The trade data are without log.

[32] Kendall and Stuart (1967) present the equation $\mu \ln[(1+r)/(1-r)]$ to calculate the critical value. The statistic $\mu \ln[(1+r)/(1-r)]$ is distributed approximately normally, with a mean of $\mu \ln[(1+\rho)/(1-\rho)]$ and a variance of group countries, where μ is the average group correlation; *r* is the estimated correlation coefficient and ρ is the null value of the correlation coefficient. The 5 percent significance level will be used to estimate the critical value. Therefore our equation is: *0.4xln[(1+r)/(1-r)]=95%* and the critical value can be calculated *r=0.83* under 95% confidential level and *r=0.81* under 90% confidential level.

trade, respectively. The lowest correlation de-trended by HP filter -0.8957 is from country pair of Italy and China in the first period and Japan-Mexico in the fourth period have the lowest real GDP de-trended by first differences. Austria - the Netherlands in the fourth and fifth period have the highest correlations for first different and HP filter respectively.

3.6 Conclusions

21 industrial countries plus China, Hong Kong and Mexico are selected for our sample since China, Hong Kong and Mexico are very important trading partners to these 21 industrial countries. The sample starts from 1959 to 2003 and is split into five equal-sized sub-periods. This chapter defines two variables that will be used in our empirical analysis, the bilateral trade intensity and the business cycle correlation representing economic integration. The bilateral trade intensity is normalised by either nominal GDP or total trade since it is hard to say which one is more appropriate. From statistical analysis we find that the trade intensity becomes closer over time. Across country pairs, we find the bilateral trade intensity depends on the location and distance between country pairs. For example, Scandinavian countries have higher trade intensities with Scandinavian countries than with other European countries. U.S. and Canada present very high trade intensity as well. Real GDP correlation is used to measure the business cycles de-trended by HP filter or first differences. We find all the European countries have much higher correlations than non-European countries and economic integration increases over time. We also drop off the international business cycle effect from the correlations and only European countries have significant correlations with each other. This result is consistent with the OCA theory that countries with positively correlated business cycles are more likely to join and to gain from an optimum currency area.

Chapter 4 Econometric Methodology

4.1 Introduction

In OCA theory entry into a currency union may increase international trade intensity. And also, high international trade can be expected to affect the nature of national business cycles. Countries that enter a currency union are likely to experience dramatically different business cycles than before. In part this will reflect the adoption of a common monetary policy; but it will also be a result of closer international trade with the other members of the union. However, if the OCA criteria are endogenous closer international trade could result in either tighter or looser correlations of national business cycle depending on inter-industry or intra-industry trade accounts for most bi-lateral trade.

In this chapter we would like to implement a formal model to investigate the relationship between trade intensity and the business cycle correlation based on the theory in chapter 2. In the previous chapter we defined the ratios of bilateral trade between country i and j to their total GDP or total trade as trade intensity and the real GDP correlation. From the statistical analysis we found that the trade intensity in our sample becomes higher over time, but the GDP correlations do not have a clear trend. The European countries have much closer correlations than non-European countries. We will start from Ordinary Least Squares model to estimate the relationship empirically.

The remainder of this chapter is organized as follows: section 4.2 outlines the model for estimation; section 4.3 considers two-stage least squares estimation considering the endogeneity of trade; Section 4.4 develops a panel data framework including both fixed and random effects model and considers the unobservable country-pair specific effects. Section 4.5 introduces the two-stage panel data model; Section 4.6 provides concluding remarks.

4.2 A Simple Ordinary Least Squares Model

In this section, we estimate the effect of trade on business cycle. Firstly, the simplest linear model which specifies a linear relationship between the dependent variable business cycle correlation and the single explanatory variable trade intensity is:

$$Corr_{ij,t} = \alpha + \beta TI_{ij,t} + \varepsilon_{ij,t} \tag{4-1}$$

where $Corr_{ij,t}$ denotes the correlation between country i and country j over time span t of real GDP de-trended by HP-filter and first differences. $TI_{ij,t}$ denotes the natural logarithm of the average bilateral trade intensity between country i and country j over time span t using trade intensity normalised by either nominal GDP or total trade. Finally the error term $\varepsilon_{ij,t}$ is assumed to be independently and identically distributed with mean zero and represents all other influences on real GDP correlations above and beyond the influences of international trade. It is also assumed to be independent of trade: $E[\varepsilon_{ij,t} | TI_{ij,t}] = 0$. The least squares line (equation (4-1)) is the line with the minimum sum of squared deviations comparing observed values of the country-pair correlations to corresponding values from the estimated correlations. The least squares estimates of intercept and slope, α and β, are the regression coefficients to be estimated. In this regression, we would like to focus on the slope coefficient β from sign and size. The sign of the slope can tell us the effects from trade on business cycle are positively or negatively (in which case, coefficient would be expected to be significantly positive). The size of the coefficient allows us to quantify the economic importance of this effect.

4.3 The Endogeneity of Trade – Two-Stage Least Squares Estimation and the Gravity Model

A simple Ordinary Least Squares regression of bilateral real GDP correlation on trade intensity might be inappropriate. The equation (4-1) assumes that the error term $\varepsilon_{ij,t}$

should be uncorrelated with $TI_{ij,t}$. However, countries are likely to peg their currencies deliberately to those of their most important trading partners, in order to capture gains associated with greater exchange rate stability. This implies that the two countries will operate monetary policy in a similar fashion, since pegging is a form of monetary policy coordination that may increase business-cycle correlation. In the OLS regression, it is not only the trade of goods and services that cause the business cycles to be correlated but rather the operation of economic policies and other influences. Therefore the assumption in OLS that $TI_{ij,t}$ is uncorrelated with the error term may not exist any more and using the OLS may give a bias result. OLS cannot identify the separate contribution from trade and the contribution from the common policies enacted because of close trading relationship. To identify the effect of bilateral trade patterns on business cycle correlation, we need exogenous determinants of bilateral trade patterns to use as instrumental variables which are highly correlated with bilateral trade intensity.

As Rose (2001) said, the gravity model explains the flow of international trade between a pair of countries and has a remarkably consistent history of success as an empirical tool. Frankel and Romer (1999) applied the gravity model for bilateral trade to explain income determinants. They find that bilateral trade is negatively related to the distance between country pairs and positively related to their size. Therefore, their instrumental variables for trade are distance between country pairs, log of population and log of area for country *i* and country *j*, and a dummy variable whether country pair landlocked. Frankel and Rose (1998) use log of distance, adjacency dummy and common language as instrumental variables to estimate bilateral trade intensity to eliminate the endogenous bias in business cycle equation. Frankel and Rose (2002) again use the gravity model to find good instrumental variables for trade intensity to estimate the real income. Distance, country *j*'s population, common language, common border, product of area and the landlocked are selected as instruments in the first stage.

A country's geographical position is a powerful determinant of bilateral trade that is not affected by the incomes of countries or by government policies. It is hard to imagine that geographical characteristics could have important effects on its business cycle and the only effects on business cycle are through trade. Therefore countries' geographic characteristics can be viewed as good instrumental variables for trade. As we reported in the last chapter that how far a country is from other countries provides considerable information about the amount that it trades. Distance acts as a deterrent to trade due to the increased transportation costs associated with longer distance. Hence distance between country pairs always is considered an important instrument.

Bilateral trade is an increasing function of each economy's size. To estimate international trade's effect on business cycle, it is necessary to control for country size. In this thesis, we would like to follow Rose and Engel (2000) to adopt product of GDP per capita as a proxy to measure economy size.[33] Dummy variables for sharing a common language and geographical adjacency also are important determinants of bilateral trade intensity which take the value of one when a country pair use the same official language or they share the common border. Hence our gravity equation for bilateral trade includes geographic characteristics: distances between country pairs, the product of GDP per capita, a dummy whether they share a common border, and a dummy when they use the same language.

Apart from these geographic characteristics, there are another two important variables that should be considered in our gravity equation. A dummy variable to establish whether a free trade agreement has a significant effect on trade and it affects business cycle through trade. The variable is an average values across five years in a period. Another dummy variable whether countries peg their currencies with each other or with the third country or whether they are in the same currency union is always to be used in literatures to explain trade or business cycle. However, it is ambiguous whether fixed exchange rates affect the business cycle directly or through trade indirectly. The Bayoumi and Eichengreen (1994) argue that the high correlation among European economies is a result not of trade links, but of Europeans' decision to relinquish monetary independence vis-à-vis their neighbour. Frankel and Rose (1998) have the same view that more similar business cycles are more natural candidates for membership in a common currency area. Furthermore, the currency union itself might change the nature of bilateral business

[33] The product of GDP per capita is justified, since gravity models predict that when two countries trade in imperfect substitutes, the variety of goods and services trade rises with size, contributing to a larger overall volume of trade as each or both economies grow (Micco *et al*., 2003)

cycles. Hence, they include the 'fixed exchange rate' in the business cycle correlation equation. Baxter and Kouparitsas (2005) also support that the effect of currency union to business cycle is a direct one.

While part of the literature has considered the direct impact from fixed exchange rate on the business cycle, some studies find that the fixed exchange rate improve the bilateral trade by decreasing the exchange rate risk associated with trade contracts and the effect on income comes through the trade route. Frankel and Rose (2002) estimate the effect of common currencies on bilateral trade by the gravity model supplemental with a currency union dummy and find that currency union have a large effect in creating trade in almost 8000 country-pair observations over 25 years. A country that joins a currency union experiences a tripling in its trade with the other members of the union and some of estimates of this effect are even higher. Furthermore they conclude that the effect of currency union on income comes through the trade route. Their results prove that fixed exchange rate is a good instrumental variable which is highly correlated with trade but not with income. Rose (2000, 2001) also finds an economically and statistically significant positive effect of a currency union on international trade in large data set, even after controlling for a host of features, including the endogenous nature of the exchange rate regime. Currency unions like EMU may lead to a large increase in international trade which is three times as much as the trade for countries with different currencies. This result is confirmed by Klein and Shambaugh (2006) as well.

Rose and Engel (2000) find that currency union impacts both bilateral trade and business cycle. Based on the gravity model, Rose and Engel show a large effect of a common currency on trade controlled by traditional instrumental variables such as distance, product of GDP per capita, area, common language, common border and so on. This effect is not from the other omitted variables and is found to be statistically robust. At the same time, they also show that countries that are members of a common currency union tend to have more highly synchronised business cycles. The business cycle correlation is perhaps 0.1 higher on average for currency union members than for non-members. To identify the impact from fixed exchange rate on business cycle correlation is directly or indirectly through trade, we will do a test in the next chapter.

Therefore, our instrumental variables include common language, distance between country i and country j, common borders, common free trade agreement, product of GDP per capita and fixed exchange rate (we assume it is in the first stage initially). The two-stage least squares estimation consists of the following two steps: (i) estimate the trade intensity by 6 instrumental variables using OLS, and retrieve the fitted trade intensity; then (ii) perform OLS estimation again using the fitted trade intensity from the first step. The equations are as follows:

$$TI_{ij,t} = \varphi_0 + \varphi_1 LAN_{ij} + \varphi_2 DIS_{ij} + \varphi_3 ADJ_{ij} + \varphi_4 FTA_{ij,t} + \varphi_5 YY_{ij,t} + \varphi_6 FIX_{ij,t} + \omega_{ij,t} \qquad (4\text{-}2)$$

$$Corr_{ij,t} = \alpha + \beta \hat{TI}_{ij,t} + \varepsilon_{ij,t} \qquad (4\text{-}3)$$

where $TI_{ij,t}$ is the trade intensity normalised by either GDP or total trade which is from last chapter and $\hat{TI}_{ij,t}$ is the estimated trade intensity from equation (4-2); LAN_{ij} is a dummy variable which equals unity if the pair of countries share a common language, 1 share the common language, 0 otherwise[34]; DIS_{ij} denotes the natural logarithm of the distance between country i and j measured in kilometres[35]; ADJ_{ij} is a dummy variable for geographic adjacency equalling one, if two countries share the common border; $FTA_{ij,t}$ equals unity when both countries participate in a bilateral free trade agreement.[36] For example, two countries are the member of the same free trade agreement since 1989, we set the dummy variable to equal one since 1989 and before 1989 the dummy is zero. $FTA_{ij,t}$ for each period is the mean of 9 years. Variable $YY_{ij,t}$ denotes the natural logarithm of product of GDP per capita measured by:

$$YY_{ij,t} = \ln\left(\frac{Y_{it}}{Pop_{it}} \times \frac{Y_{jt}}{Pop_{jt}}\right) \qquad (4\text{-}4)$$

[34] Source: CIA, 2004.
[35] Source: FREIT, 2004.
[36] Specifically, a regional trade agreement under the General Agreement on Tariffs and Trade (GATT) or notified to the World Trade Organization (WTO). SourceWTO, 2004. Our free trade agreement data include those agreements that are still in force which come from WTO website and also include the expired agreements which come from WTO Trade Policies Review Division, Regional Trade Agreements Section. We acknowledge Roberto Fiorentino for receipt of the data.

We defined the fixed exchange rate as whether two countries have a direct or indirect fixed exchange rate or they are in the same currency union. A dummy variable will be used here and equals to 1 if there was a direct or indirect fixed exchange rate between countries *i* and *j* at time *t* or they are in the same currency union. We define the direct fixed exchange rate as whether both countries fixed their currencies (announced or unannounced) to each other. For example, a peg between HK Dollar and US Dollar existed from 1972, the dummy fixed exchange rate variable between Hong Kong and USA is one from 1972. The indirect fixed exchange rate is both countries had a peg by the same third country's currency e.g. both Hong Kong and China would have had a peg to the US dollar, the dummy variable between Hong Kong and China is one.

However, how should a country's exchange rate regime be classified? The textbook will give a simple answer: either the exchange rate is fixed or it floats. Some papers, such as Rose (2001), use the IMF[37] data to define the fixed exchange rate. In the thesis we consider not only the announced fixed exchange rate but also the unannounced fixed exchange rate. Therefore, we use the Reinhart and Rogoff (2004) data to create our fixed exchange rate dummy variable. Reinhart and Rogoff (2004) defined 14 different levels of exchange rate: 1. No separate legal tender; 2. Pre announced peg or currency board arrangement; 3. Pre announced horizontal band that is narrower than or equal to +/-2%; 4. De facto peg; 5. Pre announced crawling peg; 6. Pre announced crawling band that is narrower than or equal to +/-2%; 7. De factor crawling peg; 8. De facto crawling band that is narrower than or equal to +/-2%; 9. Pre announced crawling band that is wider than or equal to +/-2%; 10. De facto crawling band that is narrower than or equal to +/-5%; 11. Moving band that is narrower than or equal to +/-2% (i.e., allows for both appreciation and depreciation over time); 12. Managed floating; 13. Freely floating; and 14. Freely falling. We follow these definitions to classify the variable of exchange rate into two categories: fixed exchange rate and floating exchange rate. We define 1 to 11 as

[37] Annual Report on Exchange Arrangements and Exchange Restrictions. IMF tracks exchange arrangements and foreign exchange systems for all member countries on an annual basis and also provides historical information on these since 1950. They define the levels of exchange rate in 1999 1. Exchange arrangement with no separate legal tender; 2. Currency board arrangement; 3. Conventional pegged arrangement; 4. Pegged exchange rate within horizontal bands; 5. Crawling peg; 6. Crawling band; 7. Managed floating with no pre-announced path for the exchange rate; 8. Independently floating.

fixed exchange rate including announced and pre-announced fixed exchange rate and 12 to 14 as floating exchange rate.

4.4 Panel Data Model

Estimating equation (4-1) by pooled OLS is not feasible for another reason. Our sample includes 24 countries across 276 country pairs from 1959 to 2003 split equally into 5 periods. There are large number of cross-sectional units and only a few periods. Thus, the time-series methods may be somewhat problematic and also cross-section OLS estimation ignores potentially important unobservable country-pair specific effects. We estimate our model using both fixed effects and random effects and in doing so control for differences in the business cycle correlation across country pairs through the level of trade intensity and potentially important unobservable factors.

Similar industry structures or a high degree of financial integration could explain a rise in the level of bilateral economic integration. Proxies can be used to measure these factors however they are likely to be measured with error. For example, Sweden and Finland are close and hence they have large trade in line with the gravity model. But being close, they also have similarities in industrial structure, such as large forest industry, which itself makes business cycles correlated. One way to control for this is include some measure of structural similarity but such a measure is likely to be very imperfect. Another and better way is to include fixed effects.[38] Fixed effects can control for all of the country pair specific effects even if they are correlated with trade intensity.

The random effects approach treats the unobservable component as randomly distributed although, unlike fixed effects, the individual effects are assumed to be independent of trade intensity.

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[38] Professor Nils Gottfries (The Scandinavian Journal of Economics editor) comments on the paper 'Trade Integration and Business Cycle Convergence: Is the Relation Robust Across Time and Space?'

Firstly, we review the theory of the panel data model. The basic framework is a regression model of the form:

$$y_{it} = \alpha + x'_{it}\beta + \mu_i + \varepsilon_{it} \qquad (4\text{-}5)$$

There are K regressors in x_{it}. The individual effect is μ_i which contains a set of individual specific variables, all of which are taken to be constant over time t. We apply our regression equation into the panel data model:

$$Corr_{ij,t} = \alpha + \beta TI_{ij,t} + \mu_{ij} + \varepsilon_{ij,t} \qquad (4\text{-}6)$$

for ij=1,…,n (n=276) and for each ij, t=1,…,T (T=5). μ_{ij} denotes the unobservable individual country-pair specific effects. The dependent variable is business cycle correlation $Corr_{ij,t}$, and we only have one independent variable, trade intensity $TI_{ij,t}$. Both of them are 276×5 matrix. The reminder residual $\varepsilon_{ij,t}$ has the normal properties (mean 0, uncorrelated with itself, uncorrelated with $TI_{ij,t}$, uncorrelated with μ_{ij}, and homoskedastic).

4.4.1 Fixed Effects

If μ_{ij} is unobserved, but correlated with $TI_{ij,t}$, then the least squares estimator of β is biased and inconsistent as a consequence of an omitted variables in equation (4-1), and we implement fixed effects model. The model assumes that differences across country-pairs can be captured in differences in μ_{ij}. Each μ_{ij} is treated as an unknown parameter to be estimated and it does not vary over time. Totally, we have 275 country-pair dummy variables plus a constant[39] (Baltagi, 2005). Therefore in equation (4-6), μ_{ij} is the vector of 275 country-pair dummies.

[39] The model has been estimated with an overall constant and ij-1 dummy variables and each dummy variable coefficient will now be an estimate of difference with constant term where dummy "1" is the omitted group. Therefore we have 276-1 [$=(1+23)\times 23\div 2$ -1] group dummy variables.

Whatever the properties of μ_{ij} and $\varepsilon_{ij,t}$, if (4-6) is true, it must also be true that

$$\overline{Corr}_{ij} = \alpha + \beta_{FE}\overline{TI}_{ij} + \mu_{ij} + \bar{\varepsilon}_{ij} \tag{4-7}$$

for ij=1,…,n (n=276) and for each ij, t=1,…,T (T=5), of which T_i periods are actually observed. $\overline{Corr}_{ij} = \sum_{t=1}^{T_i} Corr_{ij,t} / T_i$, $\overline{TI}_{ij} = \sum_{t=1}^{T_i} TI_{ij,t} / T_i$, and $\bar{\varepsilon}_{ij} = \sum_{t=1}^{T_i} \varepsilon_{ij,t} / T_i$. Subtracting (4-7) from (4-6), it must be equally true that

$$(Corr_{ij,t} - \overline{Corr}_{ij}) = \alpha + \beta_{FE}(TI_{ij,t} - \overline{TI}_{ij}) + (\varepsilon_{ij,t} - \bar{\varepsilon}_{ij}) \tag{4-8}$$

These three equations provide the basis for estimating β. Estimation (4-8) is known as the fixed effects estimator also known as the within estimator and it is performed by OLS. [40] The covariance matrix of the estimators is adjusted for the extra 275 estimated means, so results are the same as using OLS on (4-6) to estimate 275 individual dummies, μ_{ij}, directly.

Testing the Significance of the Individual Effects – FE vs. OLS

If all the differences across country-pairs are all equal, and the regression only contains a constant term, then the OLS provides consistent and efficient estimates and fixed effects are not necessary. Therefore, we are interested in difference across country pairs, and test the hypothesis that the specific effects, μ_{ij} , are all equal.

This is a simple F test with restricted residual sums of squares (RRSS) being that of OLS on the pooled model and the unrestricted residual sums of squares (URSS) being that of fixed effects regression. The null hypothesis is: $\mu_1 = \mu_2 = ... = \mu_{ij-1} = 0$ against the

[40] We select the Stata 9.0 as econometrics program, and use the command ‘xtreg, fe’ and ‘xtreg, re’ for fixed effects model (within-group) and random effects model (GLS). Details of within-groups estimations see Stata 9.0 manual (XT).

alternatively hypothesis that all unobserved country-pair specific effects exist. The *F*-statistic is calculated by:

$$F(n-1, nT-n-K) = \frac{(R^2_{FE} - R^2_{Pooled})/(n-1)}{(1-R^2_{FE})/(nT-n-K)} \quad (4\text{-}9)$$

where FE indicates the fixed effects model (or dummy variable model) and *Pooled* indicates the pooled or restricted model with only a single overall constant term. If the *F*-statistic rejects the null hypothesis, the *F*-test indicates that unobservable country-pair specific effects are different, and then the fixed effects model is more appropriate than pooled OLS.

However, fixed effects least-squares has some limitations. If we include the country pair dummy variables in the constant, 275 dummies will be in the regression. The fixed effects least-squares suffers from a large loss of degrees of freedom. We are estimating 275 extra parameters, and many dummies may aggravate the problem of multicollinearity among the regressors. The random effects model can solve this problem by putting α_i into the error term. The more important reason is the random effects treatment does allow the model to contain observed time invariant characteristics, such as the dummy variable of language, distance between country-pairs, while the fixed effects model does not, if present, they are simply absorbed into the fixed effects.

4.4.2 Random Effects

If the unobserved individual effects μ_{ij} can be assumed to be uncorrelated with the independent variables $TI_{ij,t}$, then it might be appropriate to model the individual specific constant terms as randomly distributed across cross-sectional units. This view would be appropriate if we believe that our country-pairs were drawn from a large population. The payoff to this form is that it greatly reduces the number of parameters to be estimated. The cost is we have to assume strictly that μ_{ij} is uncorrelated with $TI_{ij,t}$. Then the model may be formulated as:

$$Corr_{ij,t} = \alpha + \beta_{RE} TI_{ij,t} + \upsilon_{ij} + \varepsilon_{ij,t} \quad (4\text{-}10)$$

where $\alpha = \overline{\mu}$ and $\upsilon_{ij} = \mu_{ij} - \overline{\mu}$. Now the single constant term is the mean of the unobserved heterogeneity. The component v_{ij} is the random heterogeneity specific to the *ij*th observation and is constant through time. We assume further that:

$$\begin{aligned}
E[\varepsilon_{ij,t} | TI_{ij,t}] &= E[\upsilon_{ij} | TI_{ij,t}] = 0, \\
E[\varepsilon_{ij,t}^2 | TI_{ij,t}] &= \sigma_\varepsilon^2, \\
E[\upsilon_{ij}^2 | TI_{ij,t}] &= \sigma_\upsilon^2, \\
E[\varepsilon_{ij,t}\upsilon_{kl} | TI_{ij,t}] &= 0 \quad \text{for all } ij, t, \text{and } kl, \\
E[\varepsilon_{ij,t}\varepsilon_{kl,s} | TI_{ij,t}] &= 0 \ \text{ if } t \neq s, \text{or } ij \neq kl, \\
E[\upsilon_{ij}\upsilon_{kl} | TI_{ij,t}] &= 0 \ \text{ if } ij \neq kl.
\end{aligned} \quad (4\text{-}11)$$

Based on these assumptions, random effects model is performed by Generalised Least Squares (GLS).[41] GLS based on the true variance component is best linear unbiased estimator (BLUE) and all the feasible GLS estimators considered are asymptotically efficient as country pairs are large.

Again, the crucial distinction between fixed effect estimation and random effect estimation is whether the unobserved individual effect embodies elements that are correlated with the regressors in the model, not whether these effects are stochastic or not.

Testing Breusch-Pagan for Random Effects – RE vs. OLS

Breusch and Pagan (1980) have devised a Lagrange multiplier test for the random model based on the OLS residuals. The random effects model reduces to the pooled OLS model if the variance of the individual effects becomes zero. The null hypothesis of the test is the variance of the individual effects equal zero against not equal zero. In estimation (4-10), we let $e_{ij,t} = \upsilon_{ij} + \varepsilon_{ij,t}$.

[41] For details of GLS see Greene (2002) pp.293-98, Gujarati (2003) pp. 394-98 and Stata Manual 'XT'.

$$H_0 : \sigma_\upsilon^2 = 0 \qquad (or\ E[e_{ij,t}, e_{ij,s}] = 0),$$
$$H_1 : \sigma_\upsilon^2 \neq 0 \tag{4-12}$$

The test statistic is

$$LM = \frac{nT}{2(T-1)}\left[\frac{\sum_{ij=1}^{n}\left[\sum_{t=1}^{T} e_{ij,t}\right]^2}{\sum_{ij=1}^{n}\sum_{t=1}^{T} e_{ij,t}^2} - 1\right]^2 = \frac{nT}{2(T-1)}\left[\frac{\sum_{ij=1}^{n}(T\overline{e}_{ij})^2}{\sum_{ij=1}^{n}\sum_{t=1}^{T} e_{ij,t}^2} - 1\right]^2 \tag{4-13}$$

where n=275, T=5 and $e_{ij,t}$ is the error component. Under the null hypothesis, LM is distributed as chi-squared with one degree of freedom.[42]

4.4.3 Hausman's Specification Test for the Panel Data Model

We have presented the differences between fixed and random effects estimations. Which one should be used? From a purely practical viewpoint, the fixed effects model is costly in terms of degrees of freedom lost. But it does not need to treat the individual effects as uncorrelated with the other regressors, as is assumed in the random effects model. The random effects treatment, therefore, may suffer from the inconsistency due to this correlation between the included variables and the random effect.

The specification test devised by Hausman (1978) is used to test for orthogonality of the random effects and the regressors. The test is based on the idea that under the hypothesis of no correlation, both fixed effects model and GLS are consistent, but fixed effects model is inefficient, whereas under the alternative, fixed effects model is consistent, but GLS is not. Therefore, under the null hypothesis, the two estimates should not differ systematically, and a test can be based on the difference. The other essential ingredient for the test is the covariance matrix of the difference vector. We apply the Hausman's specification test in our sample regression and the chi-squared test is based on the Wald criterion:

[42] For details of Breusch and Pagan LM test see Baltagi (2005) Chapter 4.

$$H_{\chi^2(K-1)} = [\hat{\beta}_{FE} - \hat{\beta}_{RE}]' \hat{\Psi}^{-1} [\hat{\beta}_{FE} - \hat{\beta}_{RE}] \qquad (4\text{-}14)$$

where $\hat{\beta}_{FE}$ is the estimated slope by fixed effects model from equation (4-8), and $\hat{\beta}_{RE}$ is the estimated slope by random effects model from equation (4-10). $\hat{\Psi} = Est.Var[\beta_{FE}] - Est.Var[\beta_{RE}]$, $Est.Var[\beta_{FE}]$ and $Est.Var[\beta_{RE}]$ are the two estimated asymptotic covariance matrices (standard error covariance matrices) and $\hat{\Psi}$ is the estimated covariance matrices of the slope estimator in the fixed effects model minus the estimated covariance matrix in the random effects model, excluding the constant term. In our model, we only have one regressor, $TI_{ij,t}$. Thus all slopes and standard errors are only one value rather than matrices and the *H*-statistic change to

$$H_{\chi^2(1)} = \frac{[\hat{\beta}_{FE} - \hat{\beta}_{RE}]^2}{S.E._{FE}^2 - S.E._{RE}^2} \qquad (4\text{-}15)$$

Under the null hypothesis, *H* has a limiting chi-squared distribution with *K*-1 degrees of freedom, where is one.

4.5 Two-Stage Fixed Effects and Random Effects Model

We have presented that estimating equation (4-1) by pooled OLS is not feasible for two reasons: firstly, trade intensity could be endogenous due to the omission of relevant variables which causes inconsistency of the usual OLS estimates and requires instrumental variable methods like two-stage least squares (2SLS) to obtain consistent parameter estimates. Secondly, pooled estimations also ignore potentially important unobservable country-pair specific effects which could be solved by panel data model. Here we combine the two-stage least squares (2SLS) with panel data models.[43]

$$TI_{ij,t} = \varphi_0 + \varphi_1 LAN_{ij} + \varphi_2 DIS_{ij} + \varphi_3 ADJ_{ij} + \varphi_4 FTA_{ij,t} + \varphi_5 YY_{ij,t} + \varphi_6 FIX_{ij,t} + \varsigma_{ij} + \omega_{ij,t} \quad (4\text{-}16)$$

[43] In Stata V9.0, we use the ‘xtivreg, fe’ and ‘xtivreg, re’ command for 2SLS fixed and random effects model, respectively.

$$Corr_{ij,t} = \alpha + \beta \hat{TI}_{ij,t} + \mu_{ij} + \varepsilon_{ij,t} \tag{4-17}$$

We still use the same six instrumental variables and ς_{ij} and μ_{ij} are unobservable country-pair specific effects in the first and second stage, respectively. $\omega_{ij,t}$ and $\varepsilon_{ij,t}$ are the 'usual' residual with the usual properties (mean 0, uncorrelated with itself, uncorrelated with $TI_{ij,t}$, uncorrelated with μ_{ij}, and homoskedastic).

The 2SLS panel data estimation also consists of two steps but using panel data model rather than OLS: (i) estimate the trade intensity by 6 instrumental variables by fixed or random effects model, and retrieve the fitted trade intensity; then (ii) perform fixed or random effects estimation again using the fitted trade intensity from the first step.[44] The fixed effects model still uses the within estimator and the random effects model uses the GLS estimator.

After 2SLS fixed and random effects estimations, the Hausman's specification test again is performed to compare which model we should use following by the equation (4-15). However, in the 2SLS panel data model, we cannot perform Hausman's specification test directly after 2SLS fixed and random effects estimation. As we noticed that random effects treatment does allow the model to contain observed time invariant characteristics, then our first stage include all six instrumental variable running by random effects model. However, the three time invariant variables (distance, land adjacency and common official language) are dropped running by fixed effects model and the first stage only include three instrumental variables (fixed exchange rate, common free trade agreement and product of GDP per capita). Therefore, it does not make sense to compare the fixed and random effects models directly, because from the Hausman test is not immediately apparent whether this difference is due to the number of instruments selected or, as is normally assumed, because the individual effects are correlated with $TI_{ij,t}$.

We re-estimate (4-16) and (4-17) via random effects model but using only the time-variant instruments to estimate the slope, β_{RE3}.

[44] The details of 2SLS panel data model see Baltagi (2005) chapter 7 and Stata 9.0 manual (xtivreg).

$$TI_{ij,t} = \varphi_0 + \varphi_1 FTA_{ij,t} + \varphi_2 YY_{ij,t} + \varphi_3 FIX_{ij,t} + \varsigma_{ij} + \omega_{ij,t} \quad (4\text{-}18)$$

$$Corr_{ij,t} = \alpha + \beta_{RE3}\hat{T}I_{ij,t} + \mu_{ij} + \varepsilon_{ij,t} \quad (4\text{-}19)$$

Use the information from equations (4-18) and (4-19) to compare with fixed effects model by the Hausman test:

$$H_{\chi^2(1)} = \frac{[\hat{\beta}_{FE} - \hat{\beta}_{RE3}]^2}{S.E._{FE}^2 - S.E._{RE3}^2} \quad (4\text{-}20)$$

4.6 Conclusions

Following the OCA theory and the statistical analysis, we start to investigate the relationship between trade intensity and business cycle correlation by OLS estimation. However, countries are likely to link their currencies deliberately to those of their important trading partners in order to capture gains associated with greater exchange rate stability. In doing so, they will lose to set monetary policy independently of those neighbours. The close monetary policy might increase bilateral trade between countries. In addition, a stable exchange rate could cause both high trade and business cycle co-movement. Therefore, to identify the effect of bilateral trade patterns on business cycle correlations, we need exogenous determinants of bilateral trade patterns to use as instrumental variables. Two-stage least-squares estimation is used and the trade intensity is estimated by the gravity model. We select six instrumental variables for trade intensity: language, distance, adjacency, product of GDP per capita, and supplement them with dummies to define the bi-lateral free trade agreements and fixed exchange rate agreements trade agreement.

Pooled OLS estimation also ignores potentially important unobservable country-pair effects. Two-step fixed effects estimation is implemented since it allows for pair-specific factors being correlated with trade. Two-step random effects estimate also is used since it can avoid the loss of degree of freedom associated with fixed effect estimate and more importantly we can include the specific effect on trade intensity of language, distance and adjacency. This development of the econometric model also is one of this thesis's contributions. Hausman's specification test is used for comparing the fixed and random effects model after two-stage panel data model.

Chapter 5 Empirical Results: Aggregate Countries Results and Sensitivity Analysis

5.1 Introduction

The empirical investigation of the relationship between the bilateral trade intensity and the business cycle is presented in this chapter. As we discussed in the literature review, closer international trade could result in either tighter or looser correlations of national business cycle from a theoretical viewpoint. Closer trade ties could result in countries becoming more specialized in the goods for which they have comparative advantage. The countries might then be more sensitive to industry-specific shocks, resulting in more idiosyncratic business cycles. However, if demand shocks or other common shocks predominate, or if intra-industry trade accounts for most bi-lateral trade, then the business cycles may become more similar across countries when countries trade more. Therefore, we estimate the relationship between the trade intensity and the business cycle correlation using econometric models described in last chapter.

The estimation analysis starts with OLS. We find a positive and statistically significant estimator and the magnitude is higher than previous literature. Because of the endogeneity of trade, we develop the estimation to two-stage least square with six instrumental variables. Also considering the potentially important unobservable country-pair effects, panel data estimation is used here as well. From the two stage panel estimation, we find a stronger relationship than OLS and literature.

Furthermore, a couple of tests are used to examine the robustness of the relationship. Firstly, we apply different proxies to measure the business cycle correlation including industrial production, total employment and unemployment rate de-trended by both HP-filter and fourth difference. We also do sub-period analysis to investigate whether their significance and magnitude of relationship changes over time. Finally, we conduct a couple of sensitivity analyses, such as including time dummies in 2-stage FE estimations, splitting whole period into two sub-period, adding potential omitted variables, such as financial integration, specification, time trend and third trade partner. None of these change our main results.

The remainder of this chapter is organized as follows: section 5.2 discusses the Ordinary Least Square estimation results; section 5.3 defines 6 instrumental variables and implements two-stage least square regression to investigate the relationship in aggregate sample; Section 5.4 presents the fixed and RE estimation results and section 5.5 presents two-stage fixed and RE estimations. The sensitivity analyses are shown in section 5.6. Section 5.7 is the conclusion for this chapter.

