An Empirical Investigation of Optimum Currency Area Theory, Business Cycle Synchronization, and Intra-Industry Trade

by

Dan Li
B.A., Central University of Finance and Economics, 2009

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Supervisory Committee

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Abstract

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The dissertation is mainly made up of three empirical theses on the Optimum Currency Area theory, business cycle synchronization, and intra-industry trade. The second chapter conducts an empirical test into the theory of Optimum Currency Area. I investigate the feasibility of creating a currency union in East Asia by examining the dominance and symmetry of macroeconomic shocks. Relying on a series of structural Vector Autoregressive models with long-run and block exogeneity restrictions, I identify a variety of macroeconomic disturbances in eleven East Asian economies. To examine the nature of the disturbances, I look into the forecast error variance decomposition, correlation of disturbances, size of shocks, and speed of adjustments. Based on both statistical analysis and economic comparison, it is found that two groups of economies are subject to dominant and symmetrical domestic supply shocks, and that the two groups respond quickly to moderate-sized shocks. Therefore, it is economically feasible for the two groups of economies to foster common currency zones.

The third chapter investigates the different effects of intra- and inter-industry trade on business cycle synchronization, controlling for financial market linkage and monetary policy making. The chapter is the first attempt to use intra- and inter-industry trade

simultaneously in Instrument Variable estimations. The evidence in my paper is supportive that intra-industry trade increases business cycle synchronization, while inter-industry trade brings about divergence of cycles. The findings imply that country pairs with higher intra-industry trade intensity are more likely to experience synchronized business cycles and are more feasible to join a monetary union. My results also show that financial integration and monetary policy coordination provide no explanation for synchronization when industry-level trade are accounted for.

The fourth chapter extends the third chapter and explores how the characteristics of global trade network influence intra-industry trade. Borrowing the concept of structural equivalence, the similarity of two countries' aggregate trade relations with other countries, from the social network analysis, this study incorporates this measure of trade network to the augmented gravity model of intra-industry trade. I build up two fixed effects models to analyze intra-industry trade in the raw material and final product sectors among 182 countries from 1962 through 2000. Structural equivalence promotes intra-industry trade flows in the final product sector, but it does not influence intra-industry trade in the crude material sector. Moreover, structural equivalence has been increasingly important in boosting intra-industry trade over time.

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Dedication

To my mother and father

Shuxin Zhao and Chengxiang Li

Chapter One: General Introduction

This dissertation presents three chapters, each an empirical study, that in broad terms examine features of economic interdependence. The first study explores the suitability of East Asia for a common currency from the perspective of how these economies relate to each other – in economic terms – and how the economies relate to the global economy.[1] The second study takes a broader perspective on the same issue – interdependence and suitability for a common currency. Here the focus is on a particular channel that may support greater business cycle synchronization, intra-industry trade. Finally, the third study furthers the investigation of intra-industry trade by examining whether complex trade network interdependence explains patterns of intra-industry trade flows. Taken as a whole, the three studies all contribute to our understanding of global macroeconomic interdependence.

1. Common Currency

Common currency refers to an international economic system of two or more economies that incorporates a single currency and a common central bank. The eurozone, the most well-known existing currency union, currently involves seventeen European countries. It began in 1999 and the monetary policy of the eurozone has been governed since then by the European Central Bank. The establishment of the eurozone has motivated scholars' interest in potential monetary unions in other parts of the world. In particular, some earlier studies (Bayoumi & Eichengreen, 1992, 1994; Chow & Kim, 2003; Zhang et al., 2004) focus on the feasibility and suitability to form a common currency in East Asia. This is the focus of the second chapter of this dissertation.

[1] Common currency is interchangeably used with currency union, monetary unification, and monetary union in the dissertation.

Arguments in favor of a common currency for East Asia include the following: (1) Most of the countries in East Asia are small and very open; (2) Intra-regional trade is high and rising, and moving towards more formalized regional integration (Goto & Hamada, 1994);[2] (3) Cross-border investment flows of foreign direct investment are extensive (Kohsaka, 1996); (4) The adjustment to shocks is relatively speedy and appears to be much faster than in Europe (Eichengreen & Bayoumi, 1996). The characteristics of the East Asian countries suggest that the benefits of a common currency arrangement might outweigh the costs of sacrificing independent monetary policies.

Another rationale for an East Asian monetary union is the 1997 Asian financial crisis, in which Indonesia, South Korea, Thailand, and Malaysia were severely affected while Singapore, Hong Kong, Japan, China and Taiwan were less influenced. In the aftermath of the crisis, pegging a common currency or basket of currencies was seen as a means to financial stability and as a preventive measure against future crisis in the region.