5.2 Aggregate Countries Results Estimated by OLS

As we described in the previous chapter, the analysis starts with a simple OLS regression equation (4-1) which specifies a linear relationship between the business cycle correlation and single explanatory variable trade intensity. The estimates shown in Table 5-1 are estimated by OLS regression. We have two versions of the regressand (real GDP correlations de-trended by both HP-filter and first differences) and two versions of the regressor (bilateral trade intensity normalised by nominal GDP and total trade). They show a significant and positive relationship between the trade intensity and the business cycle correlation. Average of the β estimates has a magnitude of 0.10, suggesting that the business cycle correlation would rise by 0.069 following a doubling of trade intensity.

Coefficients from the estimation of GDP de-trended by HP filter are slightly smaller than those from the estimation of GDP de-trended by first differences and the coefficient from the estimation of trade normalised by GDP is slightly greater than those from the estimation of trade normalised by total trade. Generally, both de-trending methods and both normalisations have consistent results. The model explains 9% of the overall variations in $Corr_{ij,t}$. The overall significance of the model is established by the F-statistics, and all F-tests reject the null hypothesis at the 5% confidence level indicating that our OLS estimation fits the data well.[45]

The βs presented in Table 5-1 are larger than those reported in previous literature. For example, Frankel and Rose (1998) report a slope estimate of 0.048 using the same measure of the business cycle correlation and the trade intensity as this study, though the time period and the number of countries differ. Clark and van Wincoop (2001) report a slope estimate for trade intensity of 0.09 using data on 14 EU countries from 1963 to 1997, while Imbs (2004) reports a β estimate of 0.079 for a panel of 24 developing and industrialised countries over the period 1960 to 2000.

Table 5-1

OLS Estimates

	Normalised by Nominal GDP		Normalised by Total Trade	
	HP filter	First difference	HP filter	First difference
Constant	1.11*	1.17*	0.84*	0.91*
	(21.12)	(21.54)	(16.92)	(18.39)
$TI_{ij,t}$	0.10*	0.12*	0.07*	0.09*
	(12.48)	(13.74)	(8.04)	(10.16)
Overall Significance (F-test with p-value)	156*	189*	65*	103*
	(0.00)	(0.00)	(0.00)	(0.00)
Adjusted R^2	0.11	0.14	0.05	0.07

Notes: Pooled OLS estimates from $Corr_{ij,t} = \alpha + \beta TI_{ij,t} + \varepsilon_{ij,t}$ where $Corr_{ij,t}$ is the bilateral real GDP correlation between countries *i* and *j* de-trended by HP filter and first differences and TI_{ijt} is bilateral trade intensity normalized by GDP and total trade. t-statistics are shown in parentheses, and regressions are with robust standard errors. * denotes statistical significance at the 5% levels. Bilateral data are from 24 countries, from 1959 to 2003 which is split into five sub-periods. Sample size is 1380 including 3 omitted observations.

[45] *F*-test is calculated by $F = \frac{MSS \text{ of } ESS}{MSS \text{ of } RSS}$ with the degree of freedom (1,1375) , where MSS is mean sum of squares which is obtained by dividing *SS* by their degree of freedom, *ESS* is explained sum of square, and *RSS* is residual sum of square. The null hypothesis is H_0: coefficients of Trade and constant are both zero, and the *F*-test follows the *F*-distribution with 1 df in numerator and 1375 (n-2, since we miss 3 observations and the number of total observations is 1377) df in denominator.

5.3 Two-Stage Least-Squares Estimation Results

Table 5-2 presents the first stage linear regression results on bilateral trade intensity. The first step is to identify which instruments are important determinants of trade intensity. The OLS estimates of equation (4-2) (see Table 5-2) are all statistically significant at the 5% level, except for the $YY_{ij,t}$, using bilateral trade as a proportion of aggregate trade. The standard errors are robust to clustered heterogeneity. Estimates are correctly signed and have reasonable magnitudes, though there is some variation across trade normalisations for $FIX_{ij,t}$ and $FTA_{ij,t}$ estimates. The model explains approximately 41% of the total variation in trade intensity. Again, an F-statistics confirms the overall significance of the model.

The impact of a fixed exchange rate on trade intensity is 18.5% [$= 100 \times (e^{0.17} - 1)$] using the GDP normalisation (40.5% using the total trade normalisation). The highly statistically significant coefficients indicate a strong effect from fixed exchange rate on trade intensity. Later we are going to test this variable following equation 4-3 (the business cycle equation). Geographical factors are important determinants of bilateral trade intensity. ‘Distance’ has a negative impact and a country-pair that is twice the geographical distance compared to another would be expected on average to have one third less trade intensity. Both ‘common language’ and ‘common border’ have a significantly positive effect on trade intensity, approximately 44.1% and 232%, respectively. If two countries participate in a bilateral free trade agreement then the increase in trade intensity is on average 118.1% using the GDP normalisation or 36.3% using the total trade normalisation. Finally, the product of GDP per capita estimates are significant and positive in one case, suggesting that economic growth in either one or both of the economies, acts as a stimulus to international trade.

Table 5-2

Trade Intensity Equation estimated by OLS

	Normalised by Nominal GDP	Normalised by Total Trade
Constant	-6.31*	-3.63*
	(-12.46)	(-7.12)
$FIX_{ij,t}$	0.17*	0.34*
	(2.29)	(4.58)
LAN_{ij}	0.42*	0.31*
	(5.09)	(3.79)
DIS_{ij}	-0.31*	-0.31*
	(-8.26)	(-8.21)
ADJ_{ij}	1.11*	1.29*
	(9.01)	(10.39)
$FTA_{ij,t}$	0.78*	0.31*
	(8.36)	(3.37)
$YY_{ij,t}$	0.10*	0.02
	(5.13)	(1.05)
Overall Significance	191.51*	138.91*
(*F*-statistics)	(0.00)	(0.00)
Adjusted R^2	0.45	0.38
Test of excluded Instruments	291*	235*
	(0.00)	(0.00)
Partial R^2	0.46	0.38
Wu-Hausman F test:	288*	244*
	(0.00)	(0.00)
Durbin-Wu-Hausman	239*	207*
χ^2 test	(0.00)	(0.00)

Note: First step estimates are from: $TI_{ij,t} = \varphi_0 + \varphi_1 LAN_{ij} + \varphi_2 DIS_{ij} + \varphi_3 ADJ_{ij} + \varphi_4 FTA_{ij,t} + \varphi_5 YY_{ij,t} + \varphi_6 FIX_{ij,t} + \omega_{ij,t}$.
t-statistics for coefficients and probability values for tests are shown in parentheses and regressions are with robust standard errors. * denotes statistical significant at the 5% level. F-test indicates whether excluded instrumental variables are significantly different with the whole equation and the Wu-Hausman test and Durbin-Wu-Hausman test identifies whether it is necessary to instrument trade intensity with the above regressors. Bilateral data come from 24 countries, and are from1959 to 2003 split into five sub-periods. Sample size is 1380 including gaps. * are significant coefficients at 95% based on t value.

Table 5-3 presents instrumental variable estimation of equation (4-3). The fitted trade intensity is predicted from the first stage (4-2). The β estimates show a positive and statistically significant relationship between trade intensity and the real GDP correlation

Table 5-3

The Business Cycle Correlation Equation estimated by IV

		Normalised by Nominal GDP		Normalised by Total Trade	
HP filter	Constant	1.94* (26.56)	1.97* (20.57)	1.68* (21.13)	1.67* (15.51)
	$TI_{ij,t}$	0.23* (19.86)	0.24* (16.79)	0.23* (15.44)	0.23* (12.28)
	$FIX_{ij,t}$	-	-0.02* (-0.53)	-	0.01* (0.19)
	Overall Significance (*F*-statistics)	394* (0.00)	195* (0.00)	238* (0.00)	120* (0.00)
	Hausman Test (OLS vs. IV)	243* (0.00)	-	176* (0.00)	-
First differences	*Constant*	2.03* (27.58)	1.96* (21.30)	1.76* (22.20)	1.64* (15.81)
	$TI_{ij,t}$	0.25* (21.30)	0.24* (17.92)	0.25* (16.93)	0.23* (13.02)
	$FIX_{ij,t}$	-	0.03* (1.02)	-	0.06* (1.62)
	Overall Significance (*F*-statistics)	454* (0.00)	232* (0.00)	287* (0.00)	151* (0.00)
	Hausman Test (OLS vs. IV)	271* (0.00)	-	183* (0.00)	-

Notes: results are estimated by

$$TI_{ij,t} = \varphi_0 + \varphi_1 LAN_{ij} + \varphi_2 DIS_{ij} + \varphi_3 ADJ_{ij} + \varphi_4 FTA_{ij,t} + \varphi_5 YY_{ij,t} + \omega_{ij,t}$$

$$Corr_{ij,t} = \alpha + \beta_1 TI_{ij,t} + \beta_2 FIX_{ij,t} + \varepsilon_{ij,t}$$

$$TI_{ij,t} = \varphi_0 + \varphi_1 LAN_{ij} + \varphi_2 DIS_{ij} + \varphi_3 ADJ_{ij} + \varphi_4 FTA_{ij,t} + \varphi_5 YY_{ij,t} + \varphi_6 FIX_{ij,t} + \omega_{ij,t}$$

$$Corr_{ij,t} = \alpha + \beta_1 TI_{ij,t} + \varepsilon_{ij,t}$$

t-statistics for coefficients and probability values for tests are shown in parentheses regressions are with robust standard errors. * denotes statistical significance at the 5% levels. Hausman test compare the bilateral trade intensity from OLS and that from IV estimations and the null hypothesis is they are the same. Bilateral annually data from 24 countries, 1959 through 2003 split into five sub-periods. Maximum sample size is 1380.

for all de-trending methods and trade normalisations which is stronger than those reported in Table 5-1 and in the literature.

We do not report R^2 or adjusted R^2 since they really have no statistical meaning in the 2-stage least square and are not bounded in 0 and 1. [46] With an average magnitude of 0.24, the business cycle correlation is expected to rise by 0.17 if trade intensity were to double. The t-statistics in parentheses are calculating using robust standard errors. There is no significant difference between de-trending methods and normalisation. These results suggest that the increased bilateral trade observed in chapter 3 is the result of expanding intra-industry trade feeding through to greater economic convergence. Also F-statistics confirms the overall significance of the model.

However, it is possible that the observed relationship between the trade intensity and the business cycle correlations is spurious. As Frankel and Rose (1998) note, countries that trade more intensively with one another are more willing to join a bilateral fixed exchange rate agreement, which may influence the real GDP correlation directly through the coordination of monetary. Moreover, they could be more financially integrated (Imbs, 2004). Fixed exchange rate could be another form of economic integration that further strengthens the case that OCA criteria are endogenous. Because pegging is a form of monetary policy coordination that itself may increase the business cycle correlation. For example, regarding to the debate about Swedish membership in *EMU*, statistical correlations showed that Sweden and Finland had relatively low correlations with the rest of Europe countries and this was seen as an argument against membership. But low correlation may be due to devaluation policy which set the business cycle out of phase with the rest countries.[47] Therefore the fixed exchange rate could appear in the business cycle correlation equation directly as another indicator of economic integration.

$$TI_{ij,t} = \varphi_0 + \varphi_1 LAN_{ij} + \varphi_2 DIS_{ij} + \varphi_3 ADJ_{ij} + \varphi_4 FTA_{ij,t} + \varphi_5 YY_{ij,t} + \omega_{ij,t} \qquad (5\text{-}1)$$

[46] For two-stage least squares, some of the regressors enter the model as instruments when the parameters are estimated. However, the model sum of squares (MSS) is determined by the actual values, not the instruments for the endogenous right-hand-side variables. The model's residuals are computed over a set of regressors different from those used to fit the model. This means a constant-only model of the dependent variable is not nested within the two-stage least squares model, even though the two-stage model estimates an intercept, and the residual sum of squares (RSS) is no longer constrained to be smaller than the total sum of squares (TSS). When RSS exceeds TSS, the MSS and the R^2 will be negative. (Stata, 1999)

[47] Details see Calmfors et al. (1997) pp. 314.

$$Corr_{ij,t} = \alpha + \beta_1 TI_{ij,t} + \beta_2 FIX_{ij,t} + \varepsilon_{ij,t} \quad (5\text{-}2)$$

If the business cycle correlation is directly affected by a fixed exchange rate rather than trade intensity, then it follows that $\beta_1 = 0$ and $\beta_2 \neq 0$. However, the results in Table 5-3 show that β_1 remains significantly positive and β_2 is statistically insignificant in all de-trended methods and normalisations, suggesting that bilateral pegging of currencies only affects economic integration indirectly through its impact on international trade. Therefore we would like to follow Frankel and Rose (2002) and Shambaugh (2004) to put $FIX_{ij,t}$ variable in the first step as an instrumental variable.

5.3.1 Why Are the IV Estimates Greater than the OLS Estimates?

It is obvious that trade intensity coefficient in Table 5-3 is much greater than coefficient in Table 5-2 (average 0.24 from IV regressions and 0.10 from OLS regressions). The Hausman specific test can be used here to compare that the coefficient of bilateral trade intensity from OLS is the same with the coefficient from IV estimation.[48] The Hausman test results reported in Table 5-3 show that the coefficients from IV estimation are statistically significant different with OLS estimates.

In the first stage analysis, we find both 'distance' and 'product of GDP per capita' are very important determinants for trade intensity and including either of them increases the magnitude of β much. Thus the main reason of the IV estimates are greater than the OLS estimates is that instruments does affect the trade intensity particular for distance and product of GDP per capita and using estimated trade intensity increase the magnitude.

[48] The null hypothesis of the Hausman test is that we have two consistent estimators of β, β_{OLS} and β_{IV}. Under the alternative hypothesis, only one of these β_{IV} is consistent. The suggestion, then, is to exam d=β_{IV} - β_{OLS}. Under the null hypothesis, plim d=0, whereas under the alternative, plim $d \neq 0$. For example, the slope of trade from OLS estimation is 0.1028 with the robust standard error 0.0082 and the slope of trade from IV estimation is 0.2332 with the robust standard error 0.0117 in HP filter de-trending method and GDP normalisation regression. With these figures it is possible to carry out Hausman's test:

$$H = \frac{(\beta_{IV} - \beta_{OLS})^2}{S.E._{IV}^2 - S.E._{OLS}^2} = \frac{(0.2332 - 0.1028)^2}{0.0177^2 - 0.0082^2} = 242.73$$, the 95% critical value from the Chi-squared distribution with one degree of freedom is 3.84. So the hypothesis that OLS estimator is consistent would be rejected.

The OLS estimate is determined by the association between the trade intensity and the business cycle correlation, while the IV estimate is determined by the association between the business cycle correlation and the component of trade correlated with the instruments. Thus, the fact that the OLS estimate is smaller than the IV estimate means the business cycle's association with the component of trade that is not correlated with the instrument is weaker than its association with the component that is correlated. To explain this, we consider a simple model. In our OLS regression the coefficient of trade intensity:

$$\beta = \frac{Cov_{Corr,TI}}{\sigma_{TI}^2} = \rho_{Corr,TI} \frac{\sigma_{Corr}}{\sigma_{TI}} \qquad (5\text{-}3)$$

In this equation, the coefficient of trade intensity depends on the correlation coefficient between the business cycle and the trade intensity ($\rho_{Corr,TI}$) and the standard deviation of the business cycle and the trade intensity (σ_{Corr} and σ_{TI}). In the OLS and IV estimation, the standard deviation of the business cycle is identity. That means we should only focus on the correlation coefficients and the standard deviation of trade, i.e. compare the $\rho_{Corr,TI}$ with $\hat{\rho}_{Corr,TI}$ and σ_{TI} with $\hat{\sigma}_{TI}$.

Figure 5-1 to Figure 5-3 present these two associations. Figure 5-1 shows that there is a positive association between real GDP correlation and the component of trade is not correlated with the instrument, and the correlation coefficient is only 29.46%. Figure 5-2 and Figure 5-3 present that there is a positive association between real GDP correlation (by HP filter) and the component of trade (normalised by GDP) correlated with the instrument estimated by either FE or RE model, too.

Figure 5-2 is very similar with Figure 5-3 which proves that both FE and RE model estimate very similar result in the trade intensity equation. Also we find that the slopes in Figure 5-2 and Figure 5-3 are higher than the slope in Figure 5-1. The associations in FE and RE models (31.11% for FE and 31.69 for RE) are higher than that from estimation of actual trade intensity. The observations at the upper right and lower left result in high coefficient and lower right and upper left observations lead to low coefficient. This smaller relationship causes the OLS estimate to be less than the IV estimate. Regarding to σ_{TI} and $\hat{\sigma}_{TI}$, we find the standard deviation of trade intensity (1.40) is greater than the standard deviation of fitted trade intensity (1.33 for FE and 1.29 for RE). That is one of the reasons why the IV estimates is greater than the OLS estimates.

Also the explanation of the IV estimates exceeding the OLS estimates is that OLS is in fact biased down. The bilateral shipping of goods between countries does not raise income, but trade is a proxy for the many ways in which interactions between countries raise income by specialization, spread of idea and so on. Trade is likely to be highly correlated with the extent of such interactions. Thus trade is an imperfect measure of the business cycle correlation among countries. And since measurement error leads to downward bias, this would mean that OLS would lead to an understatement of the effect of closer business cycle interactions.

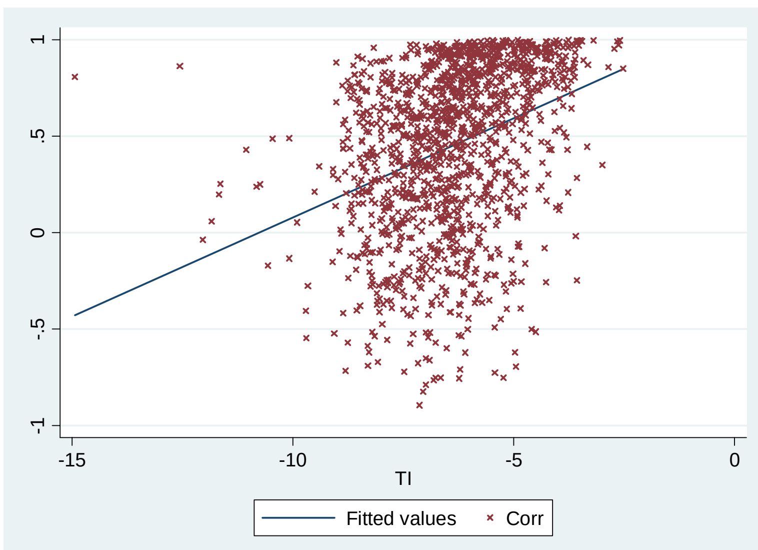

Figure 5-1. *Associations Between Real GDP Correlation and the Component of the Trade Intensity uncorrelated with Instruments*

Notes: Corr is the correlations of real GDP de-trended by HP-filter and TI is the trade intensity normalized by GDP.

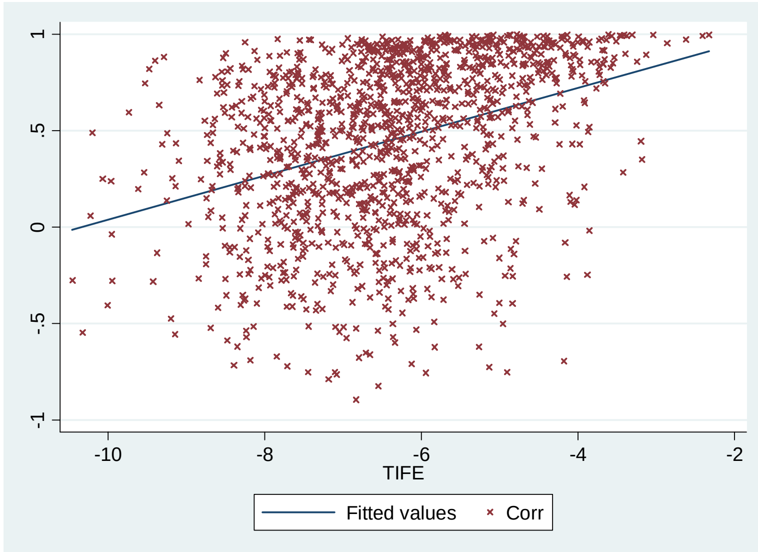

Figure 5-2. *Associations Between Real GDP Correlation and the Component of the Trade Intensity correlated with Instruments by FE Model.*

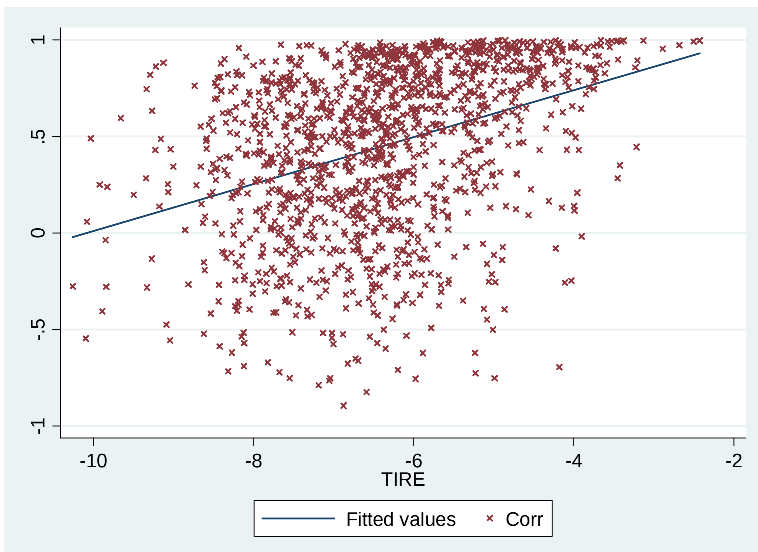

Figure 5-3. *Associations Between Real GDP Correlation and the Component of the Trade Intensity correlated with Instruments by RE Model.*

5.3.2 The Quality of Instruments

We are interested in whether these variables in the gravity model are good instrumental variables and whether they eliminate the endogeneity problem for trade intensity. As we have mentioned an instrumental variable must satisfy two requirements: it must be correlated with the included endogenous variables, and be orthogonal to the error process. The former condition may be readily tested by examining the fit of the first stage regressions. The first stage regressions are reduced form regressions of the endogenous variable trade intensity on the full set of instruments (six instruments); the relevant test statistics here relate to the explanatory power of the excluded instruments in these regressions. A statistic commonly used, as recommended for example by Bound et al. (1995) is the R^2 of the first-stage regression with the included instruments partialled-out. This is the squared partial correlation between the excluded instruments and the endogenous regressor. The values of partial R^2 are very close to our adjusted R^2 which is 0.46 for GDP normalization and 0.38 for trade normalization. Alternatively, this may be expressed as the F-statistics of the joint significance of the instruments in the first-stage regression. F-statistics significantly reject the hypothesis of excluding instruments in our first step.

Secondly, one can imagine reasons why all the variables used to estimate the trade might have some endogenous component that is correlated with the error term in the business cycle equation, particularly for fixed exchange rate and the product of GDP per capita. Indeed, that is precisely the point of much of the existing currency union literature. Regarding the 'fixed exchange rate' variable, we control for the third factors that could affect both fixed exchange rate and trade intensity, such as landlocked, colonial history, political union and so on. The fixed exchange effect remains almost as strong as ever. Also we separate the variable 'fixed exchange rate' into 'direct pegged' 'indirect pegged' and 'currency union'.[49] Three variables are still significant and have not changed other coefficients much. To control the product of GDP per capita endogenous problem, we use the product of the fitted values from the model of income determination (Frankel and Romer, 1999) in place of actual values of product of GDP per capita. After control the

[49] Direct pegged is defined by both countries pegged their national currency each other directly. For instance, China pegged the RMB with US dollar and the dummy between them is one. Indirect pegged is defined by both countries pegged their national currency with the same third country. For instance, both China and Hong Kong pegged RMB and HK dollar with US dollar, and the dummy between China and Hong Kong is one. Currency union means countries are in the same currency union, such as Euro zone.

endogenous of product of GDP per capita, we find that the product of fitted GDP per capita remains positive and has similar magnitudes. All other instruments have no significant differences.

Finally, to check that no single variable that could conceivably be endogenous is driving the results, we redo the construction of the instruments and the regressions of equation (4-2) in four ways: omitting the fixed exchange rate; excluding common language and common border; omitting the free trade agreement; and using GDP and population for country *i* and county *j* separately instead of product of GDP per capita. None of these changes has a major effect on the results and the IV estimates remain much larger than the OLS estimates. Excluding either distance or the product of GDP per capita does affect the trade intensity and change the magnitudes of coefficient in the second step. Nevertheless, it is certainly possible that an element of endogeneity remains in the instruments such as fixed exchange rate. While we do not believe that our results can be explained away by endogeneity.

In addition, we report the Durbin-Wu-Hausman (DWH) test in Table 5-2. DWH compute a test for endogeneity in a regression estimated via instrumental variables (IV), the null hypothesis for which states that an ordinary least squares (OLS) estimator of the same equation would yield consistent estimates: that is, any endogeneity among the regressors would not have deleterious effects on OLS estimates. A rejection of the null indicates that endogenous regressors' effects on the estimates are meaningful, and instrumental variables techniques are required. The test was first proposed by Durbin (1954) and separately by Wu (1973) (his T4 statistic) and Hausman (1978). The details of the DWH test are presented in the Appendix. The Durbin-Wu-Hausman tests, in both normalisations, reject the null hypothesis that an OLS estimator of the same equation would yield consistent estimates and we think the IV estimation is required. Wu-Hausman *F* tests also reported in Table 5-2 present the same results to the DWH test.

From all of the above tests, we have confidence to believe that our six instrumental variables fit the first stage well and are good instruments.

5.4 Panel Data Model

Estimating equation (4-1) by pooled OLS is not feasible for another reason. Pooled OLS estimation also ignores potentially important unobservable country-pair specific effects. The estimates shown in Table 5-4 were obtained using FE model assuming that trade is weakly exogenous. The estimates consistent with OLS estimate that a positive and statistically significant relationship exists between trade intensity and the real GDP correlation. The average coefficient is 0.09 which is very close to OLS estimate, i.e. the impact of trade intensity on the business cycle correlation is 9.4%. And there are no

Table 5-4

FE Model Results

	Normalised by Nominal GDP		Normalised by Total Trade	
	HP filter	First differences	HP filter	First differences
Constant	1.09*	1.08*	0.85*	0.94*
	(9.34)	(9.13)	(6.27)	(6.85)
TI_{ijt}	0.10*	0.10*	0.07*	0.10*
	(5.52)	(5.64)	(2.95)	(3.82)
Within R^2	0.03	0.03	0.01	0.01
Between R^2	0.23	0.28	0.11	0.15
Overall R^2	0.11	0.14	0.05	0.08
F-statistics	30.46*	31.85*	8.73*	14.59*
	(0.00)	(0.00)	(0.00)	(0.00)
F test (all μ_{ij} =0)	2.33*	2.40*	2.65*	2.77*
	(0.00)	(0.00)	(0.00)	(0.00)
Hausman Test (FE vs. OLS)	0.02	0.69	0.01	0.04
	(0.89)	(0.41)	(0.94)	(0.84)

Notes: All the results estimated by $Corr_{ij,t} = \alpha + \beta TI_{ij,t} + \mu_{ij} + \varepsilon_{ij,t}$ where μ_{ij} is the matrix of country pair dummies. Within R^2 is based on time-series component data, between R^2 is based on cross-sectional data, and overall R^2 includes both of them. The first *F*-statistics is the same with before with the null hypothesis that β =0. The F-test with the null hypothesis that all the country pair specific effects are zero indicates that the FE model report the same results with OLS. The Hausman test compares the OLS estimation and FE model. t-statistics for coefficients and probability values are shown in parentheses. * denotes statistical significance at the 5% levels. Bilateral annually data from 24 countries, 1959 through 2003 split into five sub-periods. Maximum sample size is 1380.

significant differences between de-tending methods and normalisation.

We report three R^2s: within R^2 which is based on the time-series component of the data, between R^2 which is based on the cross-sectional component of the data and overall R^2 which includes both of them. The overall R^2s are very close to the adjusted R^2 from OLS estimation which also confirm that the estimates from FE model have no significant difference with OLS estimates. Comparing the between and within R^2s, it is apparent the cross-sectional dimension of the data accounts for the largest part of the overall R^2. The F-statistics in the first panel is the same with before and confirms the overall significance of the model. Following by equation (4-9), we also implement another F-test for the joint significance of county-pair specific dummies. We find that the country pair specific effects are statistically significant thus justifying the use of panel methods. The Hausman test in Table 5-4 compares the FE estimations with OLS estimations. None of them can reject the hypothesis and we can say that results from OLS are not explained away by country-pair specific effects.

Table 5-5 presents RE estimates. Again we find a positive and significant slope, and they are very close to FE model and OLS estimation. The impact of the trade intensity on the business cycle correlation is 10%. Again we do not find any statistically significant differences between de-trending methods and normalisation. The cross-sectional dimension of the data accounts for the largest part of the overall R^2. However, these R^2s are not as useful as they are from OLS regressions. “When we estimate the model’s parameters using generalized least squares (GLS), the total sum of squares cannot be broken down in the same way, making the R^2 statistic less useful as a diagnostic tool for GLS regressions. Specifically, an R^2 statistic computed from GLS sums of squares need not be bounded between zero and one and does not represent the percentage of total variation in the dependent variable that is accounted for by the model.” (Stata, 2005)

A Wald-statistics for RE model confirms the overall significance of the model. Following equation (4-13), Breusch-Pagan Lagrangian Multiplier tests are reported to compare the pooled OLS and RE model. Again the country pair specific effects are statistically significant, justifying the use of panel methods. The Hausman test statistic for the OLS and RE estimations is close to zero, showing that the OLS and RE are not different from one another. When comparing the FE and RE, the low Hausman test statistic suggests that the FE and RE estimates are statistically indistinguishable from one another.

Table 5-5

RE Model Results

	Normalised by Nominal GDP		Normalised by Total Trade	
	HP filter	First differences	HP filter	First differences
Constant	1.10*	1.15*	0.84*	0.91*
	(17.38)	(17.71)	(13.36)	(14.12)
TI_{ijt}	0.10*	0.12*	0.07*	0.09*
	(10.61)	(11.67)	(6.43)	(7.97)
Within R^2	0.03	0.03	0.01	0.01
Between R^2	0.23	0.28	0.11	0.15
Overall R^2	0.11	0.14	0.05	0.08
Wald-test	113*	136*	41*	64*
	(0.00)	(0.00)	(0.00)	(0.00)
BP-LM test	117*	126*	165*	183*
(Var $\mu_{ij} = 0$)	(0.00)	(0.00)	(0.00)	(0.00)
Hausman Test	0.00	0.23	0.00	0.00
(RE vs. OLS)	(0.95)	(0.63)	(0.97)	(0.94)
Hausman Test	0.02	0.52	0.00	0.04
(FE vs. RE)	(0.90)	(0.47)	(0.95)	(0.85)
	RE	RE	RE	RE

Notes: All the results estimated by $Corr_{ij,t} = \alpha + \beta TI_{ij,t} + \mu_{ij} + \varepsilon_{ij,t}$ where μ_{ij} is random. Within R^2 is based on time-series component data, between R^2 is based on cross-sectional data, and overall R^2 include both of them. The Wald Chi-squared test instead of F-test in RE model with the null hypothesis that beta=0. Breusch and Pagan Lagrangian multiplier test for RE test whether the random μ_{ij} are all zero. The Hausman test compares the OLS estimation vs. FE model and FE model vs. RE model. t-statistics for coefficients and probability values for tests are shown in parentheses. * denotes statistical significance at the 5% levels. Bilateral annual data from 24 countries, 1959 through 2003 split into five sub-periods. Maximum sample size is 1380.

5.5 Two-Stage FE and RE Estimations

This section presents the result of two stage panel data estimation. The determinants of trade intensity are shown in Table 5-6. The first step is to identify which instruments are important determinants of trade intensity.

All of the estimated coefficients are strongly and statistically significant at the 5% level. Estimates are correctly signed and have reasonable magnitudes. In the FE model, time-invariant variables, LAN_{ij}, DIS_{ij}, and ADJ_{ij}, are dropped since they are constant across periods. Hence only three variables are reported in Table 5-6 and the magnitudes of coefficient vary across trade normalisations. The impact of a fixed exchange rate on trade intensity is 15% using the GDP normalisation and 27% using the total trade normalisation. If two countries participate in a bilateral free trade agreement then the increase in trade intensity is on average 68% using the GDP normalisation or 22% using the total trade normalisation. Compare with the first stage in IV estimation, the product of GDP per capita show strongly positive effect on trade in Table 5-6, 35% using GDP normalisation and 11% using total trade normalisation. The FE model explains approximately only 19% of the total variation in trade intensity, since three geographical variables are dropped. Comparing the between and within R^2, we can see that cross-sectional data and time-series data account for an equal part of the overall R^2.

RE model reports all six instrumental variables. The fixed exchange rate effect is 14% using GDP normalisation and 27% using total trade normalisation. Geographical factors are important determinants of trade intensity and indicate quite consistent magnitude across normalisation: distance has a negative impact and adjacency has a positive impact. Using the common language indicates the gain to trade to be approximately 40%. Free trade agreement has similar magnitude with FE model. Finally, positive product of GDP per capita suggests that economic growth in either one or both of the economies acts as a stimulus to international trade with the impact of 17% using GDP normalisation and 4% using trade normalisation. After including three time-invariant variables the average overall R^2s are 41% and mostly explained by cross-sectional data.

Table 5-6

First Stage Results from 2-step Panel Data Model

	Normalised by GDP			Normalised by total trade		
	FE+3IV	RE+6IV	RE+3IV	FE+3IV	RE+6IV	RE+3IV
Constant	-12.31*	-7.22*	-10.34*	-7.46*	-3.91*	-6.87*
	(-32.22)	(-14.17)	(-25.89)	(-23.90)	(-7.98)	(-17.98)
$FIX_{ij,t}$	0.14*	0.13*	0.30*	0.24*	0.28*	0.44*
	(3.19)	(2.28)	(4.99)	(6.63)	(4.91)	(7.76)
LAN_{ij}	dropped	0.38*	dropped	dropped	0.30*	dropped
		(4.06)			(3.37)	
DIS_{ij}	dropped	-0.32*	dropped	dropped	-0.32*	dropped
		(-8.33)			(-8.69)	
ADJ_{ij}	dropped	1.16*	dropped	dropped	1.32*	dropped
		(8.14)			(9.80)	
$FTA_{ij,t}$	0.52*	0.68*	1.06*	0.20*	0.28*	0.68*
	(8.35)	(8.80)	(15.04)	(3.98)	(3.69)	(10.03)
$YY_{ij,t}$	0.30*	0.16*	0.18*	0.10*	0.04*	0.06*
	(14.75)	(8.04)	(8.59)	(6.10)	(2.20)	(2.83)
Within R^2	0.27	0.27	0.26	0.09	0.09	0.09
Between R^2	0.21	0.46	0.25	0.17	0.40	0.20
Overall R^2	0.22	0.44	0.25	0.16	0.37	0.18
F-test (FE)/ Wald test (RE)	134.52*	960.00*	525*	37.65*	726.00*	260*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
F-test / BP-LM test ($\mu_{ij}=0$)	17*	1500*	1546*	28*	1924*	1886*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Note: First step estimates are from:

$TI_{ij,t} = \varphi_0 + \varphi_1 LAN_{ij} + \varphi_2 DIS_{ij} + \varphi_3 ADJ_{ij} + \varphi_4 FTA_{ij,t} + \varphi_5 YY_{ij,t} + \varphi_6 FIX_{ij,t} + \upsilon_{ij} + \omega_{ij,t}$.

FE+3IV is the FE estimates using three time-variant instruments, RE+6IV shows the RE estimator using all six instruments, and the last column is the RE estimates using the same three instruments as the FE estimator. t-statistics for coefficients and probability values for tests are shown in parentheses. * and ** denotes statistical significant at the 5% and 10% level, respectively. F-test for FE model and Wald test for RE model indicates significant level for all equation. The second F-test and BP-LM test exam whether country-pair specific effects are different with 0 for FE and RE model, respectively. Bilateral data come from 24 countries, and are from1959 to 2003 split into five sub-periods. Sample size is 1380 including gaps.

We also report RE estimates using the same three instruments as the FE estimates in RE+3IV column. In fact, LAN_{ij}, DIS_{ij}, and ADJ_{ij} add at least 19% to overall fit of the instrument equation. Dropping the time-invariant instruments also affects the magnitude of the remaining estimates. For example, we focus on the GDP normalisation, using only 3 instruments the RE estimate for FIX_{ijt} is 0.30 compared to 0.13 using all of the instruments, while the FE estimate for $YY_{ij,t}$ is 0.30 compared to 0.16 using RE with 6 instruments.

The overall significance of the model is established by the *F*- or Wald- statistics for FE and RE, respectively. All of them confirm the overall significance of the model. The country-pair specific effects are proved statistically significant by *F*- or BP-LM test for FE and RE, respectively, thus justifying the differences existing across country-pairs and confirming that panel estimation in the first stage is necessary.

Table 5-7 presents instrumental variable estimates of equation (4-17). The column of RE+6IV shows the RE estimator using the full instrument set. The β estimates suggest a stronger relationship between trade intensity and the business cycle correlation than those reported in previous tables. With an average magnitude of 0.26, the business cycle correlation is expected to rise 0.18 if trade intensity were to double. The FE+3IV reports even larger estimators, though it is derived using only 3 instruments since the time-invariant variables (distance, land adjacency, and common official language) are dropped in this case. In RE with full instrument set, we find very consistent estimates between de-trending methods and normalisations, but in FE with 3 instruments, the magnitude of estimates more than double between trade normalisations. Trade intensity normalised by total trade explain more business cycle correlation variation.[50] The size of the β estimate still is greater than those reported in the literature, such as Frankel and Rose (1998), Clark van Wincoop (2001) and Imbs (2004, 2006). This increase in magnitude can be explained by the additional instrumental variables in the first step and the extended group of

[50] When we test the variable of $FIX_{ij,t}$, we find a consistent result. When $FIX_{ij,t}$ in business cycle equation, trade intensity is still significantly positive and $FIX_{ij,t}$ is statistically insignificant, which suggests that bilateral pegging of currencies only affects economic integration through its impact on international trade.

Table 5-7

Second Step Results from 2-Step Panel Data Model

	Variable	Normalised by GDP			Normalised by total trade		
		FE+3IV	RE+6IV	RE+3IV	FE+3IV	RE+6IV	RE+3IV
HP filter	Constant	2.73*	2.08*	3.08*	4.36*	1.77*	3.08*
		(11.18)	(19.13)	(13.65)	(7.76)	(16.13)	(13.65)
	TI_{ijt}	0.36*	0.25*	0.49*	0.73*	0.25*	0.49*
		(9.36)	(15.18)	(11.73)	(6.97)	(12.18)	(11.73)
	F-test (μ_{ij} =0)	2.13*	-		1.78*	-	
		(0.00)			(0.00)		
First differences	Constant	2.89*	2.16*	2.90*	4.77*	1.85*	3.31*
		(11.50)	(19.55)	(17.81)	(8.15)	(16.77)	(13.89)
	TI_{ijt}	0.39*	0.27*	0.39*	0.81*	0.27*	0.54*
		(9.86)	(15.99)	(15.41)	(7.44)	(13.17)	(12.22)
	F-test (μ_{ij} =0)	2.14*	-		1.77*	-	
		(0.00)			(0.00)		

Notes: $Corr_{ij,t} = \alpha + \beta_{RE3}\hat{TI}_{ij,t} + \mu_{ij} + \varepsilon_{ij,t}$ where all variables are defined the same with before. Two-step fixed effect model and two-step random effect model are adopted to estimate this equation. Trade intensity is estimated by six instrumental variables which are from equation 4-2. t-statistics are shown in parentheses. * denotes statistical significance at the 5% levels. Bilateral annually data from 24 countries, 1959 through 2003 split into five sub-periods. Maximum sample size is 1380.

countries and sample period we use for estimation and also the panel data estimation technique,

rather than a pooled instrumental variable estimation method. F-test again rejects the null hypothesis that all country-pair specific effects are zero suggesting the panel estimation; however the BP-LM test can not be used for 2-stage RE estimation.

The Hausman specification test is implemented to compare the 2-stage panel data estimation with OLS, IV and Panel estimations. The 2-stage FE model is strongly different with OLS IV and FE estimations and all tests reject the null hypothesis at 5% level. RE estimation is different with OLS and RE estimation at the 5% level and different with IV estimation at 10% level when trade intensity normalised by GDP, but the hypothesis that the two estimates are the same can not be rejected for IV estimation when trade intensity is normalised by total trade.

The Hausman test statistics for FE+3IV and RE+6IV comparing two GDP de-trending methods and two trade normalisations are 8.97, 22.12, 10.30 and 25.80, showing the FE and RE estimates are different from each another. However, it is not immediately apparent whether this difference is due to the number of instruments selected or, as is normally assumed, due to the individual effects being correlated with $TI_{ij,t}$. When

Table 5-8

Hausman Specification Test-2-step Panel Data Model vs. Other Estimation

		Normalised by GDP			Normalised by total trade		
		FE+3IV	RE+6IV	RE+3IV	FE+IV	RE+IV	RE+3IV
HP filter	OLS	46.58* (0.00)	107.94* (0.00)	-	39.64* (0.00)	92.23* (0.00)	-
	IV	11.66* (0.00)	3.17** (0.07)		23.19* (0.00)	1.38 (0.24)	
	FE	58.51* (0.00)	-		41.54* (0.00)	-	
	RE	-	123.12* (0.00)		-	107.33* (0.00)	
	FE+3IV	-	8.97* (0.00) FE	0.01 (0.91) RE	-	22.12* (0.00) FE	6.15* (0.01) FE
First differences	OLS	49.38* (0.00)	110.76* (0.00)	-	43.80* (0.00)	92.90* (0.00)	-
	IV	12.97* (0.00)	3.00** (0.08)		26.86* (0.00)	1.30 (0.25)	
	FE	66.66* (0.00)	-		45.39* (0.00)	-	
	RE	-	128.44* (0.00)		-	110.09* (0.00)	
	FE+3IV	-	10.30* (0.00) FE	0.00 (0.95) RE	-	25.80* (0.00) FE	7.45* (0.01) FE

equation (4-17) is re-estimated via RE but using only the time-variant instruments (see RE+3IV columns in Table 5-7 and Table 5-8 following by equation (4-19)) the Hausman test does not exceed the relevant critical value for GDP normalisation, suggesting that the FE and RE estimates are statistically indistinguishable from one another.

Thus the use of RE is preferred given (i) the wider set of instruments available and (ii) the assumption that the randomly distributed individual effects are independent of trade intensity holds. While it is not possible to compare directly the FE estimates with those obtained using RE with all of the instruments, it is a reasonable assumption to treat distance, land adjacency and a common official language as exogenous variables. Nevertheless, in total trade normalisation panel, the Hausman test still rejects the null hypothesis and prefers FE.

5.6 Sensitivity Analysis

5.6.1 Measurements of the Business Cycle Correlation

The standard practice to measure the business cycle is real GDP which has been employed in many papers, but as Frankel and Rose (1998) said, it is difficult to select the optimal single empirical analogue to the theoretical concept of the business cycle. Industrial production, total employment and unemployment rate also are selected to measure the business cycle correlation in literature.[51] Also in chapter 3, we have found that these proxies are statistically different with real GDP. We would like to follow Frankel and Rose (1998) to use industrial production, total employment and

[51] Davidas and Szapary (2004) discuss various measures of the business cycles also from the perspective of the Central and Eastern European countries. Anderson, Kwark & Vahid (1999) use the quarterly indices of industrial production to measure the business cycles since GDP data for their countries is only available at an annual frequency and Bergman (2004), Fidrmuc (2004) use the industrial production as well. Bayoumi and Eichengreen (1994), Crosby (2003) and Calderon et al. (2007) use annual data on GDP to measure the correlations of business cycle. Clark and Van Wincoop (2000) adopt both Employment and GDP.

unemployment rate to measure the business cycle and exam the robustness of our result from above.

The data of an index of industrial production are from the IMF (IFS) database; total employment and the unemployment rate are from SourceOECD Economics Outlook. The employment and unemployment rate data of Hong Kong come from Hong Kong Census & Statistics Department (GovHK, 2004). Industrial production, total employment and unemployment rate are quarterly data. All the data (with gaps[52]) cover the same 24 sample countries from 1959 to 2003 and are transformed by the same methods with real GDP. Firstly, we take natural logarithms for industrial production and total employment but not for the unemployment rate and then de-trend them so as to isolate cyclical components of economic time series conforming to a certain definition of the business cycle by HP filter and fourth-differences, multiplying by 100, so that the resulting variable can be interpreted as a growth rate.

To be consistent with the real GDP correlations analysis, average business cycle correlations measured by industrial production, total employment and unemployment rate between 24 individuals countries with their 23 partners across 5 sub-periods are reported in Table 5-9, Table 5-10 and Table 5-11, respectively. In Table 5-9, we find that not all of European countries have closer business cycles and Greece and Norway present less business cycle synchronisation. Countries such as Australia, Canada, Japan and the USA all have reasonably high business cycle correlations. However, Hong Kong, Mexico and New Zealand remain low correlations with their partners. The average country correlations indicate that after jumping to 0.47 in the second period, the last three periods have consistent correlations between 0.31 and 0.33.

Total employment correlations have lower values than other measurements and some countries even European countries such as Greece and Norway have negative correlations for the whole period. The average employment correlations from 24 countries show that they increase progressively over time up till the 1986-94 period. All individual countries

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[52] We have no data of industrial production, employment and unemployment rate data for China and no employment, unemployment rate data for Mexico.

Table 5-9

Average Industrial Production Correlations de-trended by HP-filter

	1959-67	1968-76	1977-85	1986-94	1995-03	Change (%)	1959-03
Australia	0.09	0.58	0.34	0.40	0.26	188	0.33
Austria	0.44	0.59	0.52	0.32	0.46	5	0.46
Belgium & Luxembourg	0.42	0.65	0.42	0.42	0.27	-34	0.44
Canada	0.04	0.58	0.46	0.23	0.44	954	0.35
China							
Denmark	0.19	0.47	0.35	0.14	0.23	18	0.28
Finland	0.30	0.49	0.30	0.34	0.48	57	0.38
France	0.30	0.55	0.48	0.47	0.47	58	0.45
Germany	0.42	0.58	0.52	0.45	0.48	15	0.49
Greece	0.12	0.07	0.40	0.25	0.12	0	0.19
Hong Kong			**-0.07**	0.01	0.08		0.01
Ireland	0.16	0.55	0.34	0.40	0.34	113	0.36
Italy	**-0.13**	0.50	0.39	0.50	0.42	414	0.33
Japan	0.14	0.62	0.53	0.39	0.23	63	0.38
Mexico			0.02	0.05	0.20		0.09
Netherlands	0.42	0.59	0.48	0.25	0.38	-10	0.42
New Zealand			0.17	0.02	0.07		0.09
Norway	0.25	**-0.41**	0.43	0.16	0.11	-54	0.11
Portugal	0.34	0.51	**-0.05**	0.26	0.03	-91	0.22
Spain	0.06	0.56	0.24	0.48	0.38	499	0.35
Sweden	0.31	0.23	0.40	0.32	0.31	1	0.31
Switzerland	0.30	0.57	0.31	0.33	0.49	67	0.40
UK	0.40	0.52	0.21	0.38	0.46	13	0.39
USA	**-0.12**	0.57	0.43	0.30	0.42	469	0.32
Average	0.22	0.47	0.33	0.30	0.31	137	0.31

Notes: data are from IMF IFS, and the average industrial production correlations are calculated by the individual correlations from each country vis-à-vis their 23 partners. Bold marks are the negative correlations.

have positive correlations for the whole period when the business cycle is measured by unemployment rate. The average countries' correlations increase in the first two periods and then decrease. We do not report the business cycles de-trended by fourth difference tables here, since they have similar values with economic activities de-trended by the HP-filter.

Table 5-10

Average Total Employment Correlations de-trended by HP-filter

	1959-67	1968-76	1977-85	1986-94	1995-03	Change (%)	1959-03
Australia	0.03	0.32	0.33	0.34	**-0.14**	-565	0.18
Austria	0.23	0.31	0.36	0.17	0.36	56	0.29
Belgium & Luxembourg	0.20	0.37	0.43	0.39	0.43	114	0.36
Canada	0.01	0.11	0.40	0.24	0.19	1463	0.19
China							
Denmark	0.19	0.28	0.20	0.21	0.16	-16	0.21
Finland	0.31	**-0.10**	0.13	0.47	0.41	36	0.25
France	0.09	0.39	0.07	0.46	0.38	307	0.28
Germany	0.23	0.28	0.39	-0.09	0.38	65	0.24
Greece	0.00	-0.24	**-0.04**	0.03	**-0.02**	-234	-0.05
Hong Kong				0.08	-0.16		-0.04
Ireland	0.06	0.22	0.34	0.39	0.39	526	0.28
Italy	**-0.19**	0.13	0.29	0.27	0.26	232	0.15
Japan	**-0.09**	0.15	**-0.09**	0.16	0.02	119	0.03
Mexico							
Netherlands		0.16	0.46	0.30	0.41		0.33
New Zealand	0.03	0.25	**-0.02**	-0.15	-0.41	-1618	-0.06
Norway	**-0.12**	**-0.29**	0.18	-0.04	0.14	217	-0.03
Portugal	0.27	**-0.12**	**-0.14**	0.19	0.41	51	0.12
Spain	0.01	0.35	0.03	0.41	0.42	5701	0.24
Sweden	0.18	-0.08	0.33	0.49	0.29	58	0.24
Switzerland	**-0.05**	0.27	0.26	0.27	0.31	682	0.21
UK	0.17	0.28	0.30	0.34	0.21	22	0.26
USA	0.00	0.20	0.21	0.15	0.26	17987	0.16
Average	0.08	0.15	0.21	0.23	0.21	1260	0.17

Notes: data are from SourceOECD, and the average employment correlations are calculated by the individual correlations from each country vis-à-vis their 23 partners. Bold marks are the negative correlations.

Figure 5-4 compares the four different measures of real economic activity across time. Their trends are quite different. Real GDP correlations have the highest values and employment correlations have the lowest values. As we expected, the total employment correlations and unemployment rate correlations are relatively consistent and industrial production relatively close to real GDP correlations.

Table 5-11

Average Unemployment Rate Correlations de-trended by HP-filter

	1959-67	1968-76	1977-85	1986-94	1995-03	% Change	1959-03
Australia	0.23	0.48	0.48	0.43	0.05	-80	0.33
Austria	0.27	0.40	0.55	0.43	0.41	49	0.41
Belgium & Luxembourg	0.27	0.51	0.57	0.37	0.39	44	0.42
Canada	0.07	0.30	0.51	0.37	0.32	333	0.31
China							
Denmark	0.27	0.49	0.52	0.19	0.23	-14	0.34
Finland	0.33	0.01	0.30	0.57	0.17	-47	0.28
France	0.30	0.52	0.12	0.49	0.42	40	0.37
Germany	0.29	0.43	0.61	0.51	0.36	22	0.44
Greece	0.01	**-0.41**	0.56	0.51	**-0.17**	-1308	0.10
Hong Kong				0.09	0.14		0.12
Ireland	**-0.11**	0.39	0.48	0.55	0.38	436	0.34
Italy	**-0.18**	0.16	0.24	0.06	0.14	181	0.09
Japan	0.03	0.50	0.45	0.24	**-0.11**	-452	0.22
Mexico							
Netherlands		0.46	0.59	0.22	0.32		0.40
New Zealand	0.29	0.25	0.25	0.05	**-0.04**	-112	0.16
Norway	0.01	0.44	0.44	**-0.12**	0.14	1101	0.18
Portugal	0.26	0.14	**-0.05**	0.13	0.32	24	0.16
Spain	**-0.08**	0.44	0.04	0.39	0.37	544	0.23
Sweden	0.30	0.00	0.52	0.57	0.35	19	0.35
Switzerland	0.18	0.41	0.51	0.55	0.40	126	0.41
UK	0.25	0.45	0.40	0.49	0.22	-15	0.36
USA	**-0.05**	0.33	0.25	0.28	0.32	758	0.23
Average	0.15	0.32	0.40	0.34	0.23	82	0.28

Notes: data are from SourceOECD, and the unemployment rate correlations are calculated by the individual correlations from each country vis-à-vis their 23 partners. Bold marks are the negative correlations.

Following the different measurements of the business cycle correlation, Table 5-12 presents a positive and statistically significant relationship between the bilateral trade intensity and the business cycle correlation. All proxies, de-trending methods and trade normalisation estimated by both fixed effect and RE model have not changed results only except the case of industrial production correlation estimated by FE when trade normalised by total trade. The relationship estimated by RE with full instruments set has very consistent magnitudes across de-trending methods, proxies for the business cycle and normalisations (11%) and all are strongly significant. However, the magnitude of the estimated relationship in FE with only 3 instruments varies depending on economic activities and trade normalisation. The coefficients estimated by FE are greater than those from RE estimation which is the same with the result from real GDP correlation equation. Comparing with real GDP correlation equation, all of these proxies decrease the magnitudes of estimate more than 50% but have not change the result of a significant and positive relationship.

Recall the three columns in Table 5-7, to enable us to choose one estimate for inferences, we still can not compare the FE+3IV with RE+6IV directly. In Table 5-12, a Hausman test was computed to compare the FE estimates with the RE estimates using only time-variant instruments (i.e. FE+3IV vs. RE+3IV). If the test statistic was found to be less than the 5% critical value then RE using the full instrument set was chosen as the ‘optimal’ estimator, otherwise inferences were made from the FE results.

The RE model is more appropriate in the industrial production equation and the FE model is more appropriate in the unemployment rate equation. In the total employment equation, we find that when employment is de-trended by HP filter, the FE model is more suitable, however, when employment is de-trended by fourth difference, the random effect model is more appropriate.

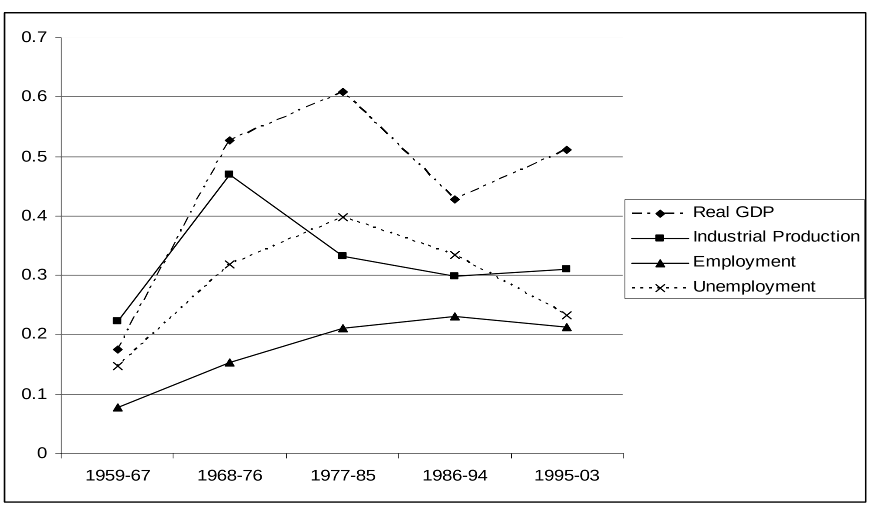

Figure 5-4. *Average Business Cycles Across Time*

Table 5-12

The Business Cycle Correlation Equation

		Variable	Industrial Production		Employment		Unemployment Rate	
			FE+3IV	RE+6IV	FE+3IV	RE+6IV	FE+3IV	RE+6IV
Bilateral Trade normalised by GDP	HP filter	Constant	1.39*	1.03*	1.84*	0.85*	2.26*	1.04*
			(5.72)	(12.71)	(5.65)	(7.48)	(6.98)	(11.93)
		TI_{ijt}	0.17*	0.11*	0.27*	0.11*	0.32*	0.12*
			(4.37)	(8.86)	(5.08)	(5.92)	(6.07)	(8.66)
		R^2	0.09		0.03		0.08	
		Hausman	3.65		8.83*		14.28*	
			RE		FE		FE	
	First differences	Constant	1.14*	0.92*	1.05*	0.88*	1.84*	0.96*
			(4.66)	(13.56)	(3.24)	(9.08)	(5.84)	(11.56)
		TI_{ijt}	0.13*	0.09*	0.14*	0.12*	0.25*	0.11*
			(3.26)	(8.67)	(2.72)	(7.45)	(4.93)	(8.16)
		R^2	0.11		0.06		0.07	
		Hausman	1.90		0.49		8.25*	
			RE		RE		FE	
Bilateral Trade normalised by total trade	HP filter	Constant	0.93*	0.96*	2.41*	0.76*	2.77*	0.96*
			(2.06)	(12.51)	(4.27)	(6.82)	(4.98)	(10.80)
		TI_{ijt}	0.11	0.12*	0.43*	0.11*	0.47*	0.13*
			(1.33)	(8.43)	(3.94)	(5.23)	(4.45)	(7.58)
		R^2	0.09		0.02		0.05	
		Hausman	0.00		6.81*		9.05*	
			RE		FE		FE	
	First differences	Constant	0.83**	0.90*	1.08*	0.86*	2.03*	0.89*
			(1.82)	(13.86)	(2.02)	(8.60)	(3.86)	(10.57)
		TI_{ijt}	0.09	0.11*	0.17**	0.13*	0.33*	0.12*
			(1.07)	(8.72)	(1.70)	(7.01)	(3.31)	(7.23)
		R^2	0.10		0.05		0.05	
		Hausman	0.00		0.12		3.98*	
			RE		RE		FE	

Notes: $Corr_{ij,t} = \alpha + \beta_{RE3}\hat{TI}_{ij,t} + \mu_{ij} + \varepsilon_{ij,t}$ where all variables are defined the same as before. Two-step fixed effect model and two-step random effect model are adopted to estimate this equation. Trade intensity is estimated by three or six instrumental variables. t-statistics are shown in parentheses. * denotes statistical significance at the 5% levels. Bilateral annual data from 24 countries, 1959 through 2003 split into five sub-periods. Maximum sample size is 1380.

Therefore, in industrial production equation, even the FE estimation has no significant estimates when trade normalised by total trade, we still can confirm significant effect from trade on the business cycle, since RE estimation is optimal method and presents a significant relationship.

5.6.2 Sub-period Analysis

Whether the relationship between the trade intensity and the business cycle correlations varied across sub-periods was tested using a cross section regression with country pair data. The first stage results are in Table 5-13 and the second stage results are in Table 5-14.

The same instruments are used in the first stage, common official language, distance, adjacency, free trade agreement, product of GDP per capita and fixed exchange rate. This result is perhaps not surprising given that tables in chapter 3 show that many of the countries are now undertaking a greater amount of bilateral trade and becoming more economically integrated in terms of the business cycle co-movements. In explaining the observed rise in trade intensity, the FIX_{ijt} coefficient is only significant for the first two sub-periods, a result which could be partly explained by the switch to floating exchange rates, among some of the countries in the sample, post-1973. LAN_{ij}'s estimates are significant and positively signed for all periods, though the marginal effect declines over time, a result that could be explained by the rising use of second languages in many countries, particularly those were English is not the first language. The DIS_{ij} estimates are statistically significant and negative for all periods and the magnitudes are broadly stable. The estimate for ADJ_{ij} is positive and significant for all the periods.

Table 5-13

IV Estimations for Each Sub-period, First-step

	Period	Const	FIX_{ijt}	LAN_{ij}	DIS_{ij}	ADJ_{ij}	FTA_{ijt}	$YY_{ij,t}$	Adjusted R^2
Bilateral Trade normalised by GDP	1959-67	-4.63*	0.60*	0.62*	-0.43*	0.66*	0.79*	0.04	0.37
		(-3.87)	(3.91)	(2.89)	(-5.42)	(2.01)	(2.98)	(0.89)	
	1968-76	-6.03*	0.70*	0.54*	-0.31*	0.85*	1.11*	0.07	0.49
		(-5.47)	(3.56)	(3.00)	(-3.63)	(3.03)	(4.21)	(1.54)	
	1977-85	-4.93*	0.15	0.48*	-0.35*	1.17*	0.61*	0.05	0.48
		(-4.19)	(0.75)	(2.80)	(-3.74)	(4.50)	(2.88)	(1.13)	
	1986-94	-4.83*	-0.23	0.32*	-0.32*	1.27*	0.86*	0.04	0.49
		(-3.95)	(-0.91)	(1.99)	(-3.46)	(5.17)	(2.92)	(0.87)	
	1995-03	-3.79*	0.13	0.23	-0.38*	1.16*	0.46*	0.03	0.45
		(-2.66)	(0.79)	(1.33)	(-4.13)	(4.55)	(2.10)	(0.52)	
Bilateral Trade normalised by total trade	1959-67	-2.34*	0.77*	0.57*	-0.33*	0.99*	0.59*	-0.06	0.35
		(-2.03)	(5.15)	(2.80)	(-4.30)	(3.15)	(2.28)	(-1.21)	
	1968-76	-2.71*	0.95*	0.46*	-0.24*	1.00*	0.78*	-0.08**	0.43
		(-2.63)	(5.17)	(2.74)	(-2.98)	(3.81)	(3.16)	(-1.93)	
	1977-85	-3.18*	0.03	0.41*	-0.33*	1.36*	0.33	0.01	0.39
		(-2.61)	(0.16)	(2.29)	(-3.44)	(5.04)	(1.52)	(0.17)	
	1986-94	-4.44*	-0.34	0.14	-0.33*	1.48*	0.58**	0.08	0.40
		(-3.35)	(-1.23)	(0.77)	(-3.35)	(5.53)	(1.80)	(1.64)	
	1995-03	-3.78*	0.06	0.05	-0.40*	1.36*	0.17	0.08	0.38
		(-2.43)	(0.33)	(0.28)	(-4.03)	(4.91)	(0.70)	(1.39)	

Notes: The regression estimated by OLS:

$$TI_{ij} = \varphi_0 + \varphi_1 LAN_{ij} + \varphi_2 DIS_{ij} + \varphi_3 ADJ_{ij} + \varphi_4 FTA_{ij} + \varphi_5 YY_{ij} + \varphi_6 FIX_{ij} + \omega_{ij}$$

Six Instrumental Variables are: Fixed exchange rate agreement, language, distance, adjacent, free trade agreement and product of GDP per capita for each period. t-statistics are shown in parentheses and regressions are with robust standard errors. * and ** denote statistical significance at the 5% and 10% levels, respectively. Bilateral annually data are from 24 countries, maximum sample size for each period is 276.

Magnitude rises across the sub-periods, suggesting a greater proportion of overall trade took place among immediate neighbours. The FTA_{ijt} estimates suggest that membership of a free trade agreement raises trade intensity, though the size of this impact does vary

Table 5-14

IV Estimations for Each Sub-period, Second-step

	Period	HP filter		First differences	
		Constant	TI_{ijt}	Constant	TI_{ijt}
Bilateral Trade normalised by GDP	1959-67	0.39*	0.03	0.47*	0.05**
		(2.19)	(1.24)	(2.53)	(1.82)
	1968-76	1.44*	0.14*	1.48*	0.15*
		(12.07)	(7.75)	(12.64)	(8.54)
	1977-85	1.95*	0.21*	2.11*	0.25*
		(14.16)	(9.86)	(13.70)	(10.61)
	1986-94	2.57*	0.35*	2.61*	0.34*
		(14.36)	(12.10)	(14.52)	(12.03)
	1995-03	2.18*	0.28*	2.30*	0.30*
		(10.67)	(8.26)	(10.71)	(8.55)
Bilateral Trade normalised by total trade	1959-67	0.30*	0.02	0.38*	0.05
		(1.92)	(0.82)	(2.35)	(1.54)
	1968-76	1.18*	0.12*	1.31*	0.15*
		(9.85)	(5.50)	(10.90)	(6.88)
	1977-85	1.38*	0.14*	1.57*	0.20*
		(10.87)	(6.16)	(11.29)	(7.85)
	1986-94	1.87*	0.27*	1.87*	0.26*
		(12.18)	(9.53)	(12.28)	(9.32)
	1995-03	1.89*	0.26*	1.97*	0.28*
		(10.45)	(7.73)	(10.44)	(7.99)

Notes: The regression estimated by IV estimation: $Corr(Y_i, Y_j)_t = \alpha + \beta\, Trade_{ij,t} + \varepsilon_{ij,t}$, the first stage results are from Table 5-13. t-statistics are in parentheses and bold marks are significant values at 95%. * and ** denote statistical significance at the 5% and 10% levels, respectively. Bilateral annually data are from 24 countries, maximum sample size for each period is 276.

somewhat over the sub-periods. We also find variability across the $YY_{ij,,t}$ estimates, switching between positive and negative values and statistical significance. The fit of regressions in first stage also confirm that all these instruments explain trade well and it is the lowest in the first period and increase around 47% for the later four periods using GDP normalisation and 40% using trade normalisation. Both normalisations present very similar results.

The β estimate is statistically insignificant for the first time period, but significance and magnitude increases progressively over time up until the 1986-94 period, when the maximum marginal effect occurs. All other de-trending methods and normalisations also report very close results and show a stronger relationship between trade intensity and the business cycle correlation across time. We do not report R^2 in the second stage, since the R^2s in IV estimations are not bounded between 0 and 1.

5.6.3 Panel Unit Root Test

Our four proxies for the business cycle, particularly the real GDP, exhibit strong trends and they are not stationary and thus are not amenable to the analysis. If a real GDP, for example, is truly $I(1)$, then shocks to it will have permanent effects. If confirmed, then this variable would mandate some rather serious reconsideration. For example, the argument that a change in bilateral trade could have a transitory effect on real output would vanish. In many cases, stationarity can be achieved by simple differencing or some other transformation. That is the reason we take the natural log (except for the unemployment rate) and de-trend them by both HP-filter and differencing.

To test the stationarity of our variables the Dickey-Fuller test (DF) and augmented Dickey-Fuller test (ADF) are used. They are the most popular unit root tests which are common practices among applied researchers and have become an integral part of econometric courses. The testing procedure for the ADF test is the same as for the Dickey-Fuller test but it is applied to the model. For example we have a model:

$$y_t = \mu + \beta t + \gamma y_{t-1} + \gamma_1 \Delta y_{t-1} + \cdots + \gamma_p \Delta y_{t-p} + \varepsilon_t \tag{5-4}$$

where μ is a constant, β the coefficient on a time trend and p the lag order of the autoregressive process. Imposing μ = 0 and β = 0 corresponds to modelling a random walk and using the β = 0 corresponds to modelling a random walk with a drift. The unit root test is then carried out under the null hypothesis γ = 1 against the alternative hypothesis of γ < 1. Once a value for the test statistic

$$DF = \frac{(\hat{\gamma} - 1)}{SE(\hat{\gamma})} \tag{5-5}$$

is computed it can be compared to the relevant critical value for the Dickey-Fuller test. If the test statistic is less than the critical value then the null hypothesis of γ = 1 is rejected and no unit root is present.

These tests can only be used with a time series data set. But in our sample the individual specific intercepts and time trends should be considered as well. Recently, a couple of papers developed the unit root test to be used in panel data, such as Levin, Lin and Chu (2002), Im et al. (2003) and Hadri (2000). The details of their methodologies are introduced in appendix III.

We apply the Levin, Lin and Chu (2002) (*LLC*), Im et al. (2003) (*IPS*) and Fisher tests to our panel data of 276 country pairs over 5 periods from 1959 to 2003. The variable of the business cycle correlations measured by GDP is a balanced panel, without gaps, and all others miss a couple of observations. Therefore, we implement *LLC* and *IPS* tests for real GDP correlations only and Fisher test for all variables.

Table 5-15 investigates the integration properties through the use of *LLC*, *IPS* and *Fisher* panel unit root tests for the 276 country pairs for the variables: Real GDP correlations; industrial production correlations; total employment and unemployment rate de-trended by HP-filter and by first or fourth difference. We test the real GDP correlations by all three panel unit root test since it is a balanced panel variable. All panel unit root statistics reject the null of a unit root. However, our other three proxies for the trade intensity and the business cycle all miss a couple of observations, and only the Fisher test can be implemented to test the panel unit root. Again, all of them reject the null hypothesis. Hence our variables are all stationary after transforming variables.

Table 5-15

Panel Unit Root Tests

		LLC t_{ρ}^{*}	*IPS* $\bar{t}$	*Fisher* χ^{2}
HP-Filter	Real GDP	-76.50* (0.00)	-3.48* (0.00)	4598* (0.00)
	Industrial Production	-	-	2239* (0.00)
	Total Employment	-	-	1816* (0.00)
	Unemployment Rate	-	-	1675* (0.00)
Differencing	Real GDP	-71.75* (0.00)	-3.00* (0.00)	4627* (0.00)
	Industrial Production	-	-	3098* (0.00)
	Total Employment	-	-	1533* (0.00)
	Unemployment Rate	-	-	1808* (0.00)
Trade normalised by GDP		-	-	2504* (0.00)
Trade normalised by total trade		-	-	2021* (0.00)

Notes: all tests have the null hypothesis that H_0: non-stationary against the H_a: stationary.

5.6.4 Other Robustness Tests

The FE two-stage estimations take into account the individuality of country pairs to let the intercept vary for each country pair but each country pair's intercept does not vary over time which is time invariant. Therefore, we would like to consider how the intercept varies over individuals as well as time here.

Just as we used the dummy variables to account for country pair effect, we can allow for time effect in the sense that the business cycle correlation equation change over time because of the factors such as changes in policies, and government regulatory or external effects such as wars or other conflicts. Such time effects can be easily accounted for if we introduce time dummies, one for each period. Since we have data for 5 periods, from 1959 to 2003, we can introduce 4 dummies as well as 275 country pair dummies. When we run the regressions, we find most time dummies are significant but this has not changed the significance and magnitude of the trade intensity on the business cycles. We also have split our data set into two sub-periods across time (instead of five) and re-estimated our equations. The resulting point-estimates of β remain similar to those recorded before.