A common currency and unified monetary policy may reduce the transaction cost of trade among the union members, enhance the credibility of anti-inflation policies, and mitigate future financial crises. Nevertheless, forming a monetary union will result in the loss of flexibility in monetary and exchange rate policies. With a specific focus on the conditions that support a common monetary policy, the second chapter will discuss the economic feasibility and desirability of an East Asian common currency.

The analysis is rooted in the theory of Optimum Currency Area, which describes the conditions under which it is optimal to form a monetary union. Given the benefits and costs of joining or forming a monetary union, the Optimum Currency Area theory provides a large

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[2] For example, ASEAN has formed bilateral free-trade agreements with Australia, New Zealand, China, India, Japan, and South Korea. A trilateral free-trade agreement among China, Japan and South Korea is under negotiation.

number of criteria that participants are anticipated to satisfy. The criteria include, but are not limited to, factor mobility and price flexibility (Mundell, 1961), openness (McKinnon, 1963), product diversification and fiscal integration (Kenen, 1969), and similarity of inflation rates (Fleming, 1971). Satisfying these criteria induces an automatic adjustment mechanism in face of idiosyncratic shocks, and reduces the need for exchange rate adjustments. These criteria, however, are notoriously difficult to measure and empirical studies that examine all of these criteria are few.[3]

Two influential studies, Bayoumi and Eichengreen (1992, 1994), argue that it is more practical to regard the nature of macroeconomic shocks when assessing optimum currency areas. Specifically, the authors focus on the similarity of disturbances and the nature of response to disturbances. When two economies have a historic record of being subject to similar shocks, forming a monetary union is relatively more stable and incurs lower cost. Similarly, for two countries both of which respond to shocks in a similar fashion and restore equilibrium at a similar pace, eliminating exchange rate flexibility may not generate notable costs. Following Bayoumi and Eichengreen, I argue that similar shocks and swift responses remove the necessity of exchange rate adjustments, and provide critical information to assess monetary unification for East Asia.

Identifying the underlying macroeconomic shocks is crucial to assess the nature of shocks relevant for assessing the optimum currency areas. Of several approaches to identify disturbances (Sims, 1980; Baxter & Stockman, 1989; Bryant et al.,1993), the approach developed by Blanchard and Quah (1989) is both economically sound and intuitive, relying on simple identification strategies to categorize economic shocks. Bayoumi and Eichengreen (1992)

[3] The exceptions that I am aware of are the studies of all aspects of the European economies undertaken by the European Commission prior to the adoption of the euro. See the European Commission or EUROPA, in particular the historical documentation of the Economic and Monetary Union and the euro.

were the first to use this methodology to examine the symmetry of shocks for Europe and a large set of other countries. Similar studies followed (Chamie et al., 1994; Zhang et al., 2004; Huang & Guo, 2005; Chow & Kim, 2003), which identify different shocks and investigate the relative importance and similarity of shocks.

I also use Blanchard and Quah (1989) methods to assess the feasibility and suitability of a common currency in East Asia. In contrast to previous studies, I exploit block exogeneity restrictions to improve the quality of the estimation. I also extend the set of economic disturbances to provide a more complete analysis of the disturbances and responses in East Asian economies. My principal conclusion is that there exist two small subsets of East Asian economies – one includes Hong Kong, South Korea, Malaysia, and Singapore, while the other is made up of Indonesia, South Korea, Malaysia, and Thailand – that appear well suited to monetary unification, at least from the perspective of the criteria I consider.

2. Business Cycle Synchronization and Components of Trade

Business cycle synchronization, which is defined as the cross-country correlation of output growth, is regarded as one of the Optimum Currency Area criteria (Frankel & Rose, 1998; Rose, 2000; Imbs, 2004; Fidrmuc & Korhonen, 2006; Calderón et al., 2007). Countries with synchronized business cycles are more suitable to join a currency union, since eliminating exchange rate adjustment is unlikely to generate remarkable costs. Earlier studies generally argue that a higher degree of business cycle synchronization across countries makes it more feasible for the countries to join a monetary union. In essence, it is a higher level analysis than the focus on shocks considered in Chapter Two. While less structural than a focus on the underlying disturbances, it has the advantage of allowing me to focus on a broad set of influences that bear on business cycle correlation.

Although earlier studies have provided a large number of economic variables that may explain business cycle synchronization (Chari et al., 1994; Christiano et al., 1996; Otto et al., 2001, 2005; Kose et al., 2003), there has been less research on how components of international trade, intra-industry and inter-industry trade, may explain synchronization. Intra-industry trade denotes simultaneous imports and exports of products in the same sector, and has become increasingly important in international trade, particularly for industrialized countries (Brulhart, 2009). Markusen (1984) argues that product differentiation and increasing returns to scale are the principal explanations for the growing importance of intra-industry trade. Consumers have different preferences and tastes towards domestic and imported goods, pushing up the degree of product differentiation. In the meanwhile, firms prefer to achieve increasing returns to scale, which requires mass production of a relatively small range of differentiated goods. The product differentiation from the consumers' side and the increasing returns to scale from the suppliers' side lead to economically significant intra-industry trade.