As Baxter and Kouparitsas (2005) mentioned a couple of variables are the key determinants of the business cycle comovement rather than trade intensity, such as sectorial structure, factor endowments. Imbs (2004, 2006) also pointed out that financial integration and industrial specification lead to changes of the business cycles. Therefore, someone may ask any omitted problems in the business cycle correlations equation. We include several potential variables to solve the omitted variables problem. A dummy variable whether a county pair share the same most important trade partner is included as a control variable since the third-country effects are very important. Close business cycle correlations could be raised by high bilateral trade, but it also could be caused by similar trade partners. Then highly correlated business cycles are likely affected by demand shocks from the common third country economies. A time trend also could be considered in the regression. There may be other trending factors in the background which affect the convergence. Still, it is reassuring to us that the effects of bilateral trade intensity on the business cycle symmetry do not seem very sensitive to the presence of these variables. Finally, we include another two additional variables, industry specialisation and financial integration and the results remain similar to those observed before. However, the interactions amongst these two variables and trade intensity are complex and we discuss them in chapter 7.

5.7 Conclusions

In this chapter, we investigated the relationship between two of the OCA criteria. The empirical analysis is used to estimate the effect of increased trade integration on the bilateral country correlation of the business cycle activity since from a theoretical viewpoint, this effect is ambiguous. Our evidence shows that economic convergence has increased among the world's major economies and the volume of international trade has risen.

To test the endogeneity of optimum currency area criteria empirically, data was obtained for a group of 24 countries over the sample period 1959 to 2003. We follow Frankel and Rose (1998) and start our empirical model from Ordinary Least Square estimation. We find that the business cycle correlation would rise by 0.069 following a doubling of trade intensity. This impact is stronger than literature since extending sample countries and sample period.

However, OLS estimation cannot provide a feasible result, because theory and a large body of literature show that bilateral trade flows are endogenous. We develop OLS model to two-stage least square estimation using six instrumental variables from the gravity model, language, distance, adjacency, free trade agreement, product of GDP per capita and fixed exchange rate. With an average magnitude of 0.24, the business cycle correlation is expected to rise by 0.17 if trade intensity were to double. The higher magnitude can be explained by the higher correlation coefficient between the business cycle correlation and the estimated trade intensity by 6 instruments and lower standard error of estimated trade intensity. Also it is because OLS is in fact biased down. We did a couple of tests to prove that our six instrumental variables from the gravity model are good instruments and they explain trade intensity very well but are not correlated with the business cycle correlation. Particularly for the fixed exchange rate, we find it is insignificant in the business cycle correlation equation but is significantly correlated with trade intensity. Furthermore, we extend the model to panel data estimation considering the unobservable country pair specific effects. Both FE and RE estimation results are reported and are found to be very close to the OLS results.

Finally, the two-stage RE model presents an average magnitude of 0.26. The business cycle correlation is expected to rise 0.18 if trade intensity were to double and the two-stage FE model reports even larger estimators, though it is derived using only 3 instruments (time-invariant variables distance, land adjacency, and common official language are dropped in this case). Hausman specification test is implemented here to select the 'optimal' estimator, but the result depends on trade normalisation. When trade intensity is normalised by GDP, the model prefers RE and when trade intensity is normalised by total trade, the model prefers FE. The ß estimates are still larger than those reported by the previous literature since the time period, number of countries and econometric methodology differs.

To prove the robustness of our result presented above, we did a couple of sensitivity analyses. We use industrial production, total employment and unemployment rate instead of real GDP to measure the business cycle correlations. We find their results are very consistent with real GDP's, and trade intensity has significant and positive impact on the business cycle. In sub-period analysis we find that the β estimate is not statistically significant for the first time period, but the magnitude increases progressively over time up until the 1986-94 period, when the maximum marginal effect occurs. We also include time dummies in our 2-stage FE estimation, split the sample into 2 periods, and add control variables in the business cycle equation, such as financial integration, specification, a time trend and a dummy variable for third trade partners. None of these change our main result and the trade intensity remains statistically significant with positive effects on the business cycles.

Chapter 6 Individual Countries and Regional Analysis

6.1 Introduction

From the aggregate estimation approach, we find a positive and statistically significant relationship between bilateral trade intensity and business cycle correlation. Although panel data estimation considers the difference between individual country pairs, the model still assumes that the slope coefficients are the same. However, different countries have different trade policies and appear to produce different relationships. If we pool all the countries together, interaction will ignore differences between countries and only generate a general result as we had before. Another significant contribution of this thesis is that we regress our model for each country as well as the main geographic regions thus identifying whether differences in the estimated relationship emerge between economies.

In this chapter we focus on the individual countries with their 23 partners and estimate coefficients individually. Two-stage panel estimation is still used here. To enable us to choose an 'optimal' estimate for inferences, a Hausman test was computed to compare the fixed effects estimates with the random effects estimates (using only time-variant instruments: $FIX_{ij,t}$, $FTA_{ij,t}$ and $YY_{ij,t}$). If the test statistic is found to be less than the 5% critical value then random effects using the full instrument set is chosen as the optimal estimator, otherwise inferences are made from the fixed effects results.

The reminder of this chapter is organized as follows: section 6.2 presents the individual country analysis, we find a significant slope estimate mainly for the European countries. Section 6.3 explains why the significant effects are only for European countries from four factors. We analyse the Asia-Pacific economies with a wider sample of 28 trade partners, and estimate different region slopes and also try to use the third country partner to explain it. Section 6.4 presents the relationship for each European country only with European county partners. The last section (6.5) is the summary of this chapter.

6.2 Disaggregated Analysis

The whole sample results presented in the previous chapter do not show significant differences between trade normalisation and de-trending methods, and only the magnitude of β increases in total trade normalisation when the regression is estimated by FE. Hence, we would like to focus on the estimation when the GDP de-trended by HP filter and trade normalised by GDP to investigate the 24 countries' relationships individually. Each country's observations are still panel data containing 23 partners across 5 periods and we still implement the 'optimal' estimation, two-stage fixed and random effects model. Variations in the sign and magnitude of the relationship between the trade intensity and the business cycle correlation could take place across countries or geographical regions, particularly given the importance of gravity variables in the determination of trade intensity.

Table 6-1 presents the determinants of trade intensity for individual countries using FE. Again, time-invariant variables, $LAN_{ij,t}$, $DIS_{ij,t}$ and $ADJ_{ij,t}$, are dropped since they are constant across periods subsumed within the individual fixed effects and only three instruments are reported in Table 6-1. The product of GDP per capita explains trade intensity very well. Except Australia Greece New Zealand and Portugal all countries present positive and statistically significant estimators. The average magnitude of the product of GDP per capita for 24 individual countries is 0.33 suggesting a gain in trade intensity of 39%. The average estimator is very close to the aggregate estimator which is 0.30. For only 9 countries the fixed exchange rate was found to be statistically significant with the average magnitude of 0.13. It is also very close to the aggregate countries' result (0.14), and the gain from doubling $FIX_{ij,t}$ is a 9% rise in trade intensity. On average, all founding members of EU[53] have a significant impact from the free trade agreement on trade. Canada, Mexico plus some other European countries, such as Ireland and the UK, also present significant estimators. The average coefficient, 0.51 is still close to the aggregate coefficient, 0.52.

[53] Belgium and Luxembourg, France, Germany, Italy, the Netherlands.

The European countries explain the overall fit of the instrument equation (using only 3 instruments) much better than non-European countries. The average R^2 for the European countries, 0.33, more three times higher than the non-European countries, 0.10. Expect China, all European countries have higher R^2 than the non-European countries. Counties like Australia Canada and Hong Kong only explain 1% on the instrument equation.

Table 6-2 presents the instrumented equation for all individual countries estimated by RE. All six instrumental variables are reported, however, some countries have constant values for particular variables and we leave '-' for them in the table. For example, there are no common borders for Australia, China, Greece, Japan and New Zealand, and their dummies are always zero. Therefore these dummies are collinear with the constant and are dropped. The instruments of language and free trade agreement have the same problem too.

Bilateral economic cooperation benefits trade intensity: Free trade agreement presents a significant impact on trade intensity; however, not many countries show a significant impact of fixed exchange rate on trade. The average $FIX_{ij,t}$ and $FTA_{ij,t}$ estimates are 0.16 and 0.73 respectively, suggesting a gain in trade intensity of 17% and 108% respectively. 19 of the 24 countries have a significant effect from the product of GDP per capita on trade and the average gain from doubling $YY_{ij,t}$ is a 25% rise in trade intensity. Geographical characteristics are important determinants of trade intensity with a gain of 263% for two countries that are adjacent to one another. Except Finland, Sweden and the UK, all other countries present a significant impact from it. A country pair that has twice the geographic distance of another would be expected to have 35% less trade, whereas the gain to trade from a common language is 46%. In all but 4 cases have significant estimates for distance emerged; however, only seven countries have significant coefficients of language. Again, European countries show a better overall fitness (with the average R^2=0.64) than non-European countries (with the average R^2=0.37).

Table 6-1

Instrumented Equation Estimated by FE for Individual Countries

Countries	Constant	$FIX_{ij,t}$	$FTA_{ij,t}$	$YY_{ij,t}$	R^2
Australia	-8.59*	-0.24**	0.36	0.10	0.00
	(-7.01)	(-1.75)	(0.74)	(1.57)	
Austria	-11.91*	0.21**	0.23	0.27*	0.33
	(-18.34)	(1.66)	(1.39)	(7.49)	
Belgium & Luxembourg	-8.35*	0.21*	0.38*	0.13*	0.47
	(-12.33)	(2.11)	(3.35)	(3.65)	
Canada	-11.41*	0.08	0.81*	0.25*	0.01
	(-8.47)	(0.74)	(2.58)	(3.59)	
China	-21.55*	1.05	-	0.93*	0.31
	(-14.32)	(1.50)		(9.43)	
Denmark	-9.55*	0.19	0.19	0.16*	0.38
	(-8.82)	(1.34)	(1.04)	(2.82)	
Finland	-14.12*	-0.04	0.03	0.39*	0.15
	(-10.13)	(-0.35)	(0.19)	(5.36)	
France	-14.42*	-0.01	0.80*	0.42*	0.30
	(-10.07)	(-0.09)	(5.07)	(5.66)	
Germany	-9.76*	0.21**	0.29*	0.23*	0.30
	(-12.21)	(1.65)	(2.02)	(5.28)	
Greece	-9.27*	0.27**	0.66*	0.07	0.54
	(-5.21)	(1.89)	(3.34)	(0.83)	
Hong Kong	-18.93*	-0.10	-	0.67*	0.01
	(-19.57)	(-0.51)		(13.03)	
Ireland	-20.27*	0.26**	0.78*	0.68*	0.54
	(-13.44)	(1.74)	(4.18)	(8.41)	

Table 6-1

Instrumented Equation Estimated by FE for Individual Countries (Continued)

Countries	Constant	$FIX_{ij,t}$	$FTA_{ij,t}$	$YY_{ij,t}$	R^2
Italy	-11.23*	0.02	0.74*	0.26*	0.32
	(-6.77)	(0.15)	(5.20)	(2.99)	
Japan	-10.93*	0.19	-	0.22*	0.00
	(-12.47)	(1.29)		(4.99)	
Mexico	-19.73*	0.02	1.33*	0.67*	0.11
	(-8.46)	(0.09)	(3.25)	(5.08)	
Netherlands	-9.98*	0.05	0.30*	0.23*	0.33
	(-10.61)	(0.45)	(1.98)	(4.51)	
New Zealand	-8.81*	-0.24	0.29	0.06	0.01
	(-2.28)	(-0.55)	(0.23)	(0.29)	
Norway	-9.62*	0.08	0.21	0.16*	0.31
	(-7.67)	(0.59)	(1.19)	(2.46)	
Portugal	-9.61*	-0.05	1.03*	0.11	0.54
	(-4.39)	(-0.26)	(4.88)	(0.96)	
Spain	-15.50*	0.15	0.80*	0.45*	0.29
	(-6.35)	(0.87)	(4.33)	(3.49)	
Sweden	-10.61*	0.00	0.13	0.24*	0.21
	(-8.53)	(0.03)	(0.89)	(3.78)	
Switzerland	-8.59*	0.18**	0.14	0.13*	0.21
	(-11.12)	(1.81)	(0.88)	(3.16)	
UK	-11.53*	0.22**	0.76*	0.30*	0.30
	(-7.68)	(1.78)	(4.40)	(3.90)	
USA	-22.97*	0.51*	0.51	0.83*	0.09
	(-9.25)	(2.21)	(0.79)	(6.59)	
Average Magnitude	-12.80	0.13	0.51	0.33	0.25

Notes: t-statistics are shown in parentheses. * and ** denote statistical significance at the 5% and 10% levels, respectively. The trade equation estimated by FE.

Table 6-2

Instrumented Equation Estimated by RE for Individual Countries

Countries	Constant	$FIX_{ij,t}$	LAN_{ij}	DIS_{ij}	ADJ_{ij}	$FTA_{ij,t}$	$YY_{ij,t}$	R^2
Australia	10.03*	-0.44	0.51*	-1.88*	-	-1.47**	0.06	0.36
	(3.33)	(-1.32)	(2.53)	(-5.52)		(-1.91)	(0.69)	
Austria	-5.69*	0.33*	0.15	-0.56*	1.20*	0.21	0.16*	0.82
	(-6.19)	(2.24)	(0.73)	(-6.86)	(5.68)	(1.10)	(4.11)	
Belgium & Luxembourg	-5.52*	-0.02	0.21	-0.45*	1.03*	0.40*	0.16*	0.87
	(-7.13)	(-0.18)	(1.53)	(-8.70)	(5.71)	(2.82)	(4.25)	
Canada	-5.91*	0.16	0.24	0.09	2.59*	1.25*	-0.09	0.27
	(-2.09)	(0.76)	(1.25)	(0.37)	(3.39)	(2.04)	(-1.17)	
China	-10.39*	1.45**	1.81**	-1.12*	-	-	0.85*	0.49
	(-2.18)	(1.86)	(1.72)	(-2.41)			(6.52)	
Denmark	-2.97*	-0.37*	-0.20	-0.84*	0.67*	0.46*	0.16*	0.79
	(-2.44)	(-2.10)	(-1.61)	(-10.53)	(2.13)	(2.07)	(3.04)	
Finland	-2.44**	-0.23**	0.36	-1.01*	0.00	0.17	0.20*	0.78
	(-1.81)	(-1.76)	(0.82)	(-9.75)	(0.00)	(1.15)	(3.70)	
France	-7.75*	-0.18	-0.09	-0.27*	1.14*	0.83*	0.18*	0.64
	(-5.20)	(-1.17)	(-0.34)	(-2.93)	(4.46)	(4.43)	(2.66)	
Germany	-5.03*	-0.03	-0.21	-0.40*	0.74*	0.35**	0.13*	0.64
	(-4.05)	(-0.18)	(-0.72)	(-4.10)	(2.58)	(1.76)	(2.63)	
Greece	-8.50*	0.14	-	-0.58*	-	0.92*	0.27*	0.62
	(-4.43)	(0.80)		(-4.17)		(4.01)	(4.31)	
Hong Kong	-6.79*	-0.15	0.73*	-1.18*	3.08*	-	0.57*	0.56
	(-2.15)	(-0.50)	(3.24)	(-4.03)	(4.13)		(7.26)	
Ireland	-14.81*	0.31**	0.26	-0.24*	1.77*	0.84*	0.48*	0.75
	(-8.75)	(1.89)	(1.01)	(-2.10)	(3.34)	(4.22)	(6.95)	

Table 6-2

Instrumented Equation Estimated by RE for Individual Countries (Continued)

Countries	Constant	$FIX_{ij,t}$	LAN_{ij}	DIS_{ij}	ADJ_{ij}	$FTA_{ij,t}$	$YY_{ij,t}$	R^2
Italy	-4.04*	0.00	-	-0.32*	0.87*	0.87*	0.01	0.53
	(-2.26)	(-0.01)		(-2.57)	(3.58)	(3.79)	(0.08)	
Japan	1.79	0.29	-	-1.28*	-	-	0.16**	0.13
	(0.75)	(1.00)		(-4.15)			(1.94)	
Mexico	-0.81	-0.19	1.33*	-1.09*	1.37**	1.54*	0.16	0.30
	(-0.16)	(-0.58)	(2.43)	(-2.27)	(1.82)	(2.43)	(1.47)	
Netherlands	-7.57*	0.19	0.33	-0.14*	1.23*	0.99*	0.14*	0.68
	(-7.07)	(1.22)	(0.77)	(-2.55)	(3.58)	(5.54)	(2.57)	
New Zealand	-7.69*	0.54	0.80*	0.00	-	2.52*	-0.02	0.31
	(-3.72)	(1.06)	(3.21)	(0.02)		(4.17)	(-0.22)	
Norway	-9.11*	0.49*	-	-0.10	1.14*	1.26*	0.13**	0.47
	(-5.17)	(2.13)		(-0.99)	(3.44)	(5.47)	(1.74)	
Portugal	-12.39*	0.58*	-	-0.19**	1.08*	1.32*	0.30*	0.66
	(-6.98)	(3.03)		(-1.77)	(2.62)	(6.94)	(4.34)	
Spain	-11.95*	0.24	1.00**	0.00	1.20*	1.06*	0.25*	0.45
	(-5.16)	(1.30)	(1.69)	(-0.02)	(2.63)	(5.64)	(2.56)	
Sweden	-1.60	-0.11	-0.39	-0.89*	0.44	0.02	0.14*	0.79
	(-1.31)	(-0.97)	(-1.05)	(-10.21)	(1.48)	(0.12)	(2.87)	
Switzerland	-4.62*	0.02	0.06	-0.43*	0.93*	0.12	0.09*	0.68
	(-4.41)	(0.12)	(0.38)	(-5.07)	(4.64)	(0.64)	(2.06)	
UK	-10.95*	0.18	0.28	0.00	0.65	0.68*	0.27*	0.35
	(-6.96)	(1.22)	(1.29)	(-0.03)	(1.38)	(3.63)	(3.77)	
USA	-23.19*	0.56*	-0.02	0.76*	3.41*	1.00	0.48*	0.32
	(-5.29)	(1.78)	(-0.06)	(2.19)	(4.27)	(1.00)	(4.26)	
Average Magnitude	-6.58	0.16	0.38	-0.51	1.29	0.73	0.22	0.55

Notes: t-statistics are shown in parentheses. * and ** denote statistical significance at the 5% and 10% levels, respectively. The trade equation estimated by RE.

Comparing Table 6-1 with Table 6-2, explanatory power is highest when using all of the instruments. In fact, LAN_{ij}, DIS_{ij} and ADJ_{ij} add 30% to the overall fit of the instrument equation. Consistent with aggregate results, dropping the time-invariant instruments also affects the magnitude of the remaining estimates. For example, using only 3 instruments the FE estimate for $FTA_{ij,t}$ is 0.51 compared to 0.73 using all of the instruments in RE, while the FE estimate for $YY_{ij,t}$ is 0.3 compared to 0.22 using RE with 6 instruments.

Table 6-3 presents individual country regressions using both fixed and random effects. The estimated trade intensity is from first step reported in Table 6-1 and Table 6-2. In line with the aggregate results nearly all of the slope estimates are positive and statistically significant. To enable us to choose an 'optimal' estimate for inferences, a Hausman test was computed to compare the fixed effects estimates with the random effects estimates (using only time-variant instruments: $FIX_{ij,t}$, $FTA_{ij,t}$ and $YY_{ij,t}$). If the test statistic was found to be less than the 5% critical value then random effects using the full instrument set was chosen as the "optimal" estimator, otherwise inferences were made from the fixed effects results. The conclusions from this selection process are shown in bold figures. For 15 countries random effects was found to be the optimal estimator.

In all but 4 cases the β estimate is found to be positive however it is only statistically significant for the 17 European countries in the sample plus China, where the t-ratio for the slope estimate just exceeds the 5% critical value and all of these significant coefficients are positive. Australia, Canada, Hong Kong, Japan and New Zealand all present insignificant estimates. Although it is statistically significant for Mexico and the USA their coefficients are negative. This result is consistent with what we find in chapter 3. Both Mexico and the USA have significant increasing trend for trade intensity from 0.004 to 0.0022 and from 0.0019 to 0.0053, respectively but less synchronized with the cycle in the other countries from 0.24 to -0.40 and from 0.16 to -0.09 respectively. Hong Kong has a similar situation but presents an insignificant slope estimate. The average slope estimate for the European countries is 0.495, with a standard deviation of 0.34. Seven of the estimates are in the range 0.15 to 0.30. FE+IV still reports higher magnitude of slopes than those from RE+IV.

Table 6-3

Individual Countries Results Estimated by Two-Stage Panel Estimation

Countries	FE+IV		RE+IV		Hausman Test	
	Constant	$TI_{ij,t}$	Constant	$TI_{ij,t}$		
Australia	6.80**	0.96**	**0.26**	**-0.02**	2.26	RE
	(1.80)	(1.70)	**(0.77)**	**(-0.36)**	(0.13)	
Austria	2.74*	0.33*	**1.93***	**0.20***	0.00	RE
	(4.49)	(3.51)	**(9.08)**	**(6.34)**	(0.95)	
Belgium & Luxembourg	**4.00***	**0.62***	1.69*	0.20*	5.28*	FE
	(5.33)	**(4.51)**	(9.52)	(6.20)	(0.02)	
Canada	0.10	-0.02	**0.28**	**0.01**	0.01	RE
	(0.10)	(-0.12)	**(0.87)**	**(0.13)**	(0.93)	
China	0.75*	0.08**	**0.64***	**0.06***	0.77	RE
	(2.54)	(1.95)	**(2.73)**	**(1.99)**	(0.38)	
Denmark	**6.45***	**0.94***	1.71*	0.18*	7.63*	FE
	(4.19)	**(3.81)**	(9.73)	(6.53)	(0.01)	
Finland	2.61*	0.31*	**1.62***	**0.16***	0.13	RE
	(3.00)	(2.37)	**(6.35)**	**(4.24)**	(0.72)	
France	2.34*	0.30*	**1.82***	**0.21***	0.02	RE
	(4.89)	(3.68)	**(6.31)**	**(4.36)**	(0.89)	
Germany	3.36*	0.54*	**1.97***	**0.27***	1.49	RE
	(4.79)	(4.02)	**(7.57)**	**(5.57)**	(0.22)	
Greece	**6.43***	**0.80***	2.12*	0.22*	4.52*	FE
	(3.33)	**(3.06)**	(8.47)	(6.39)	(0.03)	
Hong Kong	-0.54**	-0.12*	**0.21**	**0.00**	0.09	RE
	(-1.79)	(-2.57)	**(1.03)**	**(-0.08)**	(0.77)	
Ireland	2.12*	0.23*	**2.22***	**0.24***	2.74	RE
	(7.52)	(5.62)	**(9.61)**	**(7.41)**	(0.10)	

Table 6-3

Individual Countries Results Estimated by Two-Stage Panel Estimation (Continued)

Countries	FE+IV		RE+IV		Hausman Test	
	Constant	$TI_{ij,t}$	Constant	$TI_{ij,t}$		
Italy	**6.97***	**1.11***	2.40*	0.33*	9.30*	FE
	(5.36)	**(5.02)**	(6.47)	(5.35)	(0.00)	
Japan	4.11*	0.58*	**1.21***	**0.15**	0.53	RE
	(3.86)	(3.64)	**(1.96)**	**(1.58)**	(0.47)	
Mexico	**-3.21***	**-0.41***	-0.37	-0.05	54.29*	FE
	(-4.94)	**(-4.99)**	(-0.91)	(-0.99)	(0.00)	
Netherlands	**3.72***	**0.58***	1.96*	0.26*	3.84*	FE
	(4.88)	**(4.13)**	(9.70)	(6.99)	(0.05)	
New Zealand	10.59	1.31	**0.99***	**0.06**	0.39	RE
	(0.70)	(0.66)	**(2.66)**	**(1.31)**	(0.53)	
Norway	**8.29***	**1.22***	2.22*	0.26*	5.72*	FE
	(3.41)	**(3.19)**	(8.71)	(6.65)	(0.02)	
Portugal	**4.18***	**0.52***	1.97*	0.21*	4.63*	FE
	(4.15)	**(3.66)**	(8.96)	(6.79)	(0.03)	
Spain	3.21*	0.41*	**2.85***	**0.36***	**0.05**	RE
	(5.84)	(4.86)	**(7.07)**	**(5.79)**	**(0.82)**	
Sweden	3.77*	0.55*	**1.53***	**0.17***	**1.26**	RE
	(2.98)	(2.54)	**(7.55)**	**(4.89)**	**(0.26)**	
Switzerland	5.36*	0.82*	**1.91***	**0.23***	**2.03**	RE
	(3.57)	(3.20)	**(6.78)**	**(4.83)**	**(0.15)**	
UK	1.85*	0.25**	**2.06***	**0.29***	**0.19**	RE
	(2.81)	(1.97)	**(4.79)**	**(3.51)**	**(0.66)**	
USA	**-0.73****	**-0.13***	0.17	0.00	10.64*	FE
	(-1.72)	**(-2.09)**	(0.75)	(0.09)	(0.00)	
Average Magnitude	3.55	0.49	1.47	0.17	40% prefers FE	

Notes: t-statistics are shown in parentheses. * and ** denote statistical significance at the 5% and 10% levels, respectively. The first column shows the FE estimates using three instruments, the second column is RE estimator using all six instruments. A Hausman test statistic is also included to compare the FE estimates with the RE estimates using 3 instruments, from which an "optimal" estimator is chosen (see bold figures). * denotes significance at the 5% level.

For example the slope estimates in FE+IV for Italy and Norway are 1.11 and 1.22 respectively, but only are 0.33 and 0.26 with 5% significant level in RE+IV respectively. The average slope estimate for the FE+IV (0.49) is much higher than the average slope estimate for RE+IV (0.17).

Change of de-trending methods and trade normalisation does not impact the results in Table 6-3. All the β estimates are very consistent and all European countries appear positive and significant coefficients as well and Australia Canada Hong Kong Japan Mexico New Zealand and the USA remain the negative or insignificant coefficients. Different business cycle correlation proxies, such as using the correlation of industrial production, employment and unemployment rate, changes individual countries slightly, but remain the main findings that European countries present significant slope estimates but the relationship does not exist in non-European countries.

6.3 Explaining Differences in the Significance of the Estimation

In an attempt to explain the differences in the results between the European countries and the rest of the sample a number of additional hypotheses are tested. Firstly, we re-estimate the relationship for the Asia-Pacific group of countries (Australia, China, Hong Kong, Japan and New Zealand) with an extended sample of partners. For this group, a significant proportion of total trade also takes place with Indonesia, South Korea, Malaysia, Singapore and Thailand (See Appendix I). Therefore, we extend these five countries' partners to 28, initial 23 partners plus 5 additional Asian countries. The results, presented in Table 6-4 suggest two significant differences to the original set of individual country results. Firstly, the significance level of the t-ratio for the China's slope estimate has risen from 6.3% to 7.8%. Secondly, the β estimate for Hong Kong changes from 0.0001 to -0.10 and is now statistically significant at the 5% level. However, Australia, Japan, and New Zealand still present insignificant slopes.

Table 6-4

Revised Estimates for the Asia-Pacific Countries

Countries	FE+IV Constant	FE+IV $TI_{ij,t}$	RE+IV Constant	RE+IV $TI_{ij,t}$	Hausman Test	
Australia	0.36	0.00	**0.20**	**-0.03**	0.76	RE
	(0.34)	(-0.02)	**(0.62)**	**(-0.51)**	(0.38)	
China	0.76*	0.07**	**0.80***	**0.08***	0.06	RE
	(2.66)	(1.79)	**(3.38)**	**(2.33)**	0.81	
Hong Kong	**-0.29**	**-0.10***	0.77*	0.07*	25.77*	FE
	(-1.01)	**(-2.14)**	(3.72)	(2.18)	0.00	
Japan	1.26	0.15	**0.90***	**0.10**	0.20	RE
	(1.36)	(1.06)	**(2.02)**	**(1.41)**	0.66	
New Zealand	**-0.87**	**-0.17**	0.72	0.04	18.13*	FE
	(-1.00)	**(-1.51)**	(1.39)	(0.54)	(0.00)	

Notes: t-statistics are shown in parentheses. * and ** denote statistical significance at the 5% and 10% levels, respectively. Estimates derived for each country using panel data for the original 23 countries plus Indonesia, South Korea, Malaysia, Singapore and Thailand. Column 1 are the FE estimates using three instruments and column 2 shows the RE estimator using all six instruments. A Hausman test statistic is also included to compare the FE estimates with the RE estimates using 3 instruments. Robust t-ratios are shown in parentheses. Bold figures represent the "optimal" estimator. * denotes significance at the 5% level.

Another reason for the observed differences could be that the European countries have a greater number of institutional agreements that facilitate trade and therefore economic convergence indirectly. The estimates in table 5-6 suggest that free trade agreements and fixed exchange rates are important determinants of trade intensity. For the full sample, 50% of the FIX_{ijt} observations are non-zero, whereas for the European countries 77.5% are non-zero. The proportion of non-zero observations for FTA_{ijt} is 85.53% for the European countries but only 39.06% for the full sample. It is obviously that European countries have more fixed exchange rate agreements and free trade agreements with each other than non-European countries.

Also regional factors could be so important that trade with European countries is not particularly important for the NAFTA and Asia-Pacific economies. Table 6-5 presents estimates for trade amongst countries within European, NAFTA and the Asia-Pacific regions. In our sample, 16 countries are in the Europe region, 5 are in the Asia-Pacific region and 3 are NAFTA members. Both Europe and Asia-Pacific regions prefer fixed

Table 6-5

Regional Results

Countries	FE+IV		RE+IV		Hausman Test	
	Constant	$TI_{ij,t}$	Constant	$TI_{ij,t}$		
Europe	**4.56***	**0.69***	1.53*	0.15*	1436	FE
	(17.93)	**(15.17)**	(15.21)	(8.25)	(0.00)	
Asia Pacific	**3.15***	**0.51***	0.75*	0.08	19.95	FE
	(3.13)	**(2.84)**	(2.09)	(1.27)	(0.00)	
NAFTA	0.57	0.07	**0.38**	**0.03**	0.07	RE
	(0.70)	(0.43)	**(0.97)**	**(0.40)**	(0.79)	

Notes: t ratios in parentheses. * denotes significance at the 5% level. 16 of our sample are European countries, Asia-Pacific region contains 5 countries and Canada, Mexico and the USA are the three members of NAFTA. A Hausman test statistic is also included to compare the FE estimates with the RE estimates using 3 instruments. Bold figures represent the "optimal" estimator. * denotes significance at the 5% level.

effects and have statistically significant slope estimates, suggesting an impact of 100% and 66% respectively. The β estimate for the NAFTA is insignificant.

A further reason for the observed statistical significance of the European β estimates could be that third-country effects are more important in Europe. Their business cycles are highly correlated since they have more similar trade patterns compared to the non-European countries and therefore are more likely to be affected by demand shocks from common third country economies. For example, when France and the UK integrated, there was a simultaneous integration between France and Germany and the UK and Germany, e.g. demand shocks in France could affect the UK directly, however, both France and the UK are likely to be influenced by the same demand shock originating from Germany. The European countries are very open and close together and they have very strong direct and indirect (via third country) trade linkages each other. For countries outside Europe, such as USA, China, Japan, there has not been the same systematic and simultaneous integration. Trade spillovers probably also exist, but these trade spillovers are so small that they are swamped by other shocks, particularly the domestically generated business cycle.

A proxy for trade similarity that we adopted was a dummy variable that equals unity when both countries have the same top trade partner country. We therefore re-estimated

Table 6-6

Extended Results Including Trade Similarity Dummy

Countries	FE		RE
Constant	2.70* (11.13)		2.05* (17.60)
TI	0.36* (9.36)		0.25* (14.29)
Partner	0.10** (1.88)		0.02 (0.44)
Hausman Test		54.26* (0.00) FE	

Notes: t-statistics are shown in parentheses. * and ** denote statistical significance at the 5% and 10% levels, respectively. 'Partner' is a dummy variable that equals unity when both countries have the same top trade partner country.

the relationship using the full data set and regressed the business cycle correlation on trade intensity and the dummy variable for trade similarity. The results of this exercise are shown in Table 6-6. The chosen estimator in this case is fixed effects and the estimated coefficient for the trade partner regressor is positively signed (as expected) and significant at the 10% level. The business cycle correlation is expected to rise by 1.2%. The impact from trade intensity has not any changes in both FE and RE estimation. 30.87% of the total observations for the partner variable had a value different from zero, and 23.12% of the non-zero observations were for European country pairs.

6.4 European Regional Analysis

From the individual country analysis, we find trade amongst the European countries has had the most beneficial effect on the business cycle co-movements. A further test of our hypothesis it that we estimate the model for each European country only with their European trading partners (see Table 6-7). All of the slope estimates remain statistically significant and positive in both fixed and random effects estimations. Again, a Hausman test was computed to compare the fixed effects estimates with the random effects estimates using only time-variant instruments.

The random effects estimation using the full instrument set was chosen as the ‘optimal’ estimator if the test statistic was found to be less than the 5% critical value, otherwise fixed effects results were used. In Table 6-7 most countries prefer the fixed effects estimator and the magnitude increases quite considerably compared to the full sample estimates. Thus it would appear that the gain in economic convergence arising from trade is larger for the European countries when they trade with countries in Europe than trade from outside the continent.

Interestingly, the slope estimate is largest for the Scandinavian countries like Demark, Finland, Norway and Sweden, suggesting that a doubling of trade intensity would raise the business cycle correlation by more than 0.76. Finland is a member of Euro zone and Demark national currency is the Kroner, but maintains a peg with the Euro, through ERMII. We find that the level of trade intensity for these countries with the European countries is much higher than them with the non-European countries. Moreover, none of them present significant slope estimate in the group between them and non-European countries.

Table 6-7

European Countries Results Estimated by Two-Stage Panel Estimation

Countries	FE+IV		RE+IV		Hausman Test	
	Constant	$TI_{ij,t}$	Constant	$TI_{ij,t}$		
Austria	4.41*	0.62*	**1.51***	**0.13***	0.41	RE
	(7.24)	(5.99)	**(6.85)**	**(3.41)**	(0.52)	
Belgium & Luxembourg	**4.43***	**0.75***	1.33*	0.11*	26.00	FE
	(7.49)	**(6.20)**	(7.49)	(3.19)	(0.00)	
Denmark	**7.26***	**1.18***	1.39*	0.12*	7.24	FE
	(4.16)	**(3.74)**	(5.67)	(2.70)	(0.01)	
Finland	**7.13***	**1.09***	1.03*	0.06	10.37	FE
	(3.77)	**(3.40)**	(3.90)	(1.30)	(0.00)	
France	**2.69***	**0.36***	1.04*	0.05	17.12	FE
	(5.81)	**(4.21)**	(4.90)	(1.39)	(0.00)	
Germany	**4.64***	**0.84***	1.57*	0.18*	12.36	FE
	(5.75)	**(4.88)**	(6.61)	(3.68)	(0.00)	
Greece	**6.08***	**0.81***	2.46*	0.27*	4.43	FE
	(4.93)	**(4.39)**	(4.88)	(3.57)	(0.04)	
Ireland	2.84*	0.33*	**1.85***	**0.18***	0.07	RE
	(11.21)	(8.40)	**(9.89)**	**(6.09)**	(0.78)	

Table 6-7

European Countries Results Estimated by Two-Stage Panel Estimation Continued

Countries	FE+IV Constant	FE+IV $TI_{ij,t}$	RE+IV Constant	RE+IV $TI_{ij,t}$	Hausman Test	
Italy	**6.39***	**1.06***	1.56*	0.17*	14.33	FE
	(5.55)	**(5.02)**	(4.09)	(2.51)	(0.00)	
Netherlands	**5.02***	**0.89***	1.70*	0.20*	10.53	FE
	(5.34)	**(4.56)**	(6.73)	(3.86)	(0.00)	
Norway	**7.92***	**1.26***	1.59*	0.15*	4.25	FE
	(3.29)	**(2.99)**	(4.18)	(2.30)	(0.04)	
Portugal	**3.95***	**0.52***	2.49*	0.29*	11.57	FE
	(5.98)	**(5.01)**	(4.66)	(3.47)	(0.00)	
Spain	**3.28***	**0.43***	2.21*	0.25*	4.83	FE
	(7.43)	**(5.83)**	(5.75)	(3.91)	(0.03)	
Sweden	**8.29***	**1.46***	0.83*	0.02	4.03	FE
	(2.95)	**(2.70)**	(3.96)	(0.61)	(0.04)	
Switzerland	7.47*	1.25*	**1.35***	**0.12***	2.22	RE
	(3.41)	(3.09)	**(5.05)**	**(2.40)**	(0.14)	
UK	3.68*	0.61*	**3.07***	**0.48***	0.43	RE
	(4.81)	(3.94)	**(3.38)**	**(2.65)**	(0.51)	
Average Magnitude	5.34	0.84	1.69	0.17		

Notes: t-statistics are shown in parentheses. * and ** denote statistical significance at the 5% and 10% levels, respectively. Each European country only with their European trading partners.

6.5 Conclusions

The aggregate estimation suggests that the greater economic convergence is strongly influenced by rises in bilateral trade intensity. Does this relationship vary over individual countries? To account for the differences between countries, we re-estimated the two-stage panel estimation for each individual country with their own 23 partners across 5 periods. In all but four cases the β estimate is found to be positive, however, it is only statistically significant for the 17 European countries plus China with an average magnitude of 0.24, where the t-ratio for the slope estimate just exceeds the 5% critical value. Australia, Canada, Hong Kong, Japan and New Zealand present insignificant estimates. Although it is statistically significant for Mexico and the USA, their coefficients are negative. Again, changing de-trending methods or trade normalisation does not change our main conclusion. This finding would support the decision of most of these economies to join European Monetary Union from the optimal currency area theory.

We present two reasons to explain why this effect emerges only for European countries. Asia-Pacific economies have a significant amount of trade within the groups but not only with European countries. After extending their partners to 28 including additional 5 Asian countries, China and Hong Kong have significant changes but other three countries remain insignificant. Regional factors could be so important that trade with the European countries is not particularly important for the NAFTA and Asian-Pacific economies. We find a significant relationship in Europe and Asia-Pacific regions but not in the NAFTA group.

Another reason for the observed differences could be that the European countries have a greater number of institutional agreements that facilitate trade and therefore economic convergence indirectly, particularly the fixed exchange rate and free trade agreements which are important determinants of trade intensity. For the full sample, 50% of the FIX_{ijt} observations are non-zero, whereas for the European countries 77.5% are non-zero. The proportion of non-zero observations for FTA_{ijt} is 85.53% for the European countries but only 39.06% for the full sample.

Also third-country effects are more important in Europe. Their business cycles are highly correlated since they have more similar trade partners compared to the non-European countries and therefore are more likely to be affected by demand shocks from common third country economies. In individual European countries analysis, we find stronger relationship between the trade intensity and the business cycle correlation.

Chapter 7 The Effects of Trade, Specialisation and Financial Integration for the Business Cycle Synchronisation

7.1 Introduction

In theory, increased trade could result in greater industrial specialisation if most trade is inter-industry, then lead to more asynchronous business cycles. On the other hand, increased trade could tend to raise the covariance of country-specific demand shocks and aggregate productivity shocks if intra-industry trade accounts for most trade thus increasing the international coherence of the business cycles. Therefore, the positive effects from trade intensity on the business cycle correlation could be indirect through industry specialisation. In addition, trade both in goods and in financial assets may affect the cross-country synchronisation of the business cycles. We should include these two additional variables to re-estimate the relationship between the trade and the business cycle as well as interactions between trade, specialisation and financial integration.

The globalisation of financial markets has become one of the key factors in increasing world-wide economic integration. As a result, international financial markets have grown rapidly during the past decades and financial integration has increased significantly. This increase in the degree of financial integration is of major importance for research in macroeconomics because macroeconomic theories of open economies imply that the degree of financial integration can play a key role for the propagation of shocks in an open economy. The impact of financial integration on cycle synchronisation is ambiguous. There are two arguments. On the one hand, limited ability to borrow and lend internationally hampers the transfer of resources across countries and can increase GDP correlation. But on the other hand, if investors have imperfect information or face liquidity constraints, limiting capital flows can actually decrease GDP correlations, as investors herd or withdraw capital from many destinations simultaneously.

Industry specialisation is also likely to affect the business cycle directly. From theory, specialisation affects synchronisation negatively, since two economies producing the same types of goods will then be subjected to similar shocks, stochastic developments and also it may happen that a different policy affects different industrial sectors differently because of different market structures or labour markets. Then countries with similar production patterns will be synchronised.[54] Two countries will be hurt similarly by sector-specific shocks if they have economic sectors of similar nature and size.

The recent literature, e.g. Imbs (2004, 2006), Kalemli-Ozcan et al. (2003) also points to potentially important indirect interactions. Both trade of goods and assets may affect specialisation. Closer trade ties could result in countries becoming more specialised in which they have comparative advantage. The countries might then be more sensitive to industry-specific shocks, resulting in more idiosyncratic business cycles. However, as we discussed before, if demand shocks or other common shocks predominate or if intra-industry trade accounts for most trade, then more bilateral trade might result in a more similar industry structure and then closer business cycles. Similarly, financial integration may induce specialisation, "as access to an increasing range of state-contingent securities unhinges domestic consumption patterns from domestic production, which then become free to specialise according to comparative advantage" (Imbs, 2004, page 723.). Kalemli-Ozcan *et al.* (2001) explain that financial integration will likely lead to more specialisation since investors will be less reluctant to put more risks in the same basket. This is because a greater fraction of investors' income will be derived from other sources, such as internationally diversified investment funds. Furthermore, foreign investors will be buying shares in domestic firms since they will be seeking to diversify their portfolios internationally. And also governments will insist less on subsidizing diversity within national borders. Financially integrated economies would tend to specialise differently, and be less synchronised as a result. Obstfeld (1994) also introduces the idea that finance may afford specialisation in activities particularly needful of external funds. Therefore, the measured effect of finance on synchronisation could be through specialisation.

[54] See Stockman (1988).

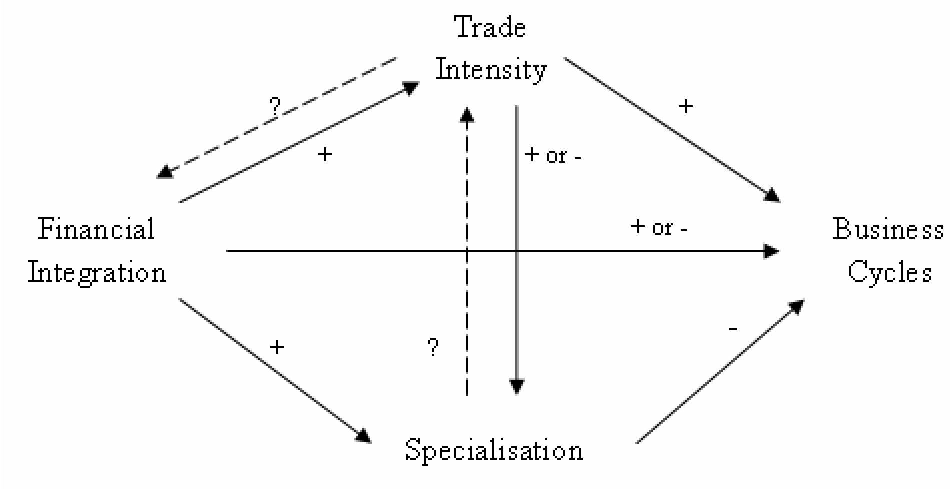

Figure 7-1. *Direct and Indirect Impacts from Trade, Specialisation and Finance on Cycle Synchronisation*

Notes: This figure summarizes the views in the literature on the interactions between goods trade intensity, financial integration, specialisation and cycle synchronisation. A + or – sign reflects a theoretical prediction that was confirmed empirically. A sign with a question mark means theory has not been tested empirically.

In addition, Imbs (2006) argues that effect of finance on synchronisation could be through trade as well. Financial flows depend on the information afforded by goods trade and are predicted by the same gravity model that captures trade in goods.[55] Thus, the measured effect of finance on cycle synchronisation could be a reflection through trade and higher financial integration across countries might result in higher trade intensity and then closer business cycles correlations. Therefore, the overall effects of financial integration are ambiguous particularly because first, the direct link's sign of financial integration is unclear in theory and second, because the indirect effect through specialisation and trade could change the direct link. We need a simultaneous-equation methodology to exam the direct as well as indirect channels between trade intensity, specialisation and financial integration on cycle synchronisation.

This chapter makes two significant contributions to the literature. Firstly, we adopt bilateral foreign direct investment position as a proxy for financial integration. In the literature, gross capital flows or portfolio stocks are usually selected to measure financial

[55] See details in Portes et al. (2001) and Lane and Milesi-Ferretti (2003)

integration.[56] Movements in the bilateral foreign direct investment position data are very close to gross capital flows, gross capital stock and portfolio investment. Furthermore, the main advantage of FDI data is that we can access bilateral FDI data across most OECD countries over more than 20 years, and these data can be consistent with our other variables to consider the unobservable country-pair specific effects in regressions. We describe more details for using FDI in section 7.3. Secondly, previous literature has used only pooled 3SLS to estimate their relationships without allowing for individual effects but our methodology panel data 3SLS does not only consider the potentially important unobservable country pair specific effects, it also allow us to disentangle the direct and indirect impact between them. Our results can be compared with literature estimated by either OSL or 3SLS to find whether unobservable individual effects or indirect effects are important.

The rest of the chapter proceeds as follows. Section 7.2 presents the related literature. Section 7.3 discusses data, variables measurement and model; section 7.4 shows the econometric methodology. The main empirical results are in section 7.5 followed by random effects three-stage least square for pooled sample and individual countries. Section 7.6 provides conclusions.

7.2 Theoretical Framework and Literature

This section reviews the relevant literature. Most of the linkages in Figure 7-1 have been investigated empirically but only Imbs's paper estimated them simultaneously.

[56] Kose, *et al.* (2003) use accumulated gross capital flows to GDP to measure financial integration. Heathcote and Perri (2004) focus on the USA and select the sum of the USA FDI position plus the equity part of the stock of portfolio investment abroad relative to the USA capital stock as USA assets and the ratio of the sum of the stock of FDI in the USA plus foreigners holdings of US stocks to the USA capital stock as USA liabilities. While Imbs (2006) uses a Coordinated Portfolio Investment Survey (CPIS) gathered by the IMF to proxy for finance. The CPIS data only include portfolio stocks while completely ignoring the FDI.

The relationship between trade and cycle synchronization has been estimated by numerous subsequent studies.[57] We have analysed this relationship carefully by 24 countries over 40 years and confirm the literature result of a statistically significant and positive effect from trade intensity to cycles.

The direct effect of industry specialisation on the business cycle synchronisation is well documented too. Otto *et al.* (2001) adopt the difference between industry structures of two economies to measure the industry specialisation and find a statistically significant role for differences in industry structure as an explanation of output correlations in 17 OECD countries sample. The greater the difference in industry structures of a pair of countries, the lower is their output correlation. Kalemli-Ozcan *et al.* (2001) show the same result empirically in 50 US states and a couple of OECD countries. Regions with a more specialised production structure exhibit business cycles that are less correlated with those of other regions. Imbs (2001) and Böwer and Guillemineau (2006) also find the same result that the more dissimilar the economies, the less correlated their cycles. However, Baxter and Kouparitsas (2005) do not find the significant relationship between the industrial structure and the business cycle correlations.

Financial market linkages are a widely acknowledged mechanism for the international transmission of the business cycle shocks. Backus et al. (1994) document that in complete markets a positive technology shock will attract capital flows into economy and away from the no-shock economy which results in a negative correlation of GDP. Keheo and Perri (2002) show that introducing enforcement constraints results in higher capital flows and drives the economy far away from the complete markets allocation and produces the positive cross-country comovements. A large amount of evidence is available to prove the negative effect from finance in empirical work. Otto *et al.* (2001) find the negative relationship empirically in 17 OECD countries over 40 years. They adopt FDI stock,

[57] Frankel and Rose (1998) estimate a strong and robust positive relationship between trade and cycle synchronisation by a single equation covering twenty one industrial countries over thirty years. Baxter and Kouparitsas (2005) extend the sample of countries to 100 developing and developed countries and Babetskii (2005) focuses on ten Central and Eastern European countries. Both of these papers found the statistically significant and positive relationship between bilateral trade and business cycle correlations. Bower and Guillemineau (2006) also found the same result for EMU. Clark and van Wincoop (2001), Canova and Dellas (1993), Schmitt-Grohe (1998), Kose and Yi (2002) have all used different methods to reproduce the magnitude of this relationship.

trade in equities and trade in long-term bonds to measure the financial integration by OLS and IV estimation and show that the higher variability in trade in assets, the higher the correlation of the business cycle. Kalemli-Ozcan *et al.* (2001) also confirm that higher capital market integration leads to less symmetric fluctuations in OECD countries and US states. Hethcote and Perri (2004) document that financial globalization, by enhancing cross-border capital flows, reduces the international correlations in GDP in the US.

But on the other hand, financial linkages could result in a higher degree of the business cycle synchronization from theory as well. For instance, if consumers from different countries have a significant fraction of their investments in a particular stock market, then a decline in that stock market could induce a simultaneous decline in the demand for consumption and investment goods in these countries. Furthermore, contagion effects that are transmitted through financial integration could also result in heightened cross-country spillovers of macroeconomic fluctuations. Baxter and Crucini (1995) have investigated it in the international business cycle models. If the assets that are tradable internationally are restricted exogenously to a single uncontingent bond, then the equilibrium allocations are similar to those arising under complete markets. A couple of empirical studies support this claim that financial integration results in synchronized business cycles.[58] Kose *et al.* (2003) find empirical evidence for the proposition that financial integration enhances global spillover of macroeconomic fluctuations in 76 countries which include developed and developing countries over 40 years. However, Bordo and Helbling (2003) do not find a clear effect from financial integration on the synchronization of business cycles across 16 countries over a long period.

Trade intensity, industry specialisation and financial integration affect cycle synchronisation directly; nevertheless the potentially important indirect interactions should be considered simultaneously. A large amount of evidence proves the effect of trade on industrial specialisation, which then affects the business cycle. Dornbusch, Fischer and Samuelson (1977) proved that falling transport costs result in a narrowing non-traded sector, as it becomes cheaper to import goods rather than produce them

[58] Calvo and Mendoza (2000) and Mendoza (2001) suggested a positive direct link from capital flows to cycle synchronisation based on portfolio theory.

domestically. Thus resources are freed up and used more intensely in fewer activities. Harrigan (2001) and Harrigan and Zakrajsec (2000) also show trade induced specialisation patterns to be significant. Recently, the evidence in Calderon et al. (2007) suggests that the link between trade intensity and cycle correlation is stronger among industrial countries than among developing countries or mixed industrial-developing country pairs. Calderon (2007) argues that the differences among developing and developed countries might be explained by the indirect effect from trade on cycle synchronisation through patterns of specialisation. He finds empirical evidence (in 147 countries over the period 1965 to 2004) that the positive trade effect on cycle correlation hinges on the degree of similarity of industry specialisation patterns.

Similarly, financial integration may induce specialisation as well. Increasing financial integration will result in domestic consumption, then industries will be free to specialise according to comparative advantage.[59] Financial integration tends to specialise differently and then be less synchronized as a result indirectly. Kalemli-Ozcan et al. (2001, 2003) provide empirical evidences for it. On the other hand, if the economy is short of external funds, such as risky funds, financial integration would tend to specialise similarly, and then be more synchronized as a result. In the meantime, specialisation in production could affect financial flows as well and then affect synchronization indirectly. For instance, large exogenous policy changes would produce more or less of a need for financial integration, but the specialisation patterns were a low-frequency phenomenon, finance will induce specialisation positively. There is also a possibility that financial integration could be an indirect manifestation of trade or trade could be an indirect effect of financial integration (Imbs, 2006).

Therefore, the overall effect is ambiguous between them as the indirect effect could either mitigate or reinforce the direct link. None of these papers consider the direct and indirect effects simultaneously except Imbs (2004, 2006). Imbs (2004) considers both direct effects of trade in goods and in financial assets and specialisation on the business cycle and indirect effects from trade in goods and assets to the business cycle synchronisation through specialisation simultaneously. Imbs (2006) focuses on financial integration, and

[59] See Helpman and Razin (1978), Grossman and Razin (1985) and Saint-Paul (1992).

considers its direct impact to synchronisation and indirect impact through trade and specialisation.

7.3 Model and Data

To investigate the determinants of the business cycle correlation, we start with a simple model which is similar to equation (3-1) in chapter 3 but includes another two additional variables: specialisation and financial integration.

$$Corr_{ij,t} = \alpha_0 + \alpha_1 TI_{ij,t} + \alpha_2 S_{ij,t} + \alpha_3 FI_{ij,t} + \varepsilon_{ij,t} \qquad (7\text{-}1)$$

where *i, j* index country pairs, $Corr_{ij,t}$ is the bilateral business cycle correlation between country *i* and country *j*, $TI_{ij,t}$ is bilateral trade intensity, *S* is a specialisation index capturing how different the sectorial allocations of resources are between country *i* and country *j*, and *FI* is bilateral financial integration. α is coefficient for each variable. As we have proved empirically in previous chapters, we expect that in equation (7-1) α_1 is significantly positive, which indicates that more bilateral trade leads to closer business cycle correlation; α_2 is negative[60] indicating that the more similar industry specialisation, the closer business cycles; while α_3 could be positive or negative[61].

Compared to the previous analysis, we reduce the sample period and sample countries since there is less bilateral FDI data available to measure financial integration. To be consistent for all four variables our sample period is from 1984 to 2003 and it is split into four periods: 1984-1988, 1989-1993, 1994-1998 and 1999-2003, and sample countries

[60] The lower value for S, the smaller difference between industrial structures and then expect to result in synchronisation. Kalemi-Ozcan et al. (2001) only include specialisation with some control variables and find more similar industrial structure lead to closer business cycle. Imbs (2001) and Bower and Guillemineau (2006) find the same results.
[61] Heathcote and Perri (2004) focus on finance and found negative coefficient. However, Koes et al (2003) present the opposite results.

cover the 15 OECD countries.[62] The total sample size is [(15×14)/2]×4=420 including missing observations.

7.3.1 *The Business Cycles Correlation and Bilateral Trade Intensity*

Following the analysis undertaken in chapter 3, we still use the same measurements for business cycle correlation and bilateral trade intensity. The business cycles correlations are measured by real GDP expressed in US dollars[63], which is de-trended by a HP filter after taking the natural logarithm. Table 7-1 presents the average GDP correlations for each country vis-à-vis the other 14 partners for each period and whole period. It appears that the average correlations for the first period (i.e. 1984 to 1988) are the highest then decrease until the third period (i.e. 1994 to 1998). In the last period's (1999-2003), correlations increase again which is consistent with our previous analysis, the GDP correlations increase till the period 1977-1985 when the marginal effects arrive and then increase again in the last period 1995-2003. In addition, our USA average GDP correlations are also consistent with Heathcote and Perri (2004)'s results that the USA business cycle was strongly correlated with others over the period 1972-1986 and much weaker over the period 1986-2000. In Table 7-1 the USA first period's (1984-1988) correlation is 77%, then decrease to 5% for 1989-1993, -54% for 1994-1998 and back to -6% for the last period. Generally, European countries' correlations are relatively higher than non-European countries. Only the UK has a negative correlation with others in the third period, 1994-1998.

Bilateral trade intensity is calculated by natural logarithms of total bilateral trade over nominal GDP[64]:

[62] 15 OECD countries are: Australia, Austria, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Sweden, Switzerland, UK, and US.
[63] The real GDP data are annual data and are from OECD's Economics Outlook over 1984 to 2003.
[64] Bilateral trade data come from IMF's direction of trade data set and nominal GDP is from OECD's Economic Outlook. Both data are denoted by US dollars.

Table 7-1

Average GDP Correlations

Periods / Countries	1984-1988	1989-1993	1994-1998	1999-2003	Full sample 1984-03
Australia	0.03	0.29	0.36	0.83	0.38
Austria	0.88	0.44	0.47	0.82	0.65
Canada	0.69	0.34	0.24	0.57	0.46
Denmark	0.87	0.57	0.54	0.82	0.70
Finland	0.90	0.45	0.41	0.77	0.63
France	0.89	0.54	0.49	0.82	0.68
Germany	0.88	0.22	0.44	0.81	0.59
Italy	0.89	0.61	0.37	0.76	0.65
Japan	0.89	-0.54	0.26	0.37	0.25
Netherlands	0.88	0.51	0.50	0.80	0.67
Norway	0.88	0.58	0.53	0.71	0.68
Sweden	0.90	0.57	0.43	0.81	0.67
Switzerland	0.88	0.58	0.47	0.77	0.68
UK	0.89	0.54	-0.34	0.82	0.48
US	0.77	0.05	-0.54	-0.06	0.05
Average	0.81	0.38	0.31	0.69	0.55

Source: SourceOECD Economics Outlook.
Notes: average GDP correlation calculated using the individual correlation from each country *vis-à-vis* their 14 partners.

$$TI_{ij,t} = \ln\left[\frac{1}{t}\sum_{t=1}^{\tau}\left(\frac{X_{ij,t} + M_{ij,t}}{Y_{i,t} + Y_{j,t}}\right)\right] \tag{7-2}$$

where $X_{ij,t}$ and $M_{ij,t}$ are bilateral exports and imports between countries i and j, Y_{it} (Y_{jt}) is nominal GDP for country i (j) expressed by US dollars. We think of higher values of TI the greater trade intensity between countries i and j.

Table 7-2 presents the average bilateral trade intensity for each country. We find that during the second period (1989-1993) most countries decrease their trade intensities a little bit and increase in the last two periods a result which is fairly consistent with that reported in chapter 3. The last period has very clear rise for most countries, especially for France Germany and the Netherlands, which cover the introduction of the Euro. Although the trade intensity’s increasing trend in this sample is not as clear as that detected in the previous sample, we still find that most European countries have

Table 7-2

Average Trade Intensity

Countries \ Periods	1984-1988	1989-1993	1994-1998	1999-2003	Full sample 1984-03
Australia	0.0019	0.0018	0.0018	0.0018	0.0018
Austria	0.0043	0.0043	0.0044	0.0057	0.0047
Canada	0.0039	0.0038	0.0042	0.0045	0.0041
Denmark	0.0060	0.0055	0.0060	0.0066	0.0060
Finland	0.0043	0.0038	0.0043	0.0048	0.0043
France	0.0081	0.0080	0.0080	0.0098	0.0085
Germany	0.0151	0.0137	0.0123	0.0146	0.0139
Italy	0.0076	0.0072	0.0076	0.0080	0.0076
Japan	0.0034	0.0032	0.0029	0.0029	0.0031
Netherlands	0.0097	0.0088	0.0091	0.0117	0.0098
Norway	0.0076	0.0067	0.0070	0.0079	0.0073
Sweden	0.0080	0.0068	0.0088	0.0093	0.0088
Switzerland	0.0062	0.0058	0.0056	0.0061	0.0059
UK	0.0101	0.0090	0.0087	0.0087	0.0092
US	0.0050	0.0052	0.0057	0.0057	0.0054
Average	0.0067	0.0062	0.0064	0.0072	0.0067

Source: Trade data are taken from the International Monetary Fund's Direction of Trade data set, Nominal GDP data are taken from SourceOECD, Economic Outlook.

Notes: Trade intensity is obtained using $TI_{ij,t} = \ln\left[\frac{1}{t}\sum_{t=1}^{\tau}\left(\frac{X_{ij,t} + M_{ij,t}}{Y_{i,t} + Y_{j,t}}\right)\right]$ and an average value obtained using the values from the country-pairs.

relatively higher bilateral trade than non-European countries, particularly for large economies such as France, Germany, Italy, the Netherlands and UK.

7.3.2 Specialisation

There are no standard measures of similarity in industry specialisation. Following Krugman (1991), Clark and van Wincoop (2001) and Imbs (2004, 2006), we use the industrial sectoral real value added index to measure the industry specialisation as follows:

$$S_{ij,t} = \ln\left(\frac{1}{T}\sum_{t}\sum_{n}^{N}\left|s_{n,i} - s_{n,j}\right|\right) \quad (7\text{-}3)$$

where $s_{n,i}$ denotes the GDP share of industry n in country i. $S_{ij,t}$ is the time average of the discrepancies in the economic structures of countries i and j. S measures the industry difference between countries. The lower of S, the more similar industry structure between two countries. We expect the coefficient of S in regression to be negative which indicates that the more similar industry structure between countries, the closer business cycle correlations. Industry structure data are two digit manufacturing value-added data in US dollars issued by the UNIDO and two-digit manufacturing level codes are in appendix II. Table 7-3 reports average specialisations for each country. We find that in the first three periods from 1984 to 1998, most countries have consistent industry specialisations at 11%, but decrease sharply in the last period. This

Table 7-3

Average Specialization

Countries \ Periods	1984-1988	1989-1993	1994-1998	1999-2003	Full sample 1984-03
Australia	0.09	0.11	0.12	0.07	0.10
Austria	0.09	0.09	0.10	0.04	0.08
Canada	0.09	0.09	0.10	0.07	0.09
Denmark	0.09	0.11	0.12	0.06	0.10
Finland	0.11	0.10	0.12	0.06	0.10
France	0.10	0.10	0.09	0.04	0.08
Germany	0.17	0.16	0.11	0.04	0.12
Italy	0.11	0.10	0.11	0.05	0.09
Japan	0.14	0.15	0.14	0.08	0.13
Netherlands	0.11	0.10	0.11	0.05	0.09
Norway	0.10	0.11	0.11	0.05	0.09
Sweden	0.11	0.10	0.11	0.05	0.09
Switzerland	0.20	0.16	0.11	0.06	0.13
UK	0.11	0.11	0.09	0.04	0.09
US	0.10	0.10	0.11	0.06	0.09
Average	0.11	0.11	0.11	0.06	0.10

Source: two digit manufacturing value-added data in US dollars issued by the UNIDO
Notes: industry specialisation is measured by $S_{ij,t} = Ln\left(\frac{1}{T}\sum_{t}\sum_{n}^{N}\left|s_{n,i} - s_{n,j}\right|\right)$, an average value obtained using the values from the country-pairs.

decrease indicates that all countries in our sample have more similar industry structures since 1999. We believe that the introduction of Euro since 1999 leads most EMU countries to similar industry structures, as well as for other European countries, such as Switzerland and Denmark. The globalisation also results in low specialisation for non-European countries.

7.3.3 Financial Integration

Financial integration is the process through which a country's financial markets become more closely integrated with those in other countries or with those in the rest of the world. It implies the elimination of barriers for foreign financial institutions from some or all countries to operate or offer cross-border financial services in others. This may imply linking banking, equity and other types of financial markets. Financial integration can be achieved in a number of ways. It may emerge as a result of formal efforts to integrate financial markets with particular partners, typically those that share membership in a regional integration agreement. It can also emerge in the absence of explicit agreements.

Financial integration can be difficult to measure effectively. Typical measures include indices capturing restrictions on capital flows, effective bilateral capital flows[65], bilateral bank flows[66], the spread among long-run and short-run interest rates[67] and so on. Most popular restrictions data on capital flows are from IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) which includes multiple exchange rates, current account restrictions, capital account restrictions and surrender of export

[65] This proxy is used by Kalemli-Ozcan et al. (2003) and Imbs (2004) which is calculated from index of risk sharing.

[66] Böwer and Guillemineau (2006) use a proxy bilateral bank flows to measure financial integration. The aggregate bank flows are defines as the change in international financial claims of a bank resident in a given country vis-à-vis the banking and non-banking sectors in another country.

[67] Schiavo (2005) define financial integration as the spread among long-run and short-run interest rates reported by the OECD: $FI_{ij} = \sqrt{(lir_i - lir_j)^2 + (sir_i - sir_j)^2}$ where *lir* is long-run interest rates and *sir* is short-run interest rates.

proceeds.[68] Recently Imbs (2006) uses a new released dataset with direct observations on bilateral asset holdings by IMF. Coordinated Portfolio Investment Survey (CPIS) data cover asset holdings which are decomposed into equities, short term and long term debt securities. However, this is survey data which maybe suffer a potential under-reporting and only portfolio stocks are included but do not consider the FDI. To examine the effect of financial integration on the business cycles, we use bilateral foreign direct investment position data.[69] Countries that are closely integrated through FDI may transmit shocks to each other through the changes in FDI positions brought about by idiosyncratic shocks and it is similar with trade. Multinational firms may distribute the effects of local macroeconomic shocks throughout the organisation thus distributing the shock, to some extent, from one economy to another. For instance, a multinational organisation retrenches staff worldwide and suffers a downturn in some of its markets. Similarly if FDI is generated by the multinational organisation sourcing from production of intermediate inputs abroad, then the effects of changes in demand for final products may be transmitted to countries providing the intermediate inputs. The same, income flows generated by FDI positions may also serve to synchronise the business cycles of countries with strong FDI linkages. Finally, FDI also can be a channel through which technology and ideas are transferred between countries, which may also contribute to the correlation of the business cycle. Therefore, we use following equation to measure financial integration:

$$FI_{ij,t} = \ln\left[\frac{1}{t}\sum_{t=1}^{\tau}\left(\frac{FDI_{Inward,ijt} + FDI_{Outward,ijt}}{FDI_{Inward,it} + FDI_{Outward,it}FDI_{Inward,jt} + FDI_{Outward,jt}}\right)\right] \quad (7\text{-}4)$$

where $FDI_{Inward,ijt}$ is bilateral foreign direct investment inward position data from country i to country j and $FDI_{Outward,ijt}$ is FDI outward position data from country i to country j. $FDI_{Inward,it}$ ($FDI_{Outward,it}$) and $FDI_{Inward,jt}$ ($FDI_{Outward,jt}$) are the total FDI inward (outward)

[68] Imbs (2004) adopt AREAER data to measure the financial integration and found the positive relationship with business cycle synchronisation.

[69] Heathcote and Perri (2004) focus on the US and use total capital flow to measure financial integration which is the sum of the US foreign direct investment position plus the equity part of the stock of portfolio investment abroad, relative to the US capital stock. However, our sample covers 15 OECD countries and we cannot access both bilateral FDI and bilateral equity data for all these countries over 1984 to 2003.

position for county i and j, respectively. All these data are denoted by US dollars and come from OECD International Direct Investment Statistics. We select total FDI position instead of sum of country i and country j's GDP because the size of FDI relative to GDP is likely to be small (the average value is only 0.62%), while the average value of financial integration measured by (7-4) is 1.97%. And also we do not anticipate that these flows will be very cyclical, certainly not the same extent as trade flows. Table 7-4 presents the average financial integration for each country vis-à-vis the other 14 partners. Most European countries have clear increasing trend, in particular Finland and Sweden, but not for the Netherlands and Switzerland. Some non-European have clear downward financial integration, such as US and Canada.

In a review of the main approaches used to proxy for financial integration, Adam et al. (2002) stress the superiority of a measure that is directly observable, bilateral rather than

Table 7-4

Average Financial Integration

Periods / Countries	1984-1988	1989-1993	1994-1998	1999-2003	Full sample 1984-03
Australia	0.0127	0.0124	0.0126	0.0084	0.0103
Austria	0.0039	0.0044	0.0044	0.0043	0.0042
Canada	0.0215	0.0176	0.0136	0.0132	0.0153
Denmark	-	0.0111	0.0106	0.0107	0.0109
Finland	0.0018	0.0068	0.0094	0.0131	0.0098
France	-	0.0233	0.0218	0.0222	0.0224
Germany	0.0253	0.0277	0.0279	0.0265	0.0268
Italy	0.0153	0.0178	0.0165	0.0138	0.0160
Japan	0.0147	0.0191	0.0148	0.0109	0.0140
Netherlands	0.0240	0.0216	0.0194	0.0173	0.0197
Norway	0.0058	0.0105	0.0124	0.0107	0.0111
Sweden	0.0166	0.0202	0.0206	0.0219	0.0200
Switzerland	0.0427	0.0338	0.0172	0.0136	0.0242
UK	0.0290	0.0307	0.0289	0.0309	0.0297
US	0.0494	0.0432	0.0414	0.0399	0.0425
Average	0.0202	0.0200	0.0181	0.0172	0.0184

Source: OECD International Direct Investment Statistics

Notes: Financial integration is measured by the ratio of bilateral FDI position and total FDI position:

$$FI_{ij,t} = \ln\left[\frac{1}{t}\sum_{t=1}^{\tau}\left(\frac{FDI_{Inward,ijt} + FDI_{Outward,ijt}}{FDI_{Inward,it} + FDI_{Outward,it}FDI_{Inward,jt} + FDI_{Outward,jt}}\right)\right]$$

aggregated across countries and capturing stocks rather than flows, if it is based on quantities rather than prices. Our bilateral FDI data fit all these three requirements. In addition, FDI data cover continually 20 years which can be used in panel data estimation and keep consistent with all other variables. This is an advantage compared with CPIS data. However, these data also have problems. Firstly, these data do not cover many countries and most countries' data only start from 1984. That is why we only focus on 15 OECD countries and over 1984 to 2003. Secondly, only FDI stocks are included, while the equity part of the stock of portfolio investment is completely ignored since we can not access bilateral data.