Inter-industry trade, the other component of trade, refers to international exchange of goods in different sectors, such as the import of wines in return for exported natural gas. For the most part, inter-industry trade are explained by the theory of comparative advantage, sourcing from either technology or relative factor endowments (Dornbusch et al., 1977; Aquino, 1978; Leamer, 1995; Bernstein & Weinstein, 2002; Feenstra, 2004).

The different nature of intra-industry trade and inter-industry trade implies that they may impose different, even contrasting, effects on business cycle synchronization across countries. Higher inter-industry trade, as a result of greater specialization, induces countries to be more sensitive to industry-specific supply shocks, tentatively leading to more idiosyncratic business cycles (Krugman, 1979). In contrast, countries with higher intra-industry trade are subject to more common demand shocks through the exchange of products in the same sector, and consequently business cycles across the countries are likely to be more synchronized.

The third chapter explores the different impacts of intra-industry and inter-industry trade on business cycle synchronization across countries. The importance of this study is two-fold. First, understanding how trade influences business cycle synchronization helps determine the suitability of forming or joining a monetary union according to the Optimum Currency Area theory. As discussed above, business cycle synchronization is a key criterion in the Optimum Currency Area theory. However, synchronization cannot be observed directly, but indirectly explained by other economic variables, such as international trade, investments in the international capital markets, and macroeconomic policies (Chari et al., 1994; Christiano et al., 1996; Otto et al., 2001, 2005; Kose et al., 2003). For the analysis on the relationship between aggregate trade and synchronization, Canova and Dellas (1993), Kenen (2000), Kollman (2001), and Baxter and Kouparitsas (2005) maintain that closer trade ties contribute to business cycle comovement, while Imbs (1999) and Kose and Yi (2001) support the opposite. In order to further explore the interdependence, one can investigate how the various components of trade affect synchronization of business cycles. As one might expect, the components of trade may have different effects on synchronization, which may better explain the relationship between aggregate trade and synchronization. This methodology is suggested by earlier studies (Gruben et al., 2002; Shin & Wang, 2004; Fidrmuc, 2004) which decompose aggregate trade into intra- and inter- industry trade. Following these analysis, I argue that the mechanism through which international trade affects business cycle synchronization can be better uncovered when intra- and inter-industry trade are accounted for separately.

The second significance of the third chapter is to provide economic implications to the European Union enlargement and monetary union establishments in other parts of the world. If intra-industry trade contributes to synchronization while inter-industry trade brings about de-synchronization, countries with intense intra-industry trade are more likely to experience synchronized business cycles and are more suitable to take monetary unification. The economic implication is in contrast with previous studies (Frankel & Rose, 1998; Kenen, 2000; Kollman, 2001) which hold that countries with higher aggregate trade usually have a higher degree of synchronization, and are better satisfying the Optimum Currency Area criteria.

There have been a number of studies on aggregate trade and business cycle synchronization (Canova & Dellas, 1993; Baxter, 1995, 2004; Kenen, 2000; Kollman, 2001; Imbs, 1999; Kose & Yi, 2001). A common issue with these studies is the implicit restriction that intra- and inter-industry trade have equal impacts on synchronization. This restriction is inconsistent with the implication of economic theory that intra- and inter-industry trade may have different impacts on synchronization, and hence it may make the estimation models mis-specified. The third chapter will explicitly separate intra-industry trade from inter-industry trade, and estimate their effects on business cycle synchronization contemporaneously.

The third chapter contributes to the empirical literature on the industry-level trade and business cycle synchronization. I use instrument variable methods to examine how intra- and inter-industry trade affect business cycle synchronization differently. I also control for additional factors that may explain synchronization, namely financial linkages and similarity in macroeconomic policies (Otto et al., 2005; Shin & Wang, 2004). The key result is that intra-industry trade robustly increase business cycle correlation, while inter-industry trade consistently decrease synchronization.

3. Structural Equivalence and Intra-Industry Trade

Structural equivalence is defined as the degree of structural similarities between individual actors within a network (Lorrain & White, 1971). When applied to international trade, it captures the similarity in two countries' trading relationship with other countries. For the most part, two countries with a higher degree of structural equivalence are those with more common trade partners.