Compared with Heathcote and Perri (2004)'s proxy, our data excludes portfolio investment, which are not available as bilateral data. To justify the use of this proxy we compare the co-movements in the FDI stock with the other measures. We find that the aggregate FDI data is highly correlated with both aggregate portfolio investment[70] and gross capital formation[71] which are 0.67 and 0.53, respectively. In addition, it is highly correlated with gross capital flows, 0.45, which are calculated by sum of financial account assets and liability[72]. The correlations between aggregate FDI and IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) and Quinn's index of capital account openness[73] are high as well which is 0.54 and 0.57, respectively. We also compare the bilateral FDI data with bilateral Coordinated Portfolio Investment Survey (CPIS) reported by IMF which is used by Imbs (2006) for financial integration and all correlations are above 0.90.[74] Therefore we have evidence to believe that bilateral

[70] Portfolio investment data are from IMF, Balance of Payments Statistics, and is the sum of portfolio investment asset and liability denoted by US $.
[71] The gross capital formation data (formerly gross domestic investment) come from World Bank, World Development Indicators, and the data is expressed by current US $. It is defined by World Bank as: outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and ""work in progress."" According to the 1993 SNA, net acquisitions of valuables are also considered capital formation.
[72] The data are from IMF, Balance of Payments Statistics.
[73] Quinn (1997) measure builds on the AREAER indices, including information on each country's individual experience.
[74] CPIS was initiated in 1997 when 29 countries participated. Since 2001, the survey has been undertaken on a yearly basis. Therefore, we only report the correlations in 1997, 2001, 2002 and 2003 which are 90%, 91%, 90% and 91%. Imbs (2006) argues that CPIS data are decomposed into equities, short-term and long-

Table 7-5

Variables Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
$Corr_{ij,t}$	420	0.55	0.49	-0.88	0.9998
$TI_{ij,t}$	420	0.0066	0.0075	0.0003	0.0397
$S_{ij,t}$	419	0.10	0.05	0.01	0.29
$FI_{ij,t}$	379	0.0197	0.0256	0.0001	0.1430

FDI position data are a good proxy for financial integration and can be instead of portfolio investment or gross capital flows.

Table 7-5 reports summary statistics for the dependent variable real GDP correlations and the three cycle determinants trade, specialisation and finance. Compared with the previous sample we find that both real GDP correlations and bilateral trade intensity have higher mean value (0.45, 0.0041 for 24 countries sample and 0.55 and 0.0066 for 15 countries sample), since countries dropped in this sample are mostly non-European countries, such as China, Hong Kong, Mexico, which have low correlations and bilateral trade with European countries. Compared to Imbs (2004) our specialisation is relative low.[75] This indicates that our European countries have more similar industry structures than Imbs's 24 countries.

7.4 Econometric Methodology: Three-Stage Least Squares in Panel Data Estimations

Estimating (7-1) by pooled OLS only provides reduced form estimates for the effects of finance, trade and structure on cycle synchronization, but provides no notion of indirect

term debt securities, which make it in principle possible to evaluate whether different components of international investment have distinct effects on real variables.
See CPIS, 2004.
[75] Imbs (2004) reports 038 and 0.54 for the sectoral similarities by the United Nations Statistical Yearbook (UNYB) and UNIDO, respectively.

as against direct effects. For instance, estimates of α_3 in equation (7-1) embed the direct impact of finance on the business cycles, but also its indirect effects working via trade intensity or specialisation as we discussed in literature review. Thus, the coefficient of finance could be significantly positive just because financial market boosts bilateral trade or results in closer industry specialisation which is an indirect effect on the business cycles, but without any direct effects of finance on cycles. As we mentioned before, trade intensity could be endogenous since countries likely to link their currencies to their most important trade partners and then fixed exchange rate between them could cause both high bilateral trade and income links. Also this will affect the specialisation and financial integration at the same time. To disentangle direct from indirect channels and eliminate the endogenous problem, we follow Imbs (2004, 2006) to approach simultaneous equations.[76]

$$Corr_{ij,t} = \alpha_1 + \alpha_2 TI_{ij,t} + \alpha_3 S_{ij,t} + \alpha_4 FI_{ij,t} + \varepsilon_{1ij,t} \quad (7\text{-}5)$$

$$TI_{ij,t} = \beta_1 + \beta_2 S_{ij,t} + \beta_3 FI_{ij,t} + \beta_4 I_2 + \varepsilon_{2ij,t} \quad (7\text{-}6)$$

$$S_{ij,t} = \gamma_1 + \gamma_2 TI_{ij,t} + \gamma_3 FI_{ij,t} + \gamma_4 I_3 + \varepsilon_{3ij,t} \quad (7\text{-}7)$$

$$FI_{ij,t} = \delta_1 + \delta_2 TI_{ij,t} + \delta_3 I_4 + \varepsilon_{4ij,t} \quad (7\text{-}8)$$

I_2: LAN_{ij}, DIS_{ij}, ADJ_{ij}, $FTA_{ij,t}$, $YY_{ij,t}$, $FIX_{ij,t}$; I_3: $YY_{ij,t}$, DIS_{ij}, $FTA_{ij,t}$, $POP_{i,t}$, $POP_{j,t}$, $DYY_{ij,t}$; *and I4:* LAN_{ij}, DIS_{ij}, ADJ_{ij}, $YY_{ij,t}$, $POP_{i,t}$, $POP_{j,t}$, $I_{i,t}$, $I_{j,t}$.

where I_2, I_3 and I_4 contain the vectors of their exogenous determinants. The instrumental variables for trade intensity are from standard gravity model which is the same as before. We select the product of GDP per capita ($YY_{ij,t}$), the log of distance (DIS_{ij}) between the capital cities of the two countries and dummy variables to account for land adjacency (ADJ_{ij}) and a common official language. Also supplementing instruments are dummies

[76] Methodology see Wooldridge (2002), chapter 9, Baltagi (2005) and Stata Manual (XT) 9.0.

that equal unity when the two countries have a fixed exchange rate agreement ($FIX_{ij,t}$) or a free trade agreement ($FTA_{ij,t}$).[77]

The degree of regional specialisation is likely to be affected by any variable that affects the volume of interregional trade. As Kalemli-Ozcan et al. (2003) said in the extreme case where all regions have a similar composition of consumption, trade and specialisation are one and the same. Following with Kalemli-Ozcan et al. (2003) and Imbs (2006), the instrumental variables for specialisation include the product of GDP per capita ($YY_{ij,t}$), the log of distance between the capital cities of the two countries (DIS_{ij}), a dummy variable whether two countries have the same free trade agreement ($FTA_{ij,t}$), measures of both countries' populations for country sizes ($POP_{i,t}$, $POP_{j,t}$) and the log of GDP disparity which is defined as $DYY_{ij,t}=Max[(Y_i/Y_j),(Y_j/Y_i)]$.[78]

We adopt gravity variables for financial integration as well, since FDI is a proxy for financial integration. The vector I_4 includes gravity variables of language (LAN_{ij}), distance (DIS_{ij}), adjacency (ADJ_{ij}), the product of GDP per capita ($YY_{ij,t}$), and measures of both countries' populations for country sizes ($POP_{i,t}$, $POP_{j,t}$) and also include the real interest rate of country *i* and county *j* ($I_{i,t}$, $I_{j,t}$).[79]

Any direct impacts on cycles are captured by estimates of α, i.e. α_2 is the direct impact from trade, α_3 is the direct impact from structure and α_4 is the direct impact from finance. In turn, $\gamma_2\alpha_2$ and $\delta_2\alpha_2$ capture the indirect effects of trade working via specialisation and finance, respectively. $\beta_2\alpha_3$ is the indirect effect of specialisation via trade and $\beta_3\alpha_4$ and $\gamma_3\alpha_4$ are the indirect impacts of finance via trade and specialisation.

[77] See all these instrumental variables measurement descriptions in chapter 5. Dummy variables of official language and land adjacency are from CIA website http://www.cia.gov. The distance data is from http://www.eiit.org/. Free trade agreement data is from the General Agreement on Tariffs and Trade (GATT), World Trade Organisation (WTO). A dummy variable of fixed exchange rate is from Reinhart and Rogoff (2004). Product of GDP per capita is from the OECD Economic Outlook and IMF International Financial Statistics.

[78] The countries populations are from IMF, IFS and all other data source is the same with I_2.

[79] High interest rate attracts more capital from domestic and overseas then increase the FDI inflow and decrease the outflow. The real interest rate data are from IMF's IFS (lending interest rate- GDP deflator).

In these simultaneous equations we assume that bilateral trade intensity affect on synchronization via specialisation and financial integration, financial integration's indirect effects are from trade and specialisation and specialisation affect synchronization via trade intensity. The procedure consists two steps, firstly, estimate them equation by equation using two-stage least squares and retrieve the covariance matrix of the equations distributions, and then perform a type of generalized least squares estimation on the stacked system, using the covariance matrix from the first step. Furthermore, as we discussed in chapter 4, the unobservable country-pair specific effects also should be considered in our simultaneous equations. Thus panel three-stage least should be adopted for equation (7-5) to (7-8).[80]

7.5 Empirical Analysis

This section reports the main results. Ordinary least squares and panel data model (both fixed effects and random effects model) results are compared with existing evidence and 3SLS and panel 3SLS estimates are presented to evaluate the effects of unobserved country-pair specific effects, simultaneity and endogeneity. A final subsection discusses the magnitude and significance of the estimates for all individual countries.

7.5.1 Aggregate Estimation

Table 7-6 reports results of equation (7-5) and focuses on GDP correlation equation to examine the direct effect only. The first column is estimated by OLS and only focus on the trade intensity. The results show a significant and positive relationship between the business cycle correlation and the trade intensity. The slope estimate is 0.17, suggesting a

[80] It is difficult to conduct panel 3SLS since no software has command that can run this regression so far. We select *Stata*'s command '*xtdata*' to transform data set of all the variables. '*xtdata, fe*' for fixed effects model and '*xtdata, re*' for random effects model and transfer the data to contain unobservable country-pair specific effects. Then we run three-stage least square for equation (7-5) to (7-8) by command 'reg3'. After '*xtdata*', the command of regress is the same with using xtreg directly. See Stata 9.0 manual for details.

doubling of trade intensity results in a correlation higher by 0.118 which is close to the estimates in Imbs (2004), Frankel and Rose (1998), Clark and van Wincoop (2001) and Kose and Yi (2002).

The second column adds the other two variables, namely specialisation $S_{ij,t}$ and financial integration $FI_{ij,t}$ and is estimated by OLS following equation (7-5). All three variables are statistically significant and present 'correct' signs. The coefficient of trade intensity increases to 0.32, suggesting that the business cycle correlation would rise by 0.222 following a doubling of trade intensity. Country pairs with low industry production have significant higher correlation i.e. similarities in economic structure result in correlated business cycles. Our coefficient of -0.16 is very close to Imbs (2004) -0.12. Finance has a strongly negative effect on synchronisation which confirms the theory that limited ability to borrow and lend internationally hampers the transfer of resources across countries and can increase GDP correlations. This is consistent with Heathcote and Perri's (2002) results. The model explains approximately 32% of total variation in GDP correlation which is more than twice than OLS (i) as two additional regressors. The overall significance of the model is tested by the F-statistic and both of them confirm the overall significance of the included independent variables in OLS (i) and OLS (ii).

The last two columns in Table 7-6 estimate equation (7-5) by both fixed effects and random effects model. Random effects estimation reports a very consistent result with OLS: trade has a significant effect on cycles and both specialisation and financial integration affect cycles negatively. All estimates' magnitudes decrease a little. The model also explains 32% of the overall variation in correlations, though comparing the between and within R^2s it is apparent that the cross-sectional dimension of the data accounts for the largest part of the overall R^2. The overall significance of the model is established by a Wald-statistic and the country pair specific effects are statistically significant from Breusch-Pagan test, thus justifying the use of panel methods. Nevertheless, the fixed effects model presents different results. Neither trade intensity nor finance has significant effects on cycles and only specialisation shows a significantly negative coefficient.

Table 7-6

Results from OLS, FE and RE Estimations

	OLS (i)	OLS (ii)	FE	RE
Constant	1.49*	1.12*	0.27	1.04*
	(15.25)	(8.23)	(0.34)	(6.09)
$TI_{ij,t}$	0.17*	0.32*	-0.02	0.28*
	(9.37)	(12.52)	(-0.14)	(8.46)
$S_{ij,t}$		-0.16*	-0.19*	-0.18*
		(-4.92)	(-4.58)	(-4.74)
$FI_{ij,t}$		-0.16*	0.06	-0.13*
		(-7.20)	(1.14)	(-5.25)
Within R^2		-	0.08	0.04
Between R^2		-	0.02	0.51
Overall R^2	0.15	0.32	0.03	0.32
<u>Significance:</u>				
Individual Effects			2.30*	22.13*
			(0.00)	(0.00)
Overall	87.77*	66.48*	7.37*	108.82*
	(0.00)	(0.00)	(0.00)	(0.00)

Notes: OLS (i) and OLS (ii) are single equation OLS estimates. FE and RE are fixed effects and random effects panel date estimates. T-ratios, that are robust to heteroscedasticity, are presented in parentheses. The F-test establishes the statistical significance of the fixed effects. The Breusch-Pagan test is for the significance of the random effects. An F- or Wald-statstic is included to establish the overall significance of the model and p-values are presented in parentheses. * denotes significance at the 5% level.

The first column of Table 7-7 reports equation by equation estimates of (7-5) to (7-8) by OLS. We have explained the GDP equation results in Table 7-6. Estimates for equation (7-6) show that the effect of specialisation on trade is significant and more similar economies result in more bilateral trade; the effect of financial integration is significant as well, and higher bilateral FDI leads to more bilateral trade. At the same time, in estimates of (7-7) and (7-8), we find reverse effects, that is, trade intensity affects finance positively and affects specialisation negatively. From equation (7-8) we also find that financial integration induces specialisation. More bilateral FDI is associated with high *S*, that is, financially integrated economies tend to have different industry structure.

Table 7-7

Results from OLS, 3SLS, FE 3SLS and RE 3SLS Estimations

		OLS	3SLS	FE 3SLS	RE 3SLS
GDP equation	Constant	1.12*	1.55*	11.52*	0.27**
		(8.23)	(4.69)	(2.92)	(1.90)
	$TI_{ij,t}$	0.32*	0.58*	1.38*	0.37*
		(12.52)	(13.43)	(2.60)	(5.39)
	$S_{ij,t}$	-0.16*	-0.03	0.17	-0.24*
		(-4.92)	(-0.26)	(1.28)	(-3.20)
	$FI_{ij,t}$	-0.16*	-0.46*	0.62*	-0.32*
		(-7.20)	(-11.11)	(2.65)	(-4.31)
TI Equation	$S_{ij,t}$	-0.08*	-1.06*	0.06	-0.55*
		(-1.73)	(-6.42)	(0.85)	(-3.57)
	$FI_{ij,t}$	0.47*	0.62*	-0.08	0.70*
		(25.92)	(16.18)	(-1.09)	(10.89)
FI Equation	$TI_{ij,t}$	1.06*	0.91*	-2.28*	0.39*
		(16.60)	(11.26)	(-5.57)	(2.50)
S Equation	$TI_{ij,t}$	-0.02*	-0.67*	-0.92**	-1.64*
		(-0.40)	(-3.70)	(-1.67)	(-5.55)
	$FI_{ij,t}$	0.10*	0.49*	0.71*	0.91*
		(3.13)	(3.98)	(1.99)	(4.59)
Hausman Test				3.15 (0.37) RE 3SLS	
Joint Test	$TI_{ij,t}$		303.16*	38.83*	61.39*
	$S_{ij,t}$		47.25*	2.78	26.27*
	$FI_{ij,t}$		305.45*	13.28*	133.75*

Notes: OLS is single equation OLS estimates equation by equation. FE 3SLS and RE 3SLS are 3SLS fixed effects and random effects panel date estimates. t-ratios are presented in parentheses. 3SLS, FE 3SLS and RE 3SLS are estimated by equation (7-5) to (7-8).* and ** denotes significance at the 5% and 10% levels. The Hausman test comparing the fixed effects 3SLS and random effects 3SLS indicates the data prefer random effects 3SLS where random effects 3SLS model drop the time-variant instrumental variables as we to be consistent with FE 3SLS.

Table 7-8

Instrumental Variables Results

	Coefficient	3SLS	RE 3SLS
Trade equation	$Language_{ij}$	-0.14*	-0.10
		(-2.02)	(-1.00)
	$Distance_{ij}$	-0.12*	-0.07
		(-3.07)	(-1.06)
	$Adjacent_{ij}$	0.17**	-0.03
		(1.82)	(-0.21)
	$FTA_{ij,t}$	0.33*	0.70*
		(3.03)	(4.68)
	$Fix_{ij,t}$	0.28*	0.15
		(3.06)	(1.22)
	$(Y_iY_j)_t$	-0.58*	-0.22*
		(-7.59)	(-5.89)
FI Equation	$Language_{ij}$	0.21**	0.69*
		(1.92)	(3.54)
	$Distance_{ij}$	0.13*	-0.24*
		(2.28)	(-2.05)
	$Adjacent_{ij}$	0.14	0.35
		(0.90)	(1.33)
	$(Y_iY_j)_t$	0.77*	-0.46*
		(5.90)	(-5.40)
	$Pop_{i,t}$	0.24*	0.21*
		(6.82)	(3.06)
	$Pop_{j,t}$	0.18*	0.14*
		(6.96)	(2.99)
	$Interest_{i,t}$	0.09*	0.03
		(4.80)	(1.32)
	$Interest_{j,t}$	0.01	-0.05*
		(0.51)	(-2.93)
S Equation	$(Y_iY_j)_t$	-0.62*	-0.59*
		(-5.23)	(-5.23)
	$Pop_{i,t}$	-0.02	0.17*
		(-0.37)	(2.67)
	$Pop_{j,t}$	-0.07	0.09
		(-1.40)	(1.57)
	$Distance_{ij}$	-0.05	-0.07
		(-0.87)	(-0.51)
	$FTA_{ij,t}$	0.31	1.59
		(1.35)	(4.47)
	$GDP\ Disparity_{ij,t}$	0.13*	-0.02
		(2.20)	(-0.26)

Notes: t-statistics are shown in parentheses. * and ** denote statistical significance at the 5% and 10% levels respectively. All instrumental variables for trade, finance, and specialisation are from equations (7-5) - (7-8).

The second column implements 3SLS on equations. Except *S* in the GDP equation, all variables are significant and have the same signs as in OLS. 3SLS tends to magnify the estimate of α_2 relative to OLS. As in Frankel and Rose (1998), instrumenting trade with gravity variables results in a higher point estimate, as it controls for an attenuating endogeneity bias, because nonsynchronised economies tend to trade more. 3SLS also magnifies the estimate of β_2 relative to OLS. The endogeneity of *S* and *TI* would upward if anything tends to bias β_2, as trading partners specialise and thus have high *S*. The negative sign can be interpreted as meaning that countries with similar economic structures have more intra-industry trade. Therefore β_2 distinguishes the effects of inter- and intra-industry trade in simultaneous estimation. Finally, 3SLS magnifies finance's direct and indirect effects. Low financial integration results in similar industry structures and close business cycles.

The main appeal of panel 3SLS is that they make it possible to disentangle the direct and indirect impacts as well as unobservable country-pair effects. The last two columns in Table 7-7 report fixed effects 3SLS and random effects 3SLS. FE 3SLS is still quite different with OLS and 3SLS. The coefficient of trade in GDP equation jumps to 1.38 which is much higher than our previous results and these in the literature.

Specialisation is insignificant and finance changes to positive. Here, FE 3SLS drop all time-invariant instrumental variables in equation (7-6), (7-7) and (7-8), such as language, distance and adjacency. In addition, the Hausman test cannot reject the hypothesis that difference in coefficients is not systematic and prefers to random effects model.[81] Therefore, we would like to focus on the RE 3SLS to explain results.

The estimates from RE 3SLS are very consistent with OLS and 3SLS. In the GDP equation, we still find a large and significant effect of trade in accounting for cycles which indicate that a doubling of trade results in a correlation higher by 0.256. The impact from RE 3SLS is larger than OLS but less than 3SLS. The coefficient of S is

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[81] Again the RE 3SLS model drop the time-variant instrumental variables (language, distance, and adjacency) to be consistent with FE 3SLS when we conduct the Hausman test. In addition, the Hausman test only focuses on the GDP equation. Thus we can believe that the RE 3SLS with full instrumental variables is better then FE 3SLS.

significantly negative suggesting that more similar economic structure leads to closer business cycles. The impact of financial integration on synchronisation is -27.4%. High financial integration results in low business cycle correlation. In trade equation, finance equation and specialisation equation, all indirect effects present significantly. We find the positive indirect impact of financial integration on cycles via trade and via specialisation; positive indirect impact of trade intensity on cycles via financial integration but negative indirect effect via S. Also S affect cycles via trade negatively. These are consistent with the theory we mentioned in literatures that 'both financial integration and trade intensity could affect specialisation in different sectors'.

The overall impact (considering both direct and indirect impacts from trade intensity, specialisation and financial integration) on synchronisation are 89.7%, -35.8% and -24.0%, respectively.[82] We find the indirect effects increase the magnitudes of trade and specialisation, especially for trade. While financial integration decrease the magnitude from -0.32 to -0.28. A Wald test is performed to test the jointly significance of overall effects for three endogenous variables. The hypothesis for the test is the coefficients in all equations by three-stage least square are zero at the same time. For instance we consider the variable of trade intensity in GDP equation, in financial integration equation and in specialisation equation at the same time and test whether they are joint significant in all equation. The results indicate that all tests reject the hypothesis and the overall effects from trade, finance and specialisation are statistically significant in both 3SLS and RE 3SLS.

Table 7-8 reports all instrumental variables' results. The 3SLS estimates strongly suggest that instrumental variables are important determinants of trade intensity and financial integration. Similarly with our previous results, all instrumental variables in trade equation indicate significant at least 10% level. However, the variables, language and product of GDP per capita change to negative effects on trade and they are different with what we expect. Except the interest rate of country j, all other instruments are significant in financial integration equation at 10% level. The distance between two countries reports a 'wrong' sign, but it change to negative in RE 3SLS. The estimates in the specialisation

[82] The corresponding coefficients for trade, specialisation and finance are: 0.64, -0.44 and -0.28.

equation do not fit as well as the other two, but the most important variables, product of GDP per capita and GDP gap, suggested by Imbs (2004, 2006) are significant with 'correct' signs. Some estimates in trade equation estimated by RE 3SLS change to insignificant and only the dummy variable free trade agreement and the product of GDP per capita are statistically significant. In financial integration equation estimated by RE 3SLS, 'distance' changes the sign to negative which is the same with what we expected: the closer to two countries, the greater their degree of financial integration. The country j's interest rate is significant which is instead of country i's in 3SLS. The product of GDP per capita and log of population in is significant in S equation.

7.5.2 Sub-period Analysis

To be consistent, whether the simultaneous relationship between the business cycles and the trade intensity, specialisation and finance varied across sub-period was tested by estimating a 3SLS with country-pair data (Table 7-9). Our sample is from 1984 to 2003 which is split into 4 periods. Firstly, in GDP equation, trade intensity reports all significant coefficients over time, and magnitude increases over time up until 1989-1993 period when the maximum marginal effect occurs which is consistent with our previous sample sub-period analysis. The coefficients increase from 0.3 in the first period to 0.9 in the second period and then decrease to around 0.6. Only the second period's specialisation presents significantly negative coefficient and all others are either positive or insignificant. Financial integration has very similar result with trade, and it is significantly negative over time which also is consistent with our overall result. Magnitude increases up until the second period again from -0.18 to -0.62 then decrease to around -0.50. This result is not as clear as the result in chapter 5 since this sample is relative shorter than before and only covers recent 20 years. All other indirect effects are strong and significant only except the effect of FI on S in second period, trade on S in third period and S on trade in last period. Hence, the evidences from the sub-periods also support our aggregate results in Table 7-7 both from direct and indirect effects.

Table 7-9

Sub-period Analysis

		1984-88	1989-93	1994-98	1999-03
GDP equation	Constant	2.80*	3.35*	-1.84	3.86*
		(8.22)	(4.40)	(-1.32)	(5.99)
	$TI_{ij,t}$	0.30*	0.90*	0.54*	0.68*
		(4.68)	(8.40)	(3.85)	(9.05)
	$S_{ij,t}$	0.63*	0.35	-1.12*	0.55*
		(4.45)	(1.26)	(-2.45)	(3.86)
	$FI_{ij,t}$	-0.18*	-0.62*	-0.55*	-0.48*
		(-3.17)	(-6.48)	(-4.52)	(-9.09)
Trade Equation	$S_{ij,t}$	-1.13*	-1.10*	-2.45*	-0.16
		(-3.30)	(-3.97)	(-2.64)	(-0.42)
	$FI_{ij,t}$	0.79*	0.62*	0.58*	0.71*
		(7.18)	(10.33)	(6.69)	(10.14)
FI Equation	$TI_{ij,t}$	0.71*	0.94*	1.02*	0.72*
		(3.33)	(5.81)	(7.52)	(5.52)
S Equation	$TI_{ij,t}$	-0.49*	-0.33**	0.28	-0.43*
		(-2.16)	(-1.80)	(1.50)	(-2.49)
	$FI_{ij,t}$	0.32*	0.19	-0.34*	0.40*
		(2.45)	(1.38)	(-2.30)	(4.09)

Notes: t-statistics are shown in parentheses. * and ** denote statistical significance at the 5% and 10% levels respectively. 3SLS is estimated for each period.

7.5.3 Individual Countries Analysis

Variation in the size of coefficients could also take place across countries, particularly given the importance of indirect effects and instrumental variables for endogeneity. Table 7-10 presents 15 individual countries with their 14 partners results estimated by RE 3SLS.

In the GDP equation, the regressor of trade intensity presents a very similar result with previous study. Firstly, all four non-European countries still show insignificant relationship with the business cycle correlation. However, not all European countries show significant coefficients. All founding members of European Union plus Demark, Norway and Switzerland have positive and statistically significant relationship between the trade and the business cycle. The average magnitude of coefficients, 0.31, is close to the aggregate country result, 0.37. However, the magnitude of coefficients for significant countries increases much, e.g. Italy’s coefficient increases to 0.82. This probably can be explained by the shorter sample period and fewer countries in the sample. We only consider the sample period after 1984 and most countries have joined EU for a few years and also we focus on OECD countries only.

Consistently with the aggregate results, we find a negative relationship between the industrial specialisation and the business cycle correlation. Nevertheless, these results are quite different with trade intensity. Most significant countries for trade show an insignificant coefficient for specialisation and insignificant countries have negative and significant coefficients except Switzerland. This probably can be explained by their GDP are relatively much higher than industry volumes. Financial integration presents similar results with trade. Expect Demark all significant countries for trade appear negative and statistically significant coefficient for financial integration. UK also has a significant coefficient at 10% level. Generally, individual countries have consistent results to the aggregate country results. However, the magnitude and significance of the estimated is not the same for all countries. The magnitude and significance of indirect effects in the trade equation, finance and specialisation equations also change across countries but in most cases remain of the same signs.

Finance affects the business cycles via both specialisation and trade positively, trade affect the business cycles via finance positively and via specialisation negatively. Specialisation has indirect effect on cycles through trade negatively. However, the indirect effects in Table 7-10 are not as clear as the aggregate country results. Some countries do not appear statistically significant coefficients. For example only five countries have significant impact for trade in finance equation and only four countries are significant for trade in specialisation equation.

Table 7-10

Individual Countries Results – Estimated by RE 3SLS

		Australia	Austria	Canada	Denmark	Finland	France	Germany	Italy	Japan	Netherlands	Norway	Sweden	Switzerland	UK	US
GDP Eq.	Const	-0.26	0.46	-0.32	1.45*	0.33	0.52	0.57**	0.75*	-0.85	0.32	0.50**	0.13	1.70*	0.19	-0.69**
		(-0.68)	(0.83)	(-0.97)	(3.50)	(1.27)	(1.26)	(1.79)	(2.04)	(-1.25)	(0.99)	(1.82)	(0.49)	(3.22)	(0.43)	(-1.66)
	$TI_{ij,t}$	0.14	0.15	-0.07	0.32*	0.16	0.43*	0.61*	0.82*	0.33	0.42*	0.43*	0.06	0.71*	0.09	0.06
		(0.66)	(0.74)	(-0.39)	(2.27)	(1.07)	(2.38)	(3.70)	(3.61)	(0.75)	(3.59)	(3.97)	(0.27)	(3.28)	(0.46)	(0.23)
	$S_{ij,t}$	-0.91*	-0.27*	-0.36**	-0.22	-0.25*	-0.07	-0.12	-0.19	-1.05*	0.06	-0.40*	-0.39*	0.82*	0.07	-0.67*
		(-3.33)	(-2.04)	(-1.68)	(-1.20)	(-2.06)	(-0.44)	(-1.26)	(-1.63)	(-2.82)	(0.31)	(-3.21)	(-2.94)	(2.48)	(0.50)	(-3.12)
	$FI_{ij,t}$	0.06	-0.01	0.07	0.00	-0.07	-0.40*	-0.51*	-0.61*	-0.29	-0.53*	-0.21*	0.06	-0.81*	-0.20**	0.01
		(0.46)	(-0.03)	(0.45)	(-0.03)	(-0.56)	(-2.54)	(-3.57)	(-3.56)	(-0.77)	(-3.50)	(-2.39)	(0.27)	(-3.24)	(-1.71)	(0.04)
Trade Eq.	$S_{ij,t}$	-0.38	-0.32**	-0.34	0.02	-0.23**	-0.21	-0.44*	-0.26*	-0.33	-0.74*	0.50*	-0.37*	0.15	-0.03	-0.25
		(-1.45)	(-1.84)	(-1.26)	(0.06)	(-1.84)	(-1.44)	(-2.45)	(-2.31)	(-1.09)	(-5.98)	(2.67)	(-1.96)	(0.54)	(-0.29)	(-1.21)
	$FI_{ij,t}$	0.51*	0.12	0.44*	0.87	0.03	0.38*	0.55*	0.63*	0.53*	0.53*	0.21**	-0.49	0.17	0.55*	0.95*
		(3.27)	(0.47)	(4.05)	(1.61)	(0.22)	(3.02)	(4.58)	(6.12)	(5.38)	(5.29)	(1.80)	(-0.81)	(0.58)	(8.32)	(9.31)
FI	$TI_{ij,t}$	2.27*	0.09	-0.33	0.14	-0.10	-0.42	-0.38	1.06*	0.69	0.36*	0.89*	0.62	0.62	1.54*	-2.03
		(4.05)	(0.09)	(-0.62)	(0.34)	(-0.18)	(-0.48)	(-0.62)	(2.32)	(0.23)	(2.57)	(2.66)	(0.79)	(1.43)	(5.95)	(-0.35)
S Eq.	$TI_{ij,t}$	-3.51*	-2.37*	0.30	-0.06	-0.91	-0.85	0.03	-3.38*	-1.08	-0.38	1.08	-3.65*	0.36	-0.66	0.27
		(-2.27)	(-4.66)	(0.52)	(-0.26)	(-1.28)	(-1.43)	(0.01)	(-3.89)	(-0.23)	(-0.90)	(1.36)	(-1.98)	(0.55)	(-0.25)	(0.36)
	$FI_{ij,t}$	1.00*	2.14*	0.30	-0.25	0.68	1.16*	-4.99*	2.35*	-2.22	1.16*	-0.11	-2.95	0.89*	0.58	0.00
		(3.33)	(4.11)	(1.07)	(-1.36)	(1.57)	(2.03)	(-1.99)	(4.09)	(-0.37)	(4.08)	(-0.29)	(-1.41)	(3.04)	(0.60)	(0.00)

Notes: t-ratios are in parentheses. * and ** denote statistical significance at the 5% and 10% levels respectively. 3SLS is estimated for each country followed by equation (7-5) to (7-8). All instrumental variables results are not reported here.

Again after considering the indirect effects, we have a look the overall effects. Both trade intensity and financial integration shows very close magnitude of coefficients between direct impact and overall impact and the average differences of magnitude only are 0.08 and 0.10. However, the specialisation has quite different magnitude, e.g. Australia, Germany, Italy, Japan, the Netherlands, Norway, Sweden, Switzerland and the UK have positive over all effect on the business cycles.

7.6 Conclusions

In this chapter we extend the determinants of the business cycles to trade intensity, specialisation and financial integration. A large theoretical and empirical literature is referred to in choosing the sets of instruments necessary to achieve identification. Simultaneity, implicit in most theories, is also revealing empirically. Thus we estimate a system of simultaneous equations to disentangle the complex interactions between these variables and the business cycle synchronisation.

The data was obtained from a group of 15 OECD countries over the sample period 1984 to 2003. Random effects three-stage least square estimation is adopted for both aggregate and individual countries analysis. The main results are as follows: the overall effect of the trade on the business cycle synchronisation is confirmed to be strong. Patterns of industry specialisation have a sizeable direct effect on the business cycle correlation, as two economies with a similar economic structure are more correlated with each other. Finally the business cycles in financial integrated economies are significantly more asymmetric. Also we find some significant indirect interactions. More bilateral trade results in more similar industry structure then leads to closer business cycles, however, closer financial integration results in countries becoming more specialised and then leads to more idiosyncratic business cycles. We also find that closer financial integration leads to more bilateral trade at the same time high trade results in high financial integration as well.

In individual countries analysis, most countries indicate the consistent results with aggregate results, particularly for European countries, however, a few of them, such as non-European countries, change the magnitude and significant of coefficients. After we extend the determinants of the business cycle correlation, all the countries with statistically significant trade intensity are still European countries which is consistent with the results in chapter 6. A couple of European countries (Austria, Finland, Sweden and the UK) present an insignificant relationship between trade intensity and the business cycle correlation. The reasons could be explained by the smaller sample period and sample countries. Also we have considered the indirect effects from financial integration and industrial specialisation on the business cycle correlation.

Chapter 8 Conclusions

8.1 Introduction

A currency union is a zone consisting of several countries or regions with a single currency circulates and a single monetary authority implements monetary policy defined at the union level. More than forty years later after the Mundell's pioneer work of Optimum Currency Areas theory, the European Monetary Union founded and the Euro was introduced in the eleven countries in 1999 comprising the European single-currency area. Euro banknotes and coins have been in circulation since 1 January 2002. Now, the Euro is the currency of thirteen European Union countries. Recently, twelve more central European countries joined the European Union and possibly join the EMU in future. In addition, North American countries have formed NAFTA in 1994; Latin America arranged MERCOSUR in 1991 and Andean Pact and Sub-Saharan African developed COMESA, SADC and SACU to promote inter-regional trade and economic integration. In Asia, the ASEAN was formed in 1967 by five states and extended to ten Southeast Asian countries now.

In deciding how large an OCA should be or whether to join an OCA potential members compare the benefits and costs of membership. A single currency eliminates the costs from currency conversion and exchange rate uncertainty thus facilitating cross-border trade and investment. However, in a currency union countries lose monetary independence thus limiting their ability to stabilise the business cycle. Therefore, the costs depend upon the degree of business cycle synchronisation between member countries. The gains from monetary autonomy are minimized if member countries are exposed to symmetric shocks or if asymmetric shocks can be absorbed for example, by having flexible labour markets. Following by Mundell (1961), McKinnon (1963) and Kenen (1969), literatures cite four criteria called the OCA criteria to evaluate the value of switching to a single currency: the degree of trade between countries who adopt a common currency; the extent to which different countries experience similar shocks; the degree of labour market mobility in each region and the amount of fiscal transfers between regions. The greater any of the four criteria, the more suitable a common currency. When most researchers judge the suitability of different regions, such as Europe, Asia, and North American, they exam whether these countries satisfy those four OCA criteria.

Frankel and Rose (1998) argue that the optimum currency criteria are endogenous; in particular the level of economic integration depends upon the trade intensity between two countries. Countries that enter a currency union are likely to experience dramatically different business cycles than before. The changes partly depend on the adoption of a common monetary policy, but it also could be a result of closer international trade with the other members of the union. From a theoretical viewpoint, closer international trade could result in either tighter or looser correlations of business cycles. Closer trade ties could result in countries becoming more specialised in the goods in which they have comparative advantage. The countries might then be more sensitive to industry-specific shocks, resulting in more idiosyncratic business cycles. However, if intra-industry trade accounts for most bilateral trade, then business cycle may become more similar across countries when countries trade more. Countries that are highly integrated with each other, with respect to international trade in goods and services, are more likely to constitute an optimum currency area. Therefore, this thesis focused on the first two OCA criteria and investigated whether more international trade results in highly business cycle correlation. We analysed whether this relationship only exists in EMU countries or EU countries or it can be applied to all countries in the world.

8.2 Research Methodology

Both bilateral trade intensity and economic integration are OCA criteria. Literatures argue that they are endogenous and the level of economic integration depends upon the trade intensity between two countries. Since the impact from trade on business cycle co-movements is ambiguous in theory, we investigate the relationship between trade intensity and the business cycle co-movement empirically to ascertain the suitability of an economy for membership of a currency union.

The study focuses on two main variables: bilateral trade intensity and business cycle correlations using 22 OECD countries plus China and Hong Kong over the period 1959 to 2003. From this we create observations for 276 country pairs and specify 5 time periods to measure average trade intensity and the business cycle correlation: 1959-1967, 1968-1976, 1977-1985, 1986-1994 and 1995-2003.

Bilateral trade intensity is measured using total bilateral trade divided by joint nominal GDP or divided by total trade. Differences between both measures will raise when at least one of the economies has a low level openness. Again, we find higher international trade in these 24 countries over time. The trade intensities amongst European countries are much higher than those amongst non-European countries. Distance is a very important factor for bilateral trade intensity. Countries which are in the same region or are very close always have more bilateral trade. For example, Scandinavian countries have higher trade intensity with Scandinavian countries than with those other European countries. The USA and Canada also present high trade intensity.

Business cycle correlations are measured using real GDP data expressed in US dollars, converted to natural logarithms and de-trended with a Hodrick-Prescott filter or first difference. It is apparent that the average GDP correlation for each country *vis-à-vis* the other 23 trading partners has increased over time, particularly for the European countries, a factor that could potentially be explained by higher trade intensity between two countries.

The investigation starts from a simple OLS regression which specifies a linear relationship between the dependent variable business cycle correlation and the single explanatory variable trade intensity and all other determinants are in error term. However, pooled OLS is not feasible for two reasons. Firstly, trade intensity could be endogenous. In theory, a couple of omitted variables in error term could impact both trade intensity and business cycle correlation, such as monetary policies or fixed exchange rate.

Countries are likely to peg their currencies deliberately to those of their most important trading partners, in order to capture gains associated with greater exchange rate stability. This implies that the two countries will operate monetary policy in a similar fashion, since pegging is a form of monetary policy coordination that may increase business-cycle correlation. In the OLS regression, it is not only the trade of goods and services that cause the business cycles to be correlated but rather the operation of economic policies and other influences. Therefore the assumption in OLS that $TI_{ij,t}$ is uncorrelated with the error term may not exist any more and using the OLS may give a bias result. OLS cannot identify the separate contribution from trade and the contribution from the common policies enacted because of close trading relationship. We therefore select six instrumental variables from the gravity model for trade to estimate the trade intensity. They are dummy variables of a fixed exchange rate agreement, membership of a free trade agreement, a common language and adjacency of two partners, and also the distance between the capital cities of the two countries and the product of GDP per capita. From a couple of tests, we find they have high quality and are good instruments for trade intensity. Then the estimated trade intensity explains the business cycle correlation in the second step.

Pooled OLS estimation also ignores potentially important unobservable country-pair specific effects. We therefore use a panel data model. Both fixed and random effects estimation that allows for endogenous regressors are used to estimate the relationship in aggregate sample. A Hausman test compares the two-stage FE and RE models here and finds that the FE model is more feasible. It is not immediately apparent whether this difference is due to the number of instruments selected or, as normally assumed, to the fact individual effects are correlated with trade intensity. Therefore, a Hausman statistics is re-computed to compare the fixed effects with the random effects estimates using only time-variant instruments.

8.3 Main Findings

The estimates using OLS, FE and RE assuming that trade intensity is weakly exogenous show a statistically significant and positive relationship between the business cycle correlation and trade intensity. The magnitude of 0.10 for slope estimates suggests that the business cycle correlation would rise by 0.069 following a doubling of trade intensity, from its mean value of 0.0063. From econometric tests, we find that country-pair specific effects are statistically significant thus justifying the use of panel methods, though they do not change the magnitudes of β in both FE and RE. The β estimates from RE with full instruments suggest a stronger relationship between the business cycle correlation and trade intensity than that reported in OLS, FE and RE. The business cycle correlation is expected to rise 0.18 if trade intensity were to double. The time-invariant instrumental variables are dropped in two-stage FE model, but the β even larger though it is derived using only three instruments. The improvement of magnitude of slopes from OLS or panel estimation to two-stage least squares or panel two-stage least squares estimation can be mainly explained by the instrumental variables. The trade intensity equation presents that all instrumental variables are important determinants of trade intensity and are correctly signed with reasonable magnitudes. We find that including either distance or product of GDP per capita as instruments increase the slope of estimated trade intensity much, and the literature present that both of these instruments are classic regressors in the gravity model.

Comparing with literature, the impact on business cycle synchronisation from trade intensity is larger in our study than that usually reported. Frankel and Rose (1998) report a slope estimate of 0.048 using the same measure of trade intensity and the business cycle correlation as this study, though the time period, and number of countries differs. Clark and van Wincoop (2001) report a slope estimate for trade intensity of 0.09 using data on 14 EU countries from 1963 to 1997. Imbs (2004) reports a β estimate of 0.079 for a panel of 24 developing and industrialised countries over the period 1960 to 2000. The increase in magnitude can be explained by the extended group of countries and sample period and also the panel data estimation technique, rather than a pooled instrumental variable estimation method. The selecting different instrumental variables in the first step also are the potential reason.

Furthermore, the sensitivity analyses confirm the robustness of the relationship between trade intensity and business cycle. Firstly, we employ alternative measures of business cycle correlation. Industrial production, total employment and unemployment rate are selected as different economic activities to measure the business cycle correlation. We take natural logarithms for industrial production and total employment but not for the unemployment rate and de-trend them so as to isolate cyclical components of economic time series conforming to a certain definition of business cycle by HP filter and fourth-differences. All of them still report the significant and positive relationship though the magnitude of slopes varied across economic activities.

Secondly, whether the relationship between trade intensity and the business cycle correlation varied across sub-periods is tested by estimating a cross section regression with country-pair data. The slope estimate is not statistically significant for the first time period but magnitude increases progressively over time up until the 1986-94 period when the maximum marginal effect occurs. This result also confirms our statistical analysis in chapter 3 that countries are now undertaking a greater amount of bi-lateral trade and are becoming more economically integrated in terms of business cycle comovements.

Finally, we include the time dummy in two-stage FE estimation; include potential omitted variables such as time trend, the dummy of the same trade partner; split the whole sample into two periods, and none of them change our results. Therefore, all these evidences present that the greater economic convergence is strongly influenced by rises in bilateral trade.

However, our detailed investigation indicates that it is not appropriate for all of the countries to form a monetary union. Variation in the sign and magnitude of the relationship could take place across countries or geographical regions, particularly given the importance of gravity variables in the determination of trade intensity. In individual countries analysis, we find that in all but 4 cases the relationship between trade intensity and business cycle is found to be positive however, it is only statistically significant for the 17 European countries in the sample plus China, where the t-ratio for the slope estimate just exceeds the 5% critical value. The average slope estimate for the European countries is 0.495, with a standard deviation of 0.34. Seven of the estimates are in the range 0.15 to 0.30. This result is perhaps not surprising given the geographical proximity of the European countries and a greater number of institutional agreements are in European countries which facilitate trade then converge economic.

There are a couple of potential reasons to explain why the significant relationship only exists in European countries (plus China). A significant proportion of total trade takes place between Asia-Pacific countries in our sample with Asian countries but not with European countries and NAFTA. Therefore we extend their partners to 28 including 5 extra Asian partners and find the higher magnitude of slope estimate for China and Hong Kong. Regional factors could be so important that trade with the European countries is not particularly important for the NAFTA and Asian-Pacific economies. We find a significant relationship in Europe and Asia-Pacific regions but not in the NAFTA members.

Another reason for the observed differences could be that the European countries have a greater number of institutional agreements that facilitate trade and therefore economic convergence indirectly. The third country effects also could be important in Europe. Their business cycles are highly correlated since they have more similar trade patterns compared to the non-European countries and therefore are more likely to be affected by demand shocks from common third country economies. We also find it does affect business cycle correlation empirically using our original data. Therefore, the case for the European countries forming a monetary union is stronger compared to the other economies in the sample. Furthermore, we find a stronger relationship between trade intensity and business cycle correlation in European countries only with their European trading partners.

In theory, bilateral trade could result in more or less similar industry structure depending on inter or intra-industry trade. Therefore, trade intensity could affect business cycle correlation through specialisation. In addition, both bilateral trades in goods or in assets could result in business cycle synchronisation. As an additional investigation, we extend the determinants of business cycle correlation to trade intensity, industry specialisation, and financial integration. Both trade intensity and business cycle correlations are measured the same as before. The industry specialisation is measured by industry sectoral real value added and financial integration is measured by the ratio of bilateral FDI position between a country-pair to total aggregate FDI position. The data are obtained from a group of 15 OECD countries over the period 1984 to 2003. Because of the FDI data limitation, the sample countries decrease to 15 and the sample period becomes shorter either. To consider the country-pair specific effects and to disentangle the complex interactions between trade intensity, specialisation financial integration, and business cycle correlation, random effects three-stage least squares estimation is used here.

After considering both the direct and indirect effects, the impact of trade intensity remains positive and statistically significant. Also the patterns of industry specialisation have a sizeable effect on business cycle correlation as two economies with a similar economic structure are more correlated with each other and business cycle in financial integrated economies are significantly more asymmetric. Also we find that higher trade intensity results in a more similar industry structure which then leads to closer business cycles. Closer financial integration results in countries becoming more specialised and then leads to more idiosyncratic business cycles.

8.4 Policy Implications and Further Researches

As we discussed in previous chapters, a currency union is not the same as an optimal currency area. Any two countries in the world could form a currency union, for example, UK and Japan; however, they may be not an OCA. The OCA is the criteria of forming a currency union. In deciding whether to join a currency union, policy makers need to compare the benefits and costs of membership. The elimination of costs from currency conversion and exchange rate uncertainty will facilitate cross-border trade and investment. However, in a currency union countries lose monetary independence thus limiting their ability to stabilise the business cycle. Based on OCA theory, four OCA criteria are used to decide whether a country should join a currency union. The greater any of the four criteria between the countries, the more suitable a common currency.

However, after join a currency union, the bilateral trade between country-pairs could increase much and the economies are likely to change dramatically. Frankel and Rose suggest that OCA criteria are endogenous, in particular the level of economic integration depends upon the trade intensity between two countries. Therefore policy makers cannot decide to join a currency union by criteria directly and the investigation of the relationship between the business cycle correlation and trade intensity is important.

We find a strong statistically significant and positive relationship between trade intensity and business cycle correlation in 24 countries across 1959 to 2003 and prove this relationship is robust by sensitivity analyses. Our detailed investigation shows that the business cycle correlation depends only upon trade intensity for the 17 European countries in the sample plus China, where the estimated coefficient is marginally statistically significant. Therefore trade amongst the European countries has had most beneficial effect on business cycle co-movements. At the same time, we also find high bilateral trade and synchronised business cycle amongst European countries in chapter 3. Therefore, the case for the European countries forming a monetary union is stronger compared to the other economies in the sample. This result is perhaps not surprising given the geographical proximity of the European countries. This finding is consistent with the OCA theory that countries with higher bilateral trade and closer business cycle correlations with other members are more suitable to join the Monetary Union.

Outside continental Europe our results raise doubts about the suitability of other currency unions being formed, for example based around the US dollar for the NAFTA economies or a Japanese Yen zone for the Asia-Pacific countries. However, it is hard to draw a conclusion for NAFTA or Asian countries based on above evidences since there are a couple of limitations for them. This is also one of this study’s limitations. Our 24 sample countries mainly focus on OECD countries and 16 of them are European countries. We include China, Hong Kong and Mexico because they are important bilateral trade partners for these European countries and the USA. Thus this aggregate countries and individual countries results are suitable for OECD countries, particularly for European countries, but they are not as good as for NAFTA and Asian countries, even we have included all three NAFTA members.

We could focus on the sample of Asian countries, such as ASEAN+3[83], East Asia countries[84] or Asia-Pacific countries because they have relative high bilateral trade and close culture background given the geographical proximity. A couple of papers have investigated the Asian countries. For example, Crosby (2003) studies 13 Asia-Pacific countries, and Kumakura (2006) investigates the 12 Asian countries and both of them implement the pooled estimation. Shin and Wang (2005) select 12 Asian countries and focus on the case of Korea with other Asian countries to analyse the relationship between trade integration and business cycle co-movements. They adopt fixed effects estimation, but do not allow for the possibility that trade intensity is endogenous. Hence we could apply the methodology to these groups of countries considering both unobservable country-pair specific effects and endogeneity of trade intensity. Also we could include a large amount of countries in our sample to investigate the general aggregate relationship between the bilateral trade intensity and the business cycle correlation, and not only focus on the OECD countries. Another further investigation could be done. We could focus on one economy but include most of its important trade partners.

As we discussed in chapter 2, in theory, more bilateral trade could result in closer business cycle correlation, and countries with a greater extent of trade or more similar shocks and cycles are more suitable for a common currency. However, the structure of these economies is likely to change dramatically as a result of monetary union. EMU is a very good example. Since the Euro was introduced in the eleven countries in 1999 and Euro banknotes and coins have been in circulation since 1 January 2002. We could

[83] Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam, plus three: China (include Hong Kong and Tai Wan but can be considered as two regions), Japan, and South Korea.
[84] China (include Hong Kong and Tai Wan), Japan, North Korea and South Korea.

compare the extent of trade and the similarity of the shocks and cycles before 2002 and after 2002 for EMU members and exam whether they receive more benefits after joining EMU. For example we could compare whether the relationship between bilateral trade intensity and the business cycle correlation change in 1996-2001 and in 2002-2007. Nevertheless, we have not enough data so far, since the business cycle co-movements need relative long period data. The maximum data at the moment are eight years.

It is also worthwhile to investigate the new EU members. In 2004, ten more central European countries joined EU and in 2007 Romania and Bulgaria joined EU as well. They should face the same question as EMU countries as they abolish national currencies and adopt the Euro. We could apply this model to these countries as well as other EU members to estimate the relationship between trade intensity and business cycle correlations aggregately or individually.

After extending to three determinants of the correlation of business cycle, the sample countries and period become even smaller which only focus on 15 OECD countries over 20 years. Then the temporal dimension is only 20 years and cross-section dimension is only 105. Usually, consistent estimators require large T and/or N. For this reason, the individual country estimations could be biased, since regressions have to estimate a lot of parameters with very few observations. However, it is difficult to find out the optimal single empirical analogue to the theoretical concept for financial integration. We could try to use other alternative series to measure the financial integration, such as interest rate across large sample countries for a long period.

Appendix I Top 20 Trade Partners (Billions US $)

	Australia		Austria		Belgium	
1	Japan	410	Germany	850	Germany	670
2	United States	330	Italy	190	France	540
3	United Kingdom	110	Switzerland	110	Netherlands	490
4	New Zealand	110	France	95	United Kingdom	270
5	China	110	United States	86	Italy	150
6	Korea	100	Hungary	73	United States	150
7	Germany	86	United Kingdom	73	Switzerland	62
8	Singapore	76	Netherlands	66	Spain	60
9	Indonesia	52	Japan	46	Sweden	56
10	Italy	51	Czech Republic	37	Japan	54
11	China, Hong Kong	50	Spain	37	Israel	33
12	Malaysia	48	Sweden	32	India	30
13	France	41	Bel-Lux	27	Austria	27
14	Canada	35	Poland	27	Denmark	24
15	Thailand	34	China	20	Saudi Arabia	22
16	Saudi Arabia	26	Slovenia	20	Finland	21
17	Papua New Guinea	26	Russia	19	Norway	21
18	Netherlands	25	Slovak Republic	18	Ireland	18
19	India	24	Denmark	16	Portugal	17
20	Sweden	21	Belgium	16	Canada	15

Appendix I Continued

	Canada		China (Mainland)		China (HongKong)	
1	United States	5300	Japan	990	China	1900
2	Japan	320	China, HongKong	880	United States	810
3	United Kingdom	160	United States	810	Japan	540
4	China	120	Korea	310	Singapore	200
5	Germany	120	Germany	250	Germany	180
6	Mexico	100	Singapore	130	Korea	180
7	France	78	United Kingdom	100	United Kingdom	160
8	Korea	74	Russia	94	France	77
9	Italy	63	Australia	93	Malaysia	76
10	Norway	41	Italy	89	Italy	73
11	Netherlands	40	France	87	Thailand	67
12	China, Hong Kong	35	Malaysia	86	Netherlands	65
13	Brazil	33	Netherlands	86	Australia	63
14	Australia	32	Canada	81	Canada	58
15	Venezuela,Rep.Bol.	26	Indonesia	66	Switzerland	53
16	Switzerland	26	Thailand	66	Philippines	49
17	Sweden	24	Brazil	41	India	41
18	Malaysia	23	Philippines	35	Indonesia	38
19	Bel-Lux	20	Saudi Arabia	33	China,P.R.:Macao	28
20	Thailand	19	Spain	32	Spain	25

Appendix I Continued

	Denmark		Finland		France	
1	Germany	330	Germany	170	Germany	1700
2	Sweden	190	Sweden	140	Italy	1000
3	United Kingdom	140	United Kingdom	110	United Kingdom	860
4	Norway	88	United States	80	United States	750
5	Netherlands	87	Russia	56	Spain	660
6	United States	86	France	55	Netherlands	530
7	France	85	Netherlands	50	Bel-Lux	490
8	Italy	64	Italy	42	Switzerland	320
9	Japan	50	Denmark	41	Belgium	270
10	Finland	44	Japan	40	Japan	240
11	Switzerland	26	Norway	39	Sweden	140
12	Spain	26	Spain	22	China	130
13	Bel-Lux	24	China	20	Portugal	130
14	Poland	22	Estonia	19	Algeria	110
15	China	20	Switzerland	18	Saudi Arabia	110
16	Austria	16	Bel-Lux	16	Norway	96
17	Ireland	14	Poland	14	Ireland	93
18	Belgium	13	Austria	14	Austria	92
19	Greenland	12	Belgium	10	Morocco	85
20	Russia	11	Australia	10	Denmark	84

Appendix I Continued

	Germany		Greece		Ireland	
1	France	1900	Germany	110	United Kingdom	450
2	Netherlands	1400	Italy	91	United States	210
3	United States	1400	France	47	Germany	150
4	Italy	1300	United Kingdom	38	France	94
5	United Kingdom	1300	Netherlands	35	Netherlands	72
6	Austria	810	United States	29	Japan	54
7	Switzerland	780	Japan	23	Italy	46
8	Bel-Lux	660	Spain	18	Belgium	40
9	Japan	600	Saudi Arabia	16	Spain	28
10	Spain	560	Russia	15	Switzerland	25
11	Sweden	380	Bel-Lux	11	Sweden	21
12	China	320	Korea	11	Bel-Lux	20
13	Denmark	310	Bulgaria	11	Singapore	19
14	Poland	290	Iran, I.R. of	10	Norway	15
15	Belgium	280	Switzerland	10	Denmark	14
16	Czech Republic	230	Turkey	10	Canada	12
17	Norway	230	Sweden	9	Malaysia	12
18	Hungary	210	Libya	9	Korea	11
19	Russia	210	China	8	China	9
20	Turkey	190	Cyprus	7	Finland	9

Appendix I Continued

	Italy		Japan		Mexico	
1	Germany	1400	United States	3400	United States	2600
2	France	1000	China	1000	Japan	110
3	United States	540	Korea	700	Germany	85
4	United Kingdom	480	Germany	550	Canada	70
5	Spain	340	China, Hong Kong	440	Spain	50
6	Netherlands	340	Australia	420	China	37
7	Switzerland	310	Indonesia	410	France	36
8	Austria	180	Singapore	370	Brazil	34
9	Bel-Lux	170	Malaysia	360	Korea	33
10	Japan	160	United Kingdom	350	United Kingdom	28
11	Libya	120	Saudi Arabia	350	Italy	27
12	China	110	Thailand	350	Switzerland	15
13	Greece	100	Canada	300	Malaysia	14
14	Russia	96	United Arab Emirates	260	Chile	14
15	Sweden	94	France	220	Argentina	11
16	Saudi Arabia	92	Netherlands	190	Singapore	11
17	Belgium	88	Philippines	190	Netherlands	11
18	Turkey	83	Italy	160	Venezuela, Rep. Bol.	11
19	Algeria	81	Switzerland	120	Sweden	9
20	Brazil	73	Mexico	100	Colombia	9

Appendix I Continued

	Netherlands		New Zealand		Norway	
1	Germany	1500	Australia	96	United Kingdom	240
2	United Kingdom	590	United States	70	Germany	190
3	France	550	Japan	68	Sweden	180
4	Bel-Lux	450	United Kingdom	30	Netherlands	99
5	United States	410	Germany	17	United States	97
6	Italy	290	China	16	France	91
7	Belgium	250	Korea	13	Denmark	80
8	Spain	150	Italy	9	Japan	41
9	Japan	150	Malaysia	8	Italy	41
10	Sweden	130	Canada	8	Finland	40
11	Switzerland	94	Singapore	8	Canada	38
12	China	83	France	7	Spain	20
13	Denmark	82	China, Hong Kong	7	Bel-Lux	19
14	Norway	76	Saudi Arabia	7	Belgium	16
15	Austria	68	Indonesia	6	China	16
16	Ireland	63	Thailand	5	Ireland	14
17	Saudi Arabia	57	Netherlands	5	Switzerland	13
18	Finland	56	Sweden	4	Portugal	11
19	Russia	48	Philippines	3	Korea	11
20	Brazil	45	Fiji	3	Russia	9

Appendix I Continued

	Portugal		Spain		Sweden	
1	Spain	180	France	640	Germany	380
2	Germany	150	Germany	520	United Kingdom	240
3	France	110	Italy	330	United States	210
4	United Kingdom	81	United Kingdom	280	Norway	200
5	Italy	60	United States	210	Finland	150
6	Netherlands	46	Portugal	180	Netherlands	140
7	United States	42	Netherlands	150	France	130
8	Japan	17	Japan	83	Denmark	93
9	Sweden	17	Belgium	59	Italy	91
10	Bel-Lux	17	Bel-Lux	58	Japan	75
11	Switzerland	14	China	52	Bel-Lux	54
12	Belgium	12	Switzerland	51	Spain	48
13	Norway	11	Mexico	50	Switzerland	44
14	Brazil	11	Sweden	46	Belgium	33
15	Denmark	10	Algeria	41	China	32
16	Nigeria	9	Saudi Arabia	39	Austria	30
17	Angola	9	Brazil	34	Poland	28
18	Saudi Arabia	8	Austria	33	Canada	22
19	Austria	8	Libya	30	Ireland	21
20	Finland	7	Morocco	30	China, Hong Kong	20

Appendix I Continued

	Switzerland		United Kingdom		United States	
1	Germany	760	Germany	1200	Canada	5200
2	France	290	United States	1200	Japan	3300
3	Italy	260	France	860	Mexico	2400
4	United States	240	Netherlands	680	Germany	1300
5	United Kingdom	170	Italy	450	China	1200
6	Austria	110	Ireland	440	United Kingdom	1200
7	Netherlands	110	Japan	350	Korea	840
8	Japan	100	Spain	290	France	690
9	Spain	55	Bel-Lux	250	Italy	530
10	Bel-Lux	50	Sweden	240	Singapore	510
11	China, Hong Kong	48	Switzerland	230	Netherlands	460
12	Sweden	43	Norway	210	China, Hong Kong	420
13	China	28	China, Hong Kong	180	Brazil	410
14	Denmark	28	Canada	160	Malaysia	400
15	Ireland	27	Belgium	160	Saudi Arabia	360
16	Belgium	21	Denmark	130	Venezuela, Rep.	330
17	Saudi Arabia	20	Finland	110	Australia	300
18	Russia	20	Australia	100	Switzerland	280
19	Israel	20	China	100	Thailand	270
20	Singapore	19	Saudi Arabia	100	Philippines	240

Appendix II The 2-digit ISIC manufacturing level codes

ISIC code	Category
31	Food, Beverages and tobacco
32	Textile, wearing apparel, and leather industies
33	Wood and wood produces, including furniture
34	Paper and paper products, printing and publishing
35	Chemicals and chemical petroleum, coal, rubber and plastic products
36	Non-metallic mineral products, except products of petroleum and coal
37	Basic metal industries
38	Fabricated metal products, machinery, and equipment
39	Other manufactured products

Appendix III Durbin-Wu-Hausman Test and Wu-Hausman Test

Denote by $\hat{\beta}^c$ the estimator that is consistent under both the null and the alternative hypotheses, and by $\hat{\beta}^e$ the estimator that is fully efficient under the null but inconsistent if the null is not true. The Hausman (1978) specification test takes the quadratic form:

$$H = n(\hat{\beta}^c - \hat{\beta}^e)' D^- (\hat{\beta}^c - \hat{\beta}^e) \text{ where } D = \left(V(\hat{\beta}^c) - V(\hat{\beta}^e) \right) \quad \text{(A-1)}$$

and where $V(\hat{\beta})$ denotes a consistent estimate of the asymptotic variance of β, and the operator $^-$ denotes a generalized inverse.

A Hausman statistic for a test of endogeneity in an IV regression is formed by choosing OLS as the efficient estimator $\hat{\beta}^e$ and IV as the inefficient but consistent estimator $\hat{\beta}^c$. The test statistic is distributed as χ^2 with K_1 degrees of freedom, this being the number of regressors being tested for endogeneity. The test is perhaps best interpreted not as a test for the endogeneity or exogeneity of regressors per se, but rather as a test of the consequence of employing different estimation methods on the same equation. Under the null hypothesis that OLS is an appropriate estimation technique, only efficiency should be lost by turning to IV; the point estimates should be qualitatively unaffected.

The Hausman statistic comes in several flavors, depending on which estimates of the asymptotic variances are used. An obvious possibility would be to use $V(\hat{\beta}_{IV})$ and $V(\hat{\beta}_{OLS})$ as generated by standard IV and OLS estimation. This is actually rarely done because, although asymptotically valid, it has the drawback of possibly generating a negative Hausman statistic in finite samples. Avoiding this problem is straightforward. The standard asymptotic covariances for IV and OLS are

$$V(\hat{\beta}_{IV}) = \hat{\sigma}_{IV}^2 (X' PzX)^{-1} \qquad V(\hat{\beta}_{IV}) = \hat{\sigma}_{OLS}^2 (X'X)^{-1} \quad \text{(A-2)}$$

Where we define the full set of instruments as *Z* and let *Pz* represent the "projection matrix" *Z*inv(Z'Z)*Z'*. Under the null, both the IV and the OLS estimates of the error variance are consistent estimators of σ, and either can be used to form the Hausman statistic. If a common estimate of σ is used, then the generalized inverse of *D* is guaranteed to exist and a positive test statistic is guaranteed. If the Hausman statistic is formed using the OLS estimate of the error variance, then the *D* matrix in Equation (19) becomes

$$D = \hat{\sigma}^2_{OLS}\left(\left(X'PzX\right)^{-1} - \left(X'X\right)^{-1}\right) \quad \text{(A-3)}$$

This version of the endogeneity test was first proposed by Durbin (1954) and separately by Wu (1973) (his T4 statistic) and Hausman (1978). If the Hausman statistic is formed using the IV estimate of the error variance, then the *D* matrix becomes

$$D = \hat{\sigma}^2_{IV}\left(\left(X'PzX\right)^{-1} - \left(X'X\right)^{-1}\right) \quad \text{(A-4)}$$

This version of the statistic was proposed by separately by Wu (1973) (his T3 statistic) and Hausman (1978).

Another asymptotically equivalent flavor of the DWH test is available for standard IV estimation under conditional homoskedasticity. This is the test statistic introduced by Wu (1973) (his T2) (Wu-Hausman statistic), and separately shown by Hausman (1978) to be calculated straightforwardly through the use of auxiliary regressions. Consider a simplified version of our basic model with a single endogenous regressor x_1:

$$y = \beta_1 x_1 + X_2\beta_2 + u \quad \text{(A-5)}$$

with $X_2 \equiv Z_2$ assumed exogenous (including the constant, if one is specified) and with excluded instruments Z_1 as usual. The auxiliary regression approach involves estimating the reduced form (first-stage) regression for x_1:

$$x_1 = Z_1\Gamma_1 + X_2\Gamma_2 + v = Z\Gamma + v \quad \text{(A-6)}$$

We are concerned with testing that $x_1 \perp u$. Since by assumption each *z* in *Z* is uncorrelated with *u*, the first stage regression implies that this condition is equivalent to a test of $v \perp u$. Exogeneity of the *z*'s implies that $\hat{u}$ the residuals from OLS estimation of the first-stage regression will be a consistent estimator of *u*. Thus, we augment

Equation 23 with $\hat{u}$ and reestimate it with OLS. A t-test of the significance of $\hat{u}$ in this auxiliary regression is then a direct test of the null hypothesis in this context, that θ=0:

$$y = \beta_1 x_1 + X_2 \beta_2 + \theta \hat{u} + \varepsilon \qquad \text{(A-7)}$$

The Wu-Hausman test may be readily generalized to multiple endogenous variables, since it merely requires the estimation of the first-stage regression for each of the endogenous variables, and augmentation of the original model with their residual series. The test statistic then becomes an F-test, with numerator degrees of freedom equal to the number of included endogenous variables. One advantage of the Wu-Hausman F-statistic over the other DWH tests for IV vs. OLS is that with certain normality assumptions, it is a finite sample test exactly distributed as *F* (see Wu (1973) and Nakamura and Nakamura (1981)). Wu (1974)'s Monte Carlo studies also suggest that this statistic is to be preferred to the statistic using just σ_{IV}^2.

An inconvenient complication here is that an ordinary F-test for the significance of θ will not be valid, because the unrestricted sum of squares needed for the denominator is wrong, and obtaining the correct SSR requires further steps (see Davidson and MacKinnon (1993), chapter 7). Only in the special case where the efficient estimator is OLS will an ordinary F-test yield the correct test statistic. The auxiliary regression approach to obtaining the Wu-Hausman statistic described above has the further disadvantage of being computationally expensive and practically cumbersome when there are more than a few endogenous variables to be tested, because a residual series must be constructed separately for every endogenous variable being tested. We have taken a different and simpler approach to programming the Wu-Hausman statistic. The Durbin flavor of the Durbin-Wu-Hausman statistic equation 21 can be written as

$$\text{Durbin DWH: } \chi^2(K_{1B}) = \frac{Q^*}{USSR/n} \qquad \text{(A-8)}$$

and the Wu-Hausman F-statistic can be written

$$\text{Wu-Hausman: } F(K_{1B}, n-K-K_{1B}) = \frac{Q^* / K_{1B}}{(USSR - Q^*)/(n-K-K_{1B})} \qquad \text{(A-9)}$$

where Q* is the difference between the restricted and unrestricted sums of squares by the equation 25, and USSR is the sum of squared residuals from the efficient estimate of the model. We can see from Equations (26) and (27) that the Wu-Hausman F-statistic can be easily calculated from the same quantities needed for the DWH statistic. This means that the Wu-Hausman F-statistic in Equation (27) does not need to be calculated using the traditional auxiliary regression method, with all the first-stage regressions and generation of residual series as described above. Instead, it can be calculated using only three additional regressions: one to estimate the restricted/efficient model, and two artificial regressions to obtain the two Sargan (1958) statistics. More precisely, we can write

$$\text{Durbin DWH: } \chi^2(K_{1B}) = \frac{\hat{u}_e' P_{Z,X_{1B}} \hat{u}_e - \hat{u}_c' P_Z \hat{u}_c}{\hat{u}_e' \hat{u}_e / n} \qquad \text{(A-10)}$$

$$\text{W-H: } F(K_{1B}, n-K-K_{1B}) = \frac{(\hat{u}_e' P_{Z,X_{1B}} \hat{u}_e - \hat{u}_c' P_Z \hat{u}_c)/K_{1B}}{\left(\hat{u}_e' \hat{u}_e - \left(\hat{u}_e' P_{Z,X_{1B}} \hat{u}_e - \hat{u}_c' P_Z \hat{u}_c\right)\right)/(n-K-K_{1B})} \qquad \text{(A-11)}$$

where $\hat{u}_e$ and $\hat{u}_c$ refer to the residuals from the restricted/efficient and unrestricted/ consistent estimations respectively, and $P_{Z,X1B}$ is the projection matrix of the instruments Z augmented by the regressors X_{1B} whose endogeneity is being tested.