Structural equivalence is not one of the economic variables that are commonly used to explain international trade. Nevertheless, earlier literature (Burt, 1987; Mizruchi, 1993; Kim & Skvoretz, 2010) argues that structural equivalence may promote bilateral trade through information flow. When firms intend to develop new markets, they need to collect and assess information on potential business opportunities. However, imperfect information is a great barrier and constraint for firms who are searching for trade partners, even with the development of information and communication technologies (Baker, 1984; Rauch & Watson, 2004; Petropoulou, 2011). Because firms have difficulty in getting access to information, networks developed through trading relationships may provide important information flows that further shape trade patterns.

Two countries with common trade partners are likely to have more information about each other, arising from information spillovers when they trade with the common partners. Imperfect information in international market makes the information flow through common partners particularly important. As defined above, a higher level of structural equivalence suggests more common trade partnerships and hence more information flow, possibly generating more trade opportunities among firms in the two countries.

Earlier studies argue that structural equivalence may promote aggregate trade (Kim & Skvoretz, 2010, 2013; Zhou & Park, 2012), but there is no a priori reason why it should not also have effects at the components of trade. In particular, the fourth chapter attempts to investigate how structural equivalence affects intra-industry trade flows. Intra-industry trade is primarily driven by product differentiation at the consumers' side and increasing returns to scale at the suppliers' side (Markusen, 1984). This implies that firms which seek intra-industry trade partners need information on consumer preference and affordability, product related standards and pricing, as well as market conditions in general. As discussed above, common trade ties may assist such information flows, and a higher degree of structural equivalence indicates more channels of such information transmission. Given that intra-industry trade is likely to be dependent on information transmitted through common trade ties, I will explore how structural equivalence influences intra-industry trade.

To examine how structural equivalence may explain trade patterns, I amend the standard gravity model of trade applied to bilateral intra-industry trade flows. Earlier empirical studies that examine intra-industry trade using the gravity model include Krugman (1979), Lancaster (1980), Balassa (1986a, 1986b), Balassa and Bauwens (1987, 1988), Bergstrand (1990), Greenaway et al. (1994, 1995), Fontagne and Freudenberg (1997), and Stone and Lee (1995). An implicit assumption of the gravity model of trade is that bilateral trade between two countries are determined exclusively by the bilateral characteristics, in particular country size and distance. This bilateral perspective possibly ignores important network effects that may help explain bilateral trade (Kim & Shin, 2002; Kim & Skvoretz, 2010, 2013; Zhou & Park, 2012). Therefore, I will incorporate structural equivalence into the gravity model of intra-industry trade.

The fourth chapter is the first attempt to empirically explain intra-industry trade flows with the characteristics of global trade network. Of the few empirical studies that use a measure of trade network to explain aggregate trade, Kim and Skvoretz (2010) and Zhou and Park (2012) hold that similarity of trade relationships with other countries robustly boosts aggregate trade flows. I complement and extend Zhou and Park (2012) by integrating structural equivalence to the gravity model of intra-industry trade, and by examining the effect of structural equivalence on intra-industry trade across different sectors. The key result from this chapter is a robust role for structural equivalence in explaining intra-industry trade and clear evidence that this role has strengthened over time.

Chapter Two: Should East Asia Form A Currency Union?

1. Introduction

The theory of Optimum Currency Area (OCA) describes the optimal characteristics for a geographical region to form a monetary union. It dates back to the 1960s (Mundell, 1961; McKinnon, 1963; Kenen, 1969), and was scarcely studied for years (Tavlas, 1993). During the 1990s, however, the OCA issue became a popular topic again. Krugman (1992) states, "it is arguable that the optimum currency area issue ought to be the centerpiece of international monetary economics" (p.18).

There are mainly two factors that motivated the revival of the OCA theory. The first factor is the reinvigoration, during the late 1980s and early 1990s, of the process towards European monetary integration, including the formation of the European Monetary System and the European Union (EU). There had been a great deal of debate over whether the European countries were suitable to form the EU. The successful launch of the Euro makes the common currency a particularly interesting option for other parts of the world, such as North America and East Asia. Second, the 1997 East Asian financial crisis provoked discussions over how to stabilize regional economies. Various plans on fostering economic cooperation in East Asia have been proposed, such as the Chiang Mai Initiative among APT, as well forming an East Asian currency union.[4]

This chapter applies the OCA theory empirically to East Asia, focusing on the dominance and symmetry of macroeconomic disturbances. A Vector Autoregressive (VAR) approach developed by Blanchard and Quah (1989) is employed to identify macroeconomic disturbances.

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[4] APT stands for ASEAN Plus Three, where ASEAN represents the 10 member states of Association of Southeast East Asian Nations (Brunei, Burma (Myanmar), Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, and Vietnam) and Three refers to China, Japan, and South Korea.

The investigations into forecast error variance decompositions (FEVD), correlations of disturbances, and Impulse Response Functions (IRF) altogether show that it is optimal to adopt a common currency in some subgroups in East Asia.

The limitations of the analysis should be recalled. Although this chapter contributes to the debate over a potential East Asian common currency, the analysis is not sufficient by itself to resolve the debate. The rational for this chapter is that if disturbances and responses are similar across economies, symmetrical policy responses will suffice, removing the need for policy autonomy. Symmetry of shocks is not, of course, the only factor influencing the choice of international monetary arrangements. Empirical tests into other OCA criteria in the case of East Asia, such as factor mobility (Mundell, 1961) and fiscal integration (Kenen, 1969), may lead to different conclusions. It is worth noting that this chapter narrowly focuses on only one of the OCA criteria, and the conclusion in this chapter should be complemented with examinations of other OCA criteria.

The second shortcoming with the study is that I have focused exclusively on the economic analysis on a potential East Asian currency union, ignoring other factors such as political commitment in the region. It is hard to argue that monetary union would have occurred in the absence of the influence of political imperatives. Goodhart (1995) and Kenen (2000) state that without the prior acceptance of central-bank independence, the European Union governments would have had great difficulty designing an efficient monetary union. Kenen and Meade (2006) maintain that political, historical and social factors are determinant to the establishment of a currency union, and political dynamics are more likely to determine whether a group of East Asian economies will move to monetary union.

Another problem is that I have based inference about the future on past data, the properties of which may not be invariant to the monetary regime. Frankel and Rose (1998) and De Grauwe and Mongelli (2005) argue that symmetry of shocks is actually endogenous. Countries who join the European Monetary Union may have more symmetrical shocks after they adopt a common currency, even though they do not satisfy the criteria ex ante. Despite these concerns on examining symmetry of shocks as the key criterion for an East Asian common currency, this study may shed light on the nature of shocks in East Asian economies, in terms of the dominance, symmetry, size, and adjustment speed.

This chapter is organized as follows: Part II presents a selective literature survey on the OCA theory; Part III and IV describe the methodology and data employed; Part V reports on the estimation outcomes and discusses their implications; finally, part VI provides a conclusion.

2. Literature Review

2.1. Theoretical OCA Criteria

There are both benefits and costs for adopting a common currency. The earlier theoretical literature of the OCA theory comment on the comprehensive criteria that potential participants are supposed to meet to make the benefits of a currency union exceed its drawbacks. In general, the greater the fulfillment of the OCA criteria, the lower the relative costs of a country's joining a currency union.

In terms of OCA criteria, the OCA theory was pioneered by Mundell (1961) and further elaborated by McKinnon (1963), Kenen (1969) and others.[5] The seminal work by Mundell proposes factor (labor and capital) mobility and price flexibility as important criteria. These two mechanisms are capable of inducing automatic adjustments in response to idiosyncratic shocks to

[5] For more comprehensive surveys on the OCA criteria, refer to Kawai (1987) and Tavlas (1993).

both aggregate demand and supply. Countries among which there is a high degree of factor mobility and price flexibility can provide a substitute for exchange rate flexibility in promoting external adjustment, and hence are considered better candidates for a currency union. McKinnon qualifies the importance of Mundell's labor mobility and argues that the cost of loss of exchange rates as a buffer to shocks is a decreasing function of the openness of a country. Absent exchange rates adjustments, alternative instruments (e.g., fiscal policies) are able to restore equilibrium in the balance of payments upon shocks, suggesting that open economies are good candidates for participating in a monetary union. Kenen raises two more criteria, the degree of product diversification and fiscal integration. On the one hand, higher product diversification provides certain insulation against a variety of asymmetric shocks, preventing the need for frequent adjustments in the terms of trade through exchange rates. On the other hand, if disturbances are imperfectly correlated across industries, diversified economies may experience smaller aggregate disturbances than highly specialized economies. Additionally, countries with higher levels of fiscal integration, usually in some form of political union, can smooth away diverse shocks through fiscal transfers, taking Canada and the United States for example.

Four other criteria have been identified as crucial to form optimum currency areas: (1) similarity of disturbances and ease of response. Bayoumi and Eichengreen (1992, 1994) maintain that two economies, who experience the same disturbances, will presumably favor the same policy responses. Abandoning policy autonomy for monetary unification will then entail relatively little cost. Similarly, if market mechanisms adjust smoothly and restore equilibrium rapidly, eliminating exchange rate flexibility which is an effective buffer for adjusting to asymmetric shocks may not imply remarkable costs; (2) similarity of national growth rates. The imports in fast-growing countries tend to grow faster than their exports, leading to chronic trade deficits. These countries must decrease their terms of trade to make their products more competitive, through either depreciation or deflation (Horvath & Ratfai, 2004). The deprecation of currency is not possible in a monetary union, while deflation will constrain the economic growth. Thus, a monetary union has a higher cost for the fast-growing countries; (3) political commitments and institutions. Mintz (1970) argues that “the major and perhaps only real condition for monetary integration is the political will to integrate on the part of the prospective members” (p.33). This view is supported empirically by Cohen (1993), who finds that economic criteria are dominated by political commitments in six successful currency areas; (4) similarity of inflation rates. Fleming (1971) states that an equilibrated flow of current account transactions is more likely to occur within countries with similar inflation rates.

2.2. Empirical Tests into the OCA Criteria

Some light can be shed on the OCA theory by looking at the empirical tests into the OCA preconditions, which can be categorized into flexibility, integration, and symmetry of shocks. The first two types of criteria are commonly difficult to measure unambiguously, and relevant empirical studies are few. Instead, a large number of studies examine the symmetry of macroeconomic shocks.

The following empirical literature is comprised of four parts. Empirical work on flexibility and integration will first be summarized. Then I will review empirical tests into symmetry of shocks, particularly those using VAR models. Finally, endogeneity problem of OCA criteria is briefly discussed.

2.2.1. Flexibility and integration

Both flexibility and integration induce automatic adjustment mechanisms upon idiosyncratic shocks, and diminish the needs of exchange rate adjustments.

Flexibility embodies factor mobility and price flexibility. In terms of labor and capital mobility, some researchers directly use them as criteria to evaluate the suitability to create a monetary union. De Grauwe and Vanhaverbeke (1991) contrast regional and national labor mobility and real exchange rate variability in Europe. They strongly justify Europe as a monetary union, since the nationwide labor mobility is much lower than that across regions, and real exchange rate variability is substantially higher at the national level. Bayoumi et al. (1999) use the Feldstein-Horioka regression as a means of measuring the degree of capital mobility.[6] They find that savings-investment correlations among the European Monetary System (EMS) members are much lower than those among non-EMS members, which implies that exchange rate stability may itself be effective in increasing capital mobility.

Some others examine the effectiveness of factor mobility as OCA criteria, especially the substitution effects between labor and capital mobility. Puhani (1999) estimates the elasticity of migration with respect to changes in unemployment and income. The labor mobility is so inelastic that it takes several years for migration to respond to an unemployment shock. So labor mobility is unlikely to be an effective adjustment channel in response to asymmetric shocks in Europe. Eichengreen (1990) argues that although both labor mobility and migration within the EU are much lower than in the US, the high mobility of capital in EU is capable of substituting for labor mobility in absorbing idiosyncratic shocks. He further finds that what really matters for shock absorption among EU members is not just financial capital mobility, but also the mobility of physical capital. Blanchard and Katz (1992) discuss the substitution effect between labor mobility and wage flexibility. They find that labor mobility across EU countries is lower than that in US, and this makes higher wage flexibility possible in Europe. However, labor mobility in

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[6] Feldstein and Horioka (1980) examine the cross-sectional correlation between domestic savings and investment across OECD countries. If there is perfect international capital mobility, the correlation will be nil.

the US plays a dominant role in adjustments given regional shocks, substituting for price flexibility to a large extent.

The degree of integration is more difficult to measure, and related empirical works is scarce. Bayoumi and Prasad (1997) investigate the degree of labor market integration by comparing US regions and EU countries, and they conclude that US seems a much more integrated labor market. Productivity trends are dominated by industry-specific factors in the US and by country-specific factors in the EU. Besides, interregional labor flows constitute a more important adjustment mechanism in the US than those across countries in Europe. Fatas (1997) analyzes national and regional business cycles in the EU, using employment growth rates as the proxy. Since cross-country co-movements of economic fluctuations had increased after the introduction of EMS, the study supports that European integration had favored specialization at the regional level.

2.2.2. Symmetry of shocks

Symmetric shocks are macroeconomic disturbances whose correlations among members of a union are statistically significant and positive. Symmetry of shocks removes the necessity of exchange rate adjustments, and justifies monetary unification directly in the OCA assessments. For such studies, a number of empirical issues arise, first and foremost being the identification of the underlying macroeconomic shocks.

As a starting point, one should think about why it is preferable to look at symmetry of shocks in empirical OCA studies. Vahid and Engle (1993), Engle and Kozicki (1993), Alesina et al. (2002), and Sato and Zhang (2006) examine whether candidate countries share common business cycles. The economies whose paths of output growth are correlated are potential participants in a currency union. However, the extent of business cycle synchronization is going to depend upon their interactions, including the exchange rate regimes they have in place and the extent of integration through trade and financial markets. Since these features will change with the shift into a common currency, it is necessary to control for these factors and identify the underlying shocks themselves. Ideally, the stochastic processes of the shocks identified are invariant to the shifts in domestic exchange rate regime.

Another option is to look at the variability of price levels and outputs within a potential currency union. Eichengreen (1991), and De Grauwe and Vanhaverbeke (1991) compare the variability of relative price in the EU with existing monetary unions like the US and Canada. If the relative price levels of European countries vary less than those of North America counterparts, it is suggested that European countries fit into a currency union because of their higher degree of relative price convergence. The problem with this approach is that the movements of relative price incorporate the effects of both disturbances themselves (impulse) and the dynamic responses to the shocks (propagation). It is not possible to identify the relevant parameters of the shocks in this way. Other studies consider the behavior of output. Weber (1991) computes sums and differences in output movements for a group of European countries. The author interprets the sums as symmetric disturbances and the differences as asymmetric disturbances. The limitation of this approach is that it confounds output movements and shocks, and fails to distinguish common from idiosyncratic disturbances.

As is seen, the robustness of such empirical studies will depend largely on the quality of the shocks identification. There are several approaches to identify disturbances underlying output and price movements. One way is to impose few assumptions as in Baxter and Stockman (1989). The paper's limitation is the lack of theoretical foundations. At the other extreme is to conduct large-scale stochastic simulations of cross-country macroeconomic models like Bryant et al.(1993), which requires a large number of country-specific assumptions.

Another option is to impose restrictions on structural VAR models. Sims (1980) imposes recursive parameterization or lower triangularization restriction on the matrix of contemporaneous coefficients. However, the method is criticized on the grounds that the recursive causal structure implied is often hard to reconcile with any economic theory. The ideal view is that economic theory should dictate which restrictions to impose. By comparison, the VAR approach developed by Blanchard and Quah (1989) provides a simple and intuitive way to identify shocks, which is consistent with commonly accepted theoretical predictions about the long-run effects of shocks. The model permits all variables to interact linearly with their own and others' current and past values. By imposing long-run restrictions on the shocks, the VAR method is able to identify macroeconomic shocks from different sources, and to distinguish the disturbances from subsequent responses. Because of the economically plausible restrictions on interactions among variables, this method has been widely used to study the source of business cycles, money supply shocks, and international transmission of shocks (Meese & Rogoff, 1983; Yun, 1996; Pesaran & Shin, 1997).

2.2.3. VAR models with long-run restrictions

The VAR model advanced by Blanchard and Quah (1989) has been put into extensive use. In the context of OCA theory, one of the first empirical papers employing the long-run restrictions is Bayoumi and Eichengreen (1992, 1994). They apply a bivariate VAR model to assess the nature of macroeconomic disturbances, premised on the Aggregate Demand-Aggregate Supply (AD-AS) framework: in the long run, a demand shock has no effect on output, while a supply shock can influence the output and price level in both the short run and long run.

The study does an excellent job in examining the symmetry of shocks and computing the size of shocks and speed of adjustments. However, the authors do not consider the distinctions between external and internal shocks. For countries within the same region, external shocks come from the same source and should be symmetric. In contrast, sources of domestic shocks vary from country to country, and hence the symmetry of internal shocks is of primary interest. Because of their diverse sources and characteristics, the two types of shocks should be separately identified. Another drawback is that they do not consider examining dominance of shocks. Dominance of shocks provides insights into the formation of a currency union. Even if country-specific shocks are highly symmetric, a currency area will be difficult to maintain if domestic shocks are strongly dominated by other shocks. It is when domestic shocks are both prevalent and symmetric that a currency union may be feasible.

Chamie et al. (1994) decompose aggregate demand shocks into real and nominal terms, because they hold that certain real shocks, like consumer preference changes, should be separated from nominal shocks. The study separates fiscal policies (policies that mainly include taxation and government expenditure and affect real demand) from monetary policies which have impacts on nominal demand only. However, the study does not consider the interaction between the two policies, since they influence each other in the IS-LM model.

Zhang et al. (2004) extend to a three-variable VAR model in open economies. The study has an advantage in recognizing the role of exchange rates in evaluating open countries' economic performances. An inherent limitation, however, is the obscure definition of monetary shocks. If the authors include monetary policy shocks aiming to stabilize exchange rates, the monetary shocks will overlap with demand shocks. In this case, the assumption that the shocks are uncorrelated will be violated and the model will lose it validity. An explicit explanation on monetary shocks will make the model sounder.

An extension by Huang and Guo (2005) builds up a four-variable VAR model. Still, the monetary shocks are unclear in definition. Another flaw is that regional shocks, fundamentally distinct from global and domestic shocks, should be taken into account. Setting aside these problems, they conclude that the East Asian economies display lower symmetry of shocks in comparison to EU members, although it may be beneficial for Hong Kong, Indonesia, South Korea, Malaysia, Singapore, and Thailand to form a currency union first.

Up to this point, the empirical studies modify the two-variable VAR model in Bayoumi and Eichengreen (1992), by adding in shocks or decomposing aggregate demand shocks. Chow and Kim (2003), taking an alternative identification method, classify aggregate supply shocks as being global, regional and country-specific, and implement FEVDs on the three shocks. Chow and Kim hold that only if regional supply shocks dominate over the other two kinds of shocks that a regional monetary integration will be optimal. Despite its advantage in assorting aggregate supply shocks, the study fails to examine the symmetry of domestic shocks across countries. When domestic shocks are slightly dominant, their asymmetry may make a currency union hard to maintain. Without checking the correlations, one may inappropriately state that monetary unification is optimal. Another imperfection is that the authors do not consider AD shocks and price levels in the VAR framework. Based on a typical AD-AS analysis, it is obvious that the effects of the two shocks are different. A positive demand shock leads to a temporary rise in production followed by a gradual return to the initial level of output, and a permanent rise in price. However, a positive supply shock affects output permanently and reduces the price levels. Besides, demand shocks reflect the shifts in fiscal and monetary policies, while supply shocks result from movements in productivity and technology. Because of these distinctions, demand shocks and supply shocks should be present separately in a VAR model. The price level, one of the fundamental economic variables, should enter the VAR model too.

So far I have focused on specific flaws in each paper. A common imperfection they share is the failure to consider possible cointegration among the time series. Previous studies implicitly assume no cointegration relationships exist, and estimate the structural VAR directly. Bernard and Durlauf (1995) maintain that cointegration implies either convergence or common trends. The former means that each country has identical long-run trends, either stochastic or deterministic, while the latter allows for proportionality of stochastic elements. In this sense, Japan and China may have cointegration relationships with the US to certain extent, because of the convergence of their output in the recent decade. If there are long-run co-movements between outputs, the structural VAR models will be mis-specified, and all the estimations and predictions based on the VAR biased and inconsistent.[7] Because of the economic and statistical considerations, I will run cointegration tests before estimations.

2.2.4. Endogeneity of OCA criteria

Endogeneity of OCA criteria refers to that joining a monetary union may make the member countries better fit into the OCA criteria ex post even if they do not prior to entry. The majority of empirical evidences focus on the potential endogeneity of trade intensity. Frankel and Rose (1998) hold that entering a currency union will raise international trade linkages. This suggests that the sustainability of a monetary union increases with its implementation since the trade intensity among members is higher after they join a monetary union. Moreover, Rose (2000), Rose and Wincoop (2001), Rose and Engel (2002), Frankel and Rose (2002), as well as Glick

[7] When cointegration exists, one can employ the Vector Error Correction (VEC) models, which restrict the long run behavior of the endogenous variables to converge to their long-run equilibrium levels and allow the short run dynamics.

and Rose (2002) set up gravity models using various data sets and conclude that membership in a currency union boosts international trade. Endogeneity of OCA criteria is not the focus of this dissertation. Awareness of endogeneity, however, affects my selection of instrument variables in Chapter Three (See footnote 17).

3. Methodology

3.1. Theoretical Method

This chapter will create a series of VAR models to analyze the nature of macroeconomic disturbances in East Asia. I start with a bivariate VAR model, categorizing shocks into global and non-global shocks. If non-global shocks dominate and are symmetric, a non-global union is optimal. Next I split the non-global shocks, and build up a three-variable VAR model of global, regional, and domestic shocks. If domestic shocks are both dominant and symmetric, a monetary union in a subgroup of the region is more appropriate than that covering the entire region. Bayoumi and Eichengreen (1994) hold, “because demand disturbances include the impact of monetary and fiscal policies, they are less likely than supply disturbances to be informative about regional patterns” (p.25). It is also noted that demand shocks have no effects on output in the long run, while supply shocks influence both the output and price. Based upon the different behavior of demand from supply factors, I subsequently divide domestic shocks into domestic supply and domestic demand shocks. Therefore, the four-variable model will identify four types of shocks – global, regional, domestic supply, and domestic demand shocks.

Global shocks affect all the economies worldwide; an example was the 2008 global economic recession. Global shocks are represented by disturbances to US output (Chow & Kim, 2003). Regional shocks are unique to economies within a region, the 1997 Asian financial crisis, for instance. I use output shocks to Japan to represent regional shocks. Both domestic supply and demand shocks are specific to economies. I depict domestic supply shocks and domestic