Appendix IV Panel Unit Root Tests

Levin, Lin and Chu (2002) (*LLC* thereafter) argued that individual unit root tests have limited power against alternative hypotheses with highly persistent deviations from equilibrium. Therefore they suggest a more powerful panel unit root test than performing individual unit roots tests for each cross-section. The null hypothesis is that each individual time series contains a unit root against the alternative that each time series is stationary. The maintained hypothesis is that:

$$\Delta y_{it} = \rho y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{it-L} + \alpha_{mi} d_{mt} + \varepsilon_{it} \qquad m = 1,2,3 \tag{A-12}$$

With d_{mt} indicating the vector of deterministic variables and α_{mi} the corresponding vector of coefficients for model $m=1,2,3$. Since the lag order p_i is unknown, *LLC* suggest a three-step procedure to implement their test. Firstly, they perform separate augmented Dickey-Fuller (ADF) regressions for each cross-section:

$$\Delta y_{it} = \rho_i y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{it-L} + \alpha_{mi} d_{mt} + \varepsilon_{it} \qquad m = 1,2,3 \tag{A-13}$$

The lag order p_i is permitted to vary across individuals. For given T, choose a maximum lag order p_{max} and then use the t-statistic of $\hat{\theta}_{iL}$ to determine if a smaller lag order is preferred. When p_i is determined, two auxiliary regressions are run to get orthogonalized residuals:

Run Δy_{it} on $\Delta y_{it-L} (L = 1,..., p_i)$ and d_{mt} to get residuals $\hat{e}_{it}$

Run Δy_{it-1} on $\Delta y_{it-L} (L = 1,..., p_i)$ and d_{mt} to get residuals $\hat{v}_{it-1}$

Standardize these residuals to control for different variances across i, $\tilde{e}_{it} = \hat{e}_{it} / \hat{\sigma}_{\varepsilon i}$ and $\tilde{v}_{it-1} = \hat{v}_{it} / \hat{\sigma}_{\varepsilon i}$. The $\hat{\sigma}_{\varepsilon i}$ is the standard error from each ADF regression for $i=1,\ldots,N$. Then estimate the ratio of long-run and short-run standard deviations. Under the null hypothesis of a unit root, the long-run variance of (A-12) can be estimated by

$$\hat{\sigma}_{yi}^2 = \frac{1}{T-1}\sum_{t=2}^{T}\Delta y_{it}^2 + 2\sum_{L=1}^{\bar{K}} w_{\bar{K}L}\left[\frac{1}{T-1}\sum_{t=2+L}^{T}\Delta y_{it}\Delta y_{it-L}\right] \quad \text{(A-14)}$$

Where $w_{\bar{K}L} = 1-(L/(\bar{K}+1))$ and $\bar{K}$ is a truncation lag that can be data-dependent. $\bar{K}$ must be obtained in a manner that ensures the consistency of $\hat{\sigma}_{yi}^2$. For each cross-section i, the ratio of the long-run standard deviation to the innovation standard deviation is estimated by $\hat{s}_i = \hat{\sigma}_{yi} / \hat{\sigma}_{\varepsilon i}$ and the average standard deviation is that divided by *N*. At last they compute the panel test statistics. Run the pooled regression:

$$\tilde{e}_{it} = \rho \hat{v}_{i,t-1} + \tilde{\varepsilon}_{it} \quad \text{(A-15)}$$

Based on $N\tilde{T}$ observations where $\tilde{T} = T - \bar{p} - 1$. $\tilde{T}$ is the average number of observations per individual in panel with $\bar{p} = \sum_{i=1}^{N} p_i / N$. $\bar{p}$ is the average lag order of individual ADF regressions. The conventional t-statistic for $H_0 : \rho = 0$ is $t_\rho = \frac{\hat{\rho}}{\hat{\sigma}(\hat{\rho})}$,

$$\hat{\rho} = \frac{\sum_{i=1}^{N}\sum_{t=2+p_i}^{T}\tilde{v}_{i,t-1}\tilde{e}_{it}}{\sum_{i=1}^{N}\sum_{t=2+p_i}^{T}\tilde{v}_{i,t-1}^2}, \quad \hat{\sigma}(\hat{\rho}) = \frac{\hat{\sigma}_{\tilde{\varepsilon}}}{\left[\sum_{i=1}^{N}\sum_{t=2+p_i}^{T}\tilde{v}_{i,t-1}^2\right]^{1/2}} \quad and \quad \hat{\sigma}_{\tilde{\varepsilon}} = \frac{1}{N\tilde{T}}\sum_{i=1}^{N}\sum_{t=2+p_i}^{T}(\tilde{e}_{it} - \hat{\rho}\tilde{v}_{i,t-1})^2$$

Compute the adjusted t-statistic:

$$t_\rho^* = \frac{t_\rho - N\tilde{T}\hat{S}_N \hat{\sigma}_{\tilde{\varepsilon}}^{-2}\hat{\sigma}(\hat{\rho})\mu_{m\tilde{T}}^*}{\sigma_{m\tilde{T}}^*}$$

Where $\mu_{m\tilde{T}}^*$ and $\sigma_{m\tilde{T}}^*$ are the mean and standard deviation adjustment provided by *LLC*. They show that t_ρ^* is asymptotically distributed as N (0,1). The Monte Carlo simulations performed by *LLC* indicate that the normal distribution provides a good approximation to the empirical distribution of the test statistic, even in relatively small sample. Also that the panel unit root test provides dramatic improvements in power over separate unit root tests for each cross-section. The limitations of *LLC* is the test crucially depends upon the independence assumption across cross-sections and is not applicable if cross-sectional correlation is present. And the assumption that all cross-sections have or do not have a unit root is restrictive. To panel sample size, *LLC* suggest using their panel unit root test for panels of moderate size with *N* between 10 and 250 and *T* between 25 and 250. However, for very large T they argue that individual unit root time series tests will be sufficiently powerful to apply for each cross-section. Also for very large N and very small T, they recommend the usual panel data procedure. Our data contain 276 country pairs which are close to their range but the period is quite small which is only 5.

The LLC test is restrictive in the sense that it requires ρ to be homogeneous across *i*. Im, Pesaran and Shin (*IPS*, 2003) allow for a heterogeneous coefficient of $y_{i,t-1}$ and propose an alternative testing procedure based on averaging individual unit root test statistics. IPS suggest an average of the ADF tests when u_{it} is serially correlated with different serial correlation properties across cross-sectional units. The null hypothesis is that each series in the panel contains a unit root, i.e., $H_0 : \rho_i = 0$ for all *i* and the alternative hypothesis allows for some (but not all) of the individual series to have unit roots:

$$H_1 : \begin{cases} \rho_i < 0 \ \ for \quad i = 1,2,...,N_1 \\ \rho_i = 0 \ \ for\ i = N_1 + 1,...,N \end{cases}$$

It requires the fraction of the individual time series that are stationary to be nonzero. This condition is necessary for the consistency of the panel unit root test. The IPS t-bar statistic is defended as the average of the individual ADF statistic as:

$$\bar{t} = \frac{1}{N}\sum_{i=1}^{N} t_{\rho_i}$$

Where t_{ρ_i} is the individual t-statistic for testing $H_0 : \rho_i = 0$ for all *i*. In case the lag order is always zero, *IPS* provide simulated critical values for $\bar{t}$ for different number of cross-sections N, series length T and DF regressions containing intercepts only or intercepts and linear trends. In the general case where the lag order may be nonzero for some cross-sections, *IPS* show that a properly standardized $\bar{t}$ has an asymptotic N(0,1) distribution. For a fixed N,

$$t_{\rho_i} \Rightarrow \frac{\int_0^1 W_{iZ} dW_{iZ}}{\left[\int_0^1 W_{iZ}^2\right]^{1/2}} = t_{iT}$$

IPS assume that t_{iT} are IID and have finite mean and variance. Then

$$t_{IPS} = \frac{\sqrt{N}(\bar{t} - 1/N\sum_{i=1}^{N} E[t_{iT} | \rho_i = 0])}{\sqrt{1/N\sum_{i=1}^{N}\text{var}[t_{iT} | \rho_i = 0]}} \Rightarrow N(0,1)$$

The values of $E[t_{iT} | \rho_i = 0]$ and $\text{var}[t_{iT} | \rho_i = 0]$ have been computed by *IPS* via simulations for different values of *T* and p_i's. In Monte Carlo experiments, they show that if a large enough lag order is selected for underlying ADF regressions, then the small sample performance of the t-bar test is reasonably satisfactory and generally better than the *LLC* test.

Maddala and Wu (1999) and Choi (2001) proposed a Fisher-type test:

$$P = -2\sum_{i=1}^{N} \ln p_i$$

Which combines the p-values from unit root tests for each cross-section *i* to test for unit root in panel data. Note that $2\ln p_i$ has a χ^2 distribution with 2 degrees of freedom. This means that P is distributed as χ^2 with 2N degrees of freedom as $T_i \to \infty$. Maddala and Wu (1999) argued that the *IPS* and Fisher tests relax the restrictive assumption of the *LLC* test that ρ_i is the same under the alternative. Both the *IPS* and Fisher tests combine information based on individual unit root tests. However, the Fisher test has the advantage over the *IPS* test in that it does not require a balanced panel. Also, the Fisher test can use different lag lengths in the individual ADF regressions and can be applied to any other unit root tests. The disadvantage is that the p-values have to be derived by Monte Carlo simulations. Maddala and Wu (1999) find that the Fisher test with bootstrap-based critical values performs the best and is the preferred choice for testing nonstationary as the null and also in testing for cointegration in panels.

Bibliography

Adam, K. (2002). ‘Analyse, Compare, and Apply Alternative Indicators and Monitoring Methodologies to Measure the Evolution of Capital Market Integration in the European Union’, *EU-Report.*

Anderson J.E. (1979). ‘A Theoretical Foundation for the Gravity Equation’, *The American Economic Review*, vol. 69(1), pp.106-16.

Anderson J.E., and van Wincoop, E. (2003). ‘Gravity with Gravitas: A Solution to the Border Puzzle’, *The American Economic Review*, vol. 93(1), pp.170-92.

Anderson, H.M., Kwark, N.S., and Vahid, F. (1999). ‘Does International Trade Synchronize Business Cycles?’, *Monash Econometrics and Business Statistics Working Papers*, No. 8/99.

Artis, M.J., Kontolemis, Z.G., and Osborn, D.R. (1997). ‘Business Cycles for G7 and European Countries’, *Journal of Business*, vol. 70(2), pp. 249-79.

Artis, M.J. and Zhang, W. (1997). ‘International Business Cycles and the ERM: Is There a European Business Cycle?’, *International Journal of Finance and Economics*, vol. 2(1), pp. 1-16.

Babetskii, I. (2005). ‘Trade Integration and Synchronization of Shocks’, *Economics of Transition*, vol. 13(1), pp. 105-38.

Backus, D.K. Kehoe, P.J., and Kydland, F.E. (1994). ‘Dynamics of the Trade Balance and the Terms of Trade: The J-Curve’, *The American Economic Review*, vol. 84(1), pp. 84-103.

Backus, D.K., Kehoe, P.J., and Kydland, F.E. (1995). ‘International Business Cycles: Theory and Evidence’, in Thomas F. Cooley ed., Frontiers of Business Cycle Research. Princeton, NJ: Princeton University Press, pp. 331-57.

Baltagi, B.H., (2005), *Econometric Analysis of Panel Data*, 3rd Edition, Chichester: John Wiley & Sons.

Baxter, M. 1994. "Real Exchange Rates and Real Interest Differentials: Have we Missed the Business-Cycle Relationship?" *Journal of Monetary Economics*, vol. 33, pp. 5-37.

Baxter, M. and Crucini M.J. (1995). 'Business Cycles and the Asset Structure of Foreign Trade', *International Economic Review*, vol. 36(4), pp. 821-54.

Baxter, M., and King, R.G. (1999). 'Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series', *Review of Economics and Statistics*, vol. 81(4), pp. 575-93.

Baxter, M., and Kouparitsas, M.A. (2005). 'Determinants of Business Cycle Comovement: A Robust Analysis', *Journal of Monetary Economics* vol. 52(1), pp. 113-57.

Bayoumi, T., and Eichengreen, B., (1994). 'One Money or Many? Analyzing the Prospects for Monetary Unification in Various Parts of the World', *Princeton Studies in International Finance No. 76*, Princeton.

Bayoumi, T., and Eichengreen, B. (1996). 'Optimum Currency Areas and Exchange Rate Volatility: Theory and Evidence Compared', *International Trade and Finance New Frontiers for Research: Essays in Honor of Peter Kenen* (Edited by Benjamin J. Cohen), Cambridge: Cambridge University Press.

Bergman, M. (2004). 'How Similar Are European Business Cycles?', *EPRU Working Paper Series*, No 04-13.

Beveridge, S. and Nelson, C. (1981). 'A New Approach to Decomposition of Economic Time Series into Permanent and Transitory Components with Particular Attention to Measurement of the Business Cycle', *Journal of Monetary Economics*, vol. 7, pp. 151–174.

Blanchard, O.J. and Quah, D. (1989). ‘The Dynamic Effects of Aggregate Demand and Supply Disturbances’, *The American Economic Review*, vol. 79(4), pp. 655-73.

Bordo, M.D. and Helbling T. (2003). ‘Have National Business Cycles Become More Synchronized?’, *NBER Working Paper No. 10130.*

Bordo, M.D. and Jonung, L. (2000). *Lessons for EMU from the history of monetary unions*, London: Institute of Economic Affairs.

Bound, J., Jaeger, D.A. and Baker, R. (1995). ‘Problems with Instrumental Variables Estimation When the Correlation between the Instruments and the Endogeneous Explanatory Variable Is Weak’, *Journal of the American Statistical Association*, vol. 90, pp. 443-50.

Böwer, U. and Guillemineau C. (2006). ‘Determinants of Business Cycle Synchronisation across Euro Area Countries’, *European Central Bank Working Paper Series*, No:587.

Breusch, T.S. and Pagan, A.R. (1980). ‘The Lagrange Multiplier Test and Its Application to Model Specification in Econometrics’, *Review of Economic Studies*, vol. 47(1), pp. 239-53.

Burns, A. M. and Mitchell., W. C. (1946). *Measuring Business-Cycles*, National Bureau of Economic Research.

Calderón C. (2007). ‘Trade, Specialization and Cycle Synchronization: Explaining Output Comovement between Latin America, China and India’, *the World Bank Working Paper*, LCRCE.

Calderón C., Chong, A., and Stein, E. (2007). ‘Trade Intensity and Business Cycle Synchronization: Are Developing Countries Any Different?’, *Journal of International Economics*, vol. 71(1), pp. 2-21.

Calmfors, L., Gottfries, N., Matlary, J.H., Jerneck, M., Lindahl, R., Berntsson, C.N., Rabinowics E. and Vredin, A. (1997). *EMU - A Swedish Perspective*. Kluwer Academic Publishers: Boston.

Calvo, G. and Mendoza E. (2000). 'Rational Contagion and the Globalization of Securities Markets', *Journal of International Economics*, vol. 51(1), pp. 79-113.

Canova, F. (1998). 'Detrending and Business Cycle Facts', *Journal of Monetary Economics*, vol. 41(3), pp. 475-512.

Canova, F. and Dellas H. (1993). 'Trade Interdependence and the International Business Cycles', *Journal of International Economics*, vol. 34, pp. 23-47.

Central Intelligence Agency (CIA), (2004). 'The World Factbook', Retrieved 05th April, 2004, available from World Wild Web: https://www.cia.gov/library/publications/the-world-factbook/index.html.

Choe, J. (2001). 'An Impact of Economic Integration through Trade: on Business Cycles for 10 East Asian Countries', *Journal of Asian Economics*, vol. 12(4), pp. 569-86.

Choi, I. (2001). 'Unit Root Tests for Panel Data', *Journal of International Money and Finance*, vol. 20, pp. 249–72.

Chow, H.K., and Kim, Y. (2003) 'A Common Currency Peg in East Asia? Perspectives from Western Europe', *Journal of Macroeconomics*, vol. 25(3), pp. 331-35.

Cheung, Y.W., and Yuen, J. (2004). 'An Output Perspective on a Northeast Asia Currency Union', *CESifo Working Paper*, No. 1250.

Clark, T.E., and Shin, K. (1998). 'The Sources of Fluctuations within and across Countries', *FRB Kansas City Research Working Paper*, No. 98-04.

Clark, T.E., and van Wincoop, E. (2001). 'Border and Business Cycles', *Journal of International Economics*, vol. 55(1), pp. 59-85.

Cohen, D. and Wyplosz, C. (1989). 'The European Monetary Union: An Agnostic Evaluation', *CEPR Discussion Papers*, number 306.

Cogley, T. and Nason. J. (1995). 'Effects of the Hodrick-Prescott Filter on Trend and Difference Stationary Time Series: Implications for Business-Cycle Research.' *Journal of Economic Dynamics and Control*, vol. 19, 253-78.

Copeland, L.S. (2005). *Exchange Rates and International Finance*, 4th edition, London: Financial Times Prentice Hall

Coordinated Portfolio Investment Survey (CPIS), (2004). 'Portfolio Investment: Coordinated Portfolio Investment Survey (CPIS): Background', Retrieved 24th November, 2005, available from World Wild Web: http://www.imf.org/external/np/sta/pi/cpis.htm.

Crosby, M., (2003). 'Business Cycle Correlations in Asia-Pacific', *Economics Letters*, vol. 80(1), pp. 35-44.

Davidas, Z., and Szapary, G. (2004). 'Business Cycle Synchronization in the Enlarged EU: Comovements in the New and Old Members', *Hungarian National Bank Budapest Working paper*, No. 1.

Davidson, R. and MacKinnon, J.G. (1993). *Estimation and Inference in Econometrics*, New York: OUP.

De Grauwe, P. (2005). 'The Theory of Optimum Currency Areas, A Critique', *The Economics of Monetary Integration*, 6th edition, Oxford: OUP.

De Grauwe, P. and Vanhaverbeke, W. (1993). 'Is Europe an Optimum Currency Area? Evidence from Regional Data', in Masson, P. and Taylor, M. (eds.), *Policy Issues in the Operation of Currency Unions*, Cambridge: Cambridge University Press.

Deardorff, A.V. (1998). ‘Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?’, in Frankel J.A. (ed.), *The regionalization of the world economy*, Chicago: Chicago University Press.

Demarks National Bank, (1998). ‘Denmark's Participation in ERM II’, *Monetary Review - 4th Quarter,* Retrieved 01st April, 2007, available from World Wild Web: http://www.nationalbanken.dk/C1256BE9004F6416/side/Monetary_Review_4_Quarter_1998/$file/NB11.htm.

Devereux, M.B. and Lane, P.R. (2003). ‘Understanding Bilateral Exchange Rate Volatility’, *Journal of International Economics*, vol. 60, pp. 109-32.

Dornbusch, R., Fischer S. and Samuelson P.A. (1977). ‘Comparative Advantage, Trade, and Payments in a Ricardian Model with a Continuum of Goods’, *The American Economic Review*, vol. 67(5), pp. 823-39.

Doroodian, K. (1999). ‘Does Exchange Rate Volatility Deter International Trade in Developing Countries?’, *Journal of Asian Economics,* vol. 10(3), pp. 465-74.

Durbin, J. (1954). ‘Errors in Variables’, *Review of the International Statistical Institute*, vol. 22, pp. 23-32.

European Commission (1990). ‘One Market, One Money: An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union’, *European Economy,* No. 44, Brussels: Commission for the European Communities.

Eichengreen, B. (1992). ‘Should the Masstricht Treaty be Saved?’, *Princeton Studies in International Finance*, No.74, International Finance Section, Princeton University.

EUROPA, (2006). ‘United Kingdom: EMU opt-out clause’, Retrieved 01st April, 2007, available from World Wild Web:
http://europa.eu/scadplus/leg/en/lvb/l25060.htm.

Evenett, S.J., and Keller, W. (1998). ‘On Theories Explaining the Success of the Gravity Equation’, *National Bureau of Economic Research Working paper,* no 6529.

Feenstra, R.G., Markusen, J., and Rose, A. (1998). ‘Understanding the Home Market Effect and the Gravity Equation: the Role of Differentiation Goods’, *National Bureau of Economic Research working paper*, no 6804.

Fidrmuc, J., (2004). ‘The Endogeneity of the Optimum Currency Area Criteria, Intra-industry Trade, and EMU Enlargement’, *Contemporary Economic Policy*, vol. 22(1), pp. 1-12.

Frankel, J.A. and Romer D. (1999). ‘Does Trade Cause Growth’, *The American Economic Review*, vol. 89(3), pp. 379-99.

Frankel, J.A., and Rose, A.K., (1998). ‘The Endogeneity of the Optimum Currency Area Criteria’, *Economic Journal*, vol. 108(449), pp. 1009-25.

Frankel, J.A., and Rose, A.K. (2002). ‘An Estimate of the Effect of Common Currencies on Trade and Income’, *European Economic Review*, vol. 46(2), 1125-51.

Forum for Research in Empirical International Trade (FREIT), (2004). ‘Distance Measure’, Retrieved 05th April, 2004, available from World Wild Web: http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/Data/Gravity/dist.txt.

Fuceri, D., and Karras, G. (2006). ‘Are the New EU Members Ready for the EURO?: A Comparison of Costs and Benefits’, *Journal of Policy Modeling*, vol. 28(1), pp. 25-38.

Government Offices of Sweden, (2006). ‘Sweden and the EMU’, Retrieved 01st April, 2007, available from World Wild Web: http://www.sweden.gov.se/sb/d/3470/a/20684;jsessionid=a1CtOqUjgOBg.

GovHK: Census and Statistics Department, the Government of Hong Kong Special Administrative Region, (2004). ‘Industrial Production’, Retrieved 22nd March, 2004, available from World Wild Web: http://www.censtatd.gov.hk/products_and_services/products/thematic_long_list/industrial_production/index.jsp.

Greene, W. H. (2002). *Econometric Analysis*, 5th edition, New York: Prentice Hall.

Gregory, A.W., Head, A.C., and Raynauld, J. (1997). ‘Measuring World Business Cycles’, *International Economics Review*, 38(3), pp. 667-702.

Gros, D. and Thygesen, N. (1998) *European Monetary Integration*, 2nd edition, New York: Longman

Grossman, G. and Razin, A. (1985). ‘International Capital Movements under Uncertainty’, *Journal of Political Economy*, vol. 92, pp. 286-306.

Gruben, W.C., Koo, J. and Millis, E. (2002). ‘How Much does International Trade Affect Business Cycle Synchronization?’, *Federal Reserve Bank of Dallas in its series Working Papers*, number 02 03.

Gujarati, N.D. (2003). *Basic Econometrics*, 4th edition. New York: McGraw Hill.

Haan, J., Inklaar, R. and Sleijpen, O. (2002). ‘Have Business Cycles Become More Synchronized?’, *Journal of Common Market Studies*, vol. 40(1), pp. 23-42.

Hadri, K. (2000). ‘Testing for Stationary in Heterogeneous Panel Data’, *Econometrics Journal*, vol. 3, pp. 148-61.

Harrigan, J. & Zakrajsek E., (2000). ‘Factor Supplies and Specialization in the World Economy’, *NBER Working Papers*, No:7848.

Harrigan, J. (2001). ‘Specialization and the Volumn of Trade: Do the Data obey the Law?’, *The handbook of International Trade*, Basil: Blackwell.

Harvey, A.C. and Jaeger, A. (1993). ‘Detrending, Stylized Facts and the Business Cycle’, *Journal of Applied Econometrics*, vol. 8(3), pp. 231-47.

Hasler, J., Lundvik, P., Persson, T. and Soderlind. P. (1994). ‘The Swedish Business-Cycle: Stylized Facts Over 130 Years.’ In *Measuring and Interpreting Business-Cycles*, ed. V. Berstrom and A. Vredin. Oxford: Clarendon Press, pp. 7-108.

Hausman, J.A. (1978). ‘Specification Tests in Econometrics’, *Econometrica*, vol. 46(6), pp. 1251-71.

Heathcote, J. and Perri, F. (2003). ‘Why Has the U.S. Economy Become Less Correlated with the Rest of the World?’, *The American Economic Review*, vol. 93(2), pp. 63-69.

Heathcote, J. and Perri, F. (2004). ‘Financial Globalization and Real Regionalization’, *Journal of Economic Theory*, vol. 119(1), pp. 207-43.

Helpman, E. and Razin, A. (1978). *A Theory of International Trade under Uncertainty*, New York: Academic Press.

Hodrick, R., and Prescott, E. (1980). ‘Post-War U.S. Business Cycles: An Empirical Investigation’, *Carnegie Mellon University Discussion Paper*, No.451.

Hooper, P. and Kohlhagen, S.W., (1978). ‘The Effects of Floating Exchange Rate Uncertainty on the Prices and Volume of International Trade’, *Journal of International Economics*, vol. 8, pp. 483–511.

Huang, Y. and Guo, F. (2006) ‘Is Currency Union a Feasible Option in East Asia?: A Multivariate Structural VAR Approach’, *Research in International Business and Finance*, vol. 20(1). pp. 77-94.

Im, K.S., Pesaran, M.H. and Shin, Y. (2003). ‘Testing for Unit Roots in Heterogeneous Panels’, *Journal of Econometrics*, vol.115, pp. 53-74.

Imbs, J. (2001). ‘Co-fluctuations’, *CEPR Discussion paper*, no.2267.

Imbs, J.M. (2004). ‘Trade, Finance, Specialization, and Synchronization’, *The Review of Economics and Statistics*, vol. 86(3), pp. 723-34.

Imbs, J.M. (2006). ‘The Real Effects of Financial Integration’, *Journal of International Economics*, vol. 68(2), pp. 296-324.

Kalemli-Ozcan, S., Sørensen, B.E. and Yosha O. (2001). ‘Economic Integration, Industrial Specialization, and the Asymmetry of Macroeconomic Fluctuations’, *Journal of International Economics*, vol. 55(1), pp. 107-37.

Kalemli-Ozcan, S., Sørensen, B.E. and Yosha O. (2003). ‘Risk Sharing and Industrial Specialization: Regional and International Evidence’, *The American Economic Review*, vol. 93(3), pp. 903-18.

Kalman, R.E. (1960). ‘A New Approach to Linear Filtering and Prediction Problems’, *Journal of Basic Engineering*, Transactions of the ASME Series D, vol. 82, pp. 35-45.

Karras, G. (2005). ‘Is There a Yen Optimum Currency Area? Evidence From 18 Asian and Pacific Economies’, *Japan and the World Economy*, vol. 17(4), pp. 456-69.

Kehoe, P.J. and Perri, F. (2002). ‘International Business Cycles with Endogenous Incomplete Markets’, *Econometrica*, vol. 70(3), pp. 907-28.

Kendall, M. G., and Stuart, A. (1967). *The Advanced Theory of Statistics*, 2nd edition, New York: Hafner.

Kenen, P. (1969). ‘The Theory of Optimum Currency Areas: An Eclectic View’ (in R. Mundell and A. Swoboda, eds.), *Monetary Problems in the International Economy*, Chicago: University of Chicago Press.

Kenen, P.B. (2000). ‘Currency Areas, Policy Domains, and the Institutionalization of Fixed Exchange Rates’, *CEP Discussion Papers*, Centre for Economic Performance, LSE, 0467.

King, R. G. and Rebelo. S. (1993). 'Low Frequency Filtering and Real Business-Cycles.', *Journal of Economic Dynamics and Control*, vol. 17, pp. 207-31.

King, R. G., Stock J. H. and Watson. M. (1995). 'Temporal Instability of thenemployment-Inflation Relationship'. *Economic Perspectives*. Federal Reserve Bank of Chicago. Vol. 19, pp. 753-95.

Klein, M.W., and Shambaugh, J.C. (2006). 'Fixed Exchange Rates and Trade', *Journal of International Economics*, vol. 70(2), pp. 359-83.

Kmenta, J. (1986). *Elements of Econometrics*, New York: Macmillan.

Kose, M.A., Otrok, C., and Whiteman, C.H. (2003). 'International Business Cycles: World, Region, and Country-Specific Factors', *The American Economic Review*, vol. 93(4), pp. 1216-39.

Kose, M.A., Prasad, E.E. and Terrones, M.E. (2003). 'How Does Globalization Affect the Synchronization of Business Cycles?', *The American Economic Review*, vol. 93(2), pp. 57-62.

Kose, M.A. and Yi, K.M. (2001). 'International Trade and Business Cycles: Is Vertical Specialization the Missing Link?', *The American Economic Review*, vol. 91(2), pp. 371-75.

Kose, M.A. and Yi, K.M. (2002). 'The Trade Comovement Problem in International Macroeconomics', *Federal Reserve Bank of New York in its series Staff Reports*, No:155.

Kose, M.A., and Yi, K.M. (2006). 'Can the Standard International Business Cycle Model Explain the Relation Between Trade and Comovement?', *Journal of International Economics*, vol. 68(2), pp. 267-29.

Krugman, P. (1991), *Geography and Trade*, Cambridge: MIT Press.

Krugman, P. (1993). 'Lessons of Massachusetts for EMU', (in F. Giavazzi and F. Torres eds.), *The Transition to Economic and Monetary Union in Europe*, New York: Cambridge University Press, pp. 241-61.

Kumakura, M. (2006). 'Trade and Business Cycle Co-movements in Asia-Pacific', *Journal of Asian Economics*, vol. 17(4), pp. 622-45.

Lane, P.R. and Milesi-Ferretti, G.M. (2003). 'International Investment Patterns', *CEPR Discussion Papers*, number 4499.

Leamer, E., (1983). 'Let's Take the Con Out of Econometrics', *The American Economic Review*, vol. 73(1), pp. 31–43.

Levin, A., Lin, C.F. and Chu, C. (2002). 'Unit Root Test in Panel Data: Asymptotic and Finite Sample Properties', *Journal of Econometrics*, vol. 108, pp. 1-25.

Lumsdaine, R.L., and Prasad, E. (2003). 'Identifying the Common Component in International Economic Fluctions', *Economic Journal*, 113(484), pp. 101-27.

Maddala, G.S. and Wu, S. (1999). 'A Comparative Study of Unit Root Tests With Panel Data and A New Simple Test', *Oxford Bulletin of Economics and Statistics*, vol. 61, 631-52.

Massmann, M. (2003). 'Do National Business Cycles Have an International Origin?', *Empirical Economics*, vol. 28(2), pp. 223-47.

Massmann, M, and Mitchell, J (2003). 'Reconsidering the Evidence: Are Eurozone Business Cycles Converging?', *NIESR Discussion Papers*, No:210.

McCallum, J. (1995). 'National Borders Matter: Canada-U.S. Regional Trade Patterns', *The American Economic Review*, vol. 85(3), pp. 615-23.

McKenzie, M.D. (1999). 'The Impact of Exchange Rate Volatility on International Trade Flows', *Journal of Economic Surveys*, vol. 13(1), pp. 71-106.

McKinnon, R. (1963). ‘Optimum Currency Areas’, *The American Economic Review*, vol. 53(4), pp. 717-24.

Mendoza, E. (2001). ‘Credit, Prices, and Crashes: Business Cycles with a Sudden Stop’, *NBER Working Papers*, No:8338.

Micco, A., Stein, E. and Ordonez, G. (2003). ‘The Currency Union Effect on Trade: Early Evidence from EMU’, *Economic Policy*, vol. 18(37), pp. 315-56.

Miles, D. and Scott, A. (2005). *Macroeconomics: Understanding the Wealth of Nations*, 2nd edition, US: John Wiley & Sons.

Mundell, R. (1961). ‘A Theory of Optimum Currency Areas’, *The American Economic Review*. Vol. 51(4), pp. 657-65.

Nakamura, A., and M. Nakamura. (1981). ‘On the Relationships Among Several Specification Error Tests Presented by Durbin, Wu, and Hausman’, *Econometrica*, vol. 49, pp. 1583-88.

Nelson, C. R. and C. Plosser. (1982). ‘Trends and Ransom Walks in Macroeconomic Time Series.’, *Journal of Monetary Economics*, vol. 10, pp. 139-67.

Obstfeld, M. (1994). ‘Risk-sharing, Global Diversification and Growth’, *The American Economic Review*. Vol. 84, pp. 1310-29.

Otto, G., Voss, G., and Willard, L. (2001). ‘Understanding OECD Output Correlations’, *RBA Research Discussion Papers*, number rdp2001-05.

Quinn, D. (1997). ‘The Correlates of Change in International Financial Regulation’, *American Political Science Review*, vol. 91, pp. 531-51.

Parkin, M. (2005). *Economics*, 7th edition, London: Pearson Addison Wesley.

Portes, R., Rey, H., and Oh, Y. (2001). ‘Information and capital flows: The Determinants of Transactions in Financial Assets’, *European Economic Review*, vol. 45(4-6), pp. 783-96.

Reinhart, C.M. and Rogoff K.S. (2004). ‘The Modern History of Exchange Rate Arrangements: A Reinterpretation’, *The Quarterly Journal of Economics*, vol. 119(1), pp. 1-48.

Rose, A.K. (2000). ‘One Money, One Market: The Effect of Common Currencies on Trade’, *Economic Policy*, vol. 15(30), pp. 7-33.

Rose, A.K. (2001), ‘Currency Unions and Trade: the Effect is Large’, *Economic Policy*, vol. 16(33), pp. 433-62.

Rose, A.K., and Engel C. (2002). ‘Currency Unions and International Integration’, *Journal of Money, Credit and Banking*, vol. 34(4), pp. 1067-89.

Rose, A. K. and van Wincoop, E. (2001). ‘National Money as a Barrier to International Trade: The Real Case for Currency Union’, *The American Economic Review*, vol. 91(2), p386-90.

Saint-Paul, G. (1992). ‘Technological Choice, Financial Markets and Economic Development’, *European Economic Review*, vol. 36, pp. 763-81.

Sargan, J.D. (1958). ‘The Estimation of Economic Relationships Using Instrumental Variables’, *Econometrica*, vol. 26, pp. 393-415.

Schiavo, S. (2005). ‘Financial Integration, GDP Correlation and the Endogeneity of Optimum Currency Areas’, *University of Verona Working Papers*, No. 25.

Schmitt-Grohe, S. (1998). ‘The International Transmission of Economic Fluctuations: Effect of U.S. Business Cycles on Canadian Economy’, *Journal of International Economics*, vol. 44, pp. 257-87.

Shambaugh, J.C. (2004). ‘The Effect of Fixed Exchange Rates on Monetary Policy’, *The Quarterly Journal of Economics*, vol. 119(1), pp. 300-51.

Shin K. and Wang, Y. (2004). ‘Trade Integration and Business Cycle Co-movements: the Case of Korea with Other Asian Countries’, *Japan and the World Economy*, vol. 16(2), pp. 213-30.

Shin K. and Wang, Y. (2005). ‘The Impact of Trade Integration on Business Cycle Co-movements in Europe’, *Review of World Economics*, vol. 141(1), pp. 104-23.

Sorensen, P.B., and Whitta-Jacobsen, H.J. (2005). *Introducing advanced macroeconomics : growth and business cycles*, London : McGraw-Hill.

Stata, (1999). ‘FAQ: Negative and Missing R-squared for 2SLS/IV’, Retrieved 19th October, 2005, available from World Wild Web: http://www.stata.com/support/faqs/stat/2sls.html.

Stata. (2003). *Stata Manual (XT) V9.0*, Texas: Stata Press.

Stata, (2005). ‘Why does xtgls not report an R-squared statistic?’, Retrieved 18th May, 2005, available from World Wild Web: http://www.stata.com/support/faqs/stat/xtgls2.html.

Stockman, A. (1988). ‘Sectoral and National Aggregate Disturbances to Industrial Output in Seven European Countries’, Journal of Monetary Economics, vol. 21(2-3), pp. 387-409.

Tang, H.C. (2006). ‘An Asian Monetary Union?’, *CAMA Working Papers from Australian National University*, Centre for Applied Macroeconomic Analysis.

Tavlas, G. (1992). ‘The ‘New’ Theory of Optimal Currency Areas’, International Monetary Fund, Washington, DC.

Vallee A.J. (2002). 'Business Cycles: Cyclical Comovement within the European Union in the Period 1960—1999. A frequency Domain Approach'. WP 5-02, Banco do Portugal, Lisbon, Portugal.

Wooldridge, J. M. (2002). *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA: MIT Press.

World Trade Organization (WTO), (2004). 'Search General Agreement on Tariffs and Trade (GATT)', Retrieved 05th April, 2004, available from World Wild Web: http://www.wto.org/english/docs_e/gattdocs_e.htm.

Wu, D. (1973). 'Alternative Tests of Independence Between Stochastic Regressors and Disturbances', *Econometrica*, vol. 41(4), pp. 733-750.

Wynne, M.A., and Koo, J. (2000). 'Business Cycle under Monetary Union: A Comparison of the EU and the US.', *Economica*, vol. 67(267), pp. 347-74.

Zhang, Z., Kiyotaka S. and McAleer, M. (2004). 'Is a Monetary Union Feasible for East Asia?', *Applied Economics*, vol. 36(10), pp. 1031-43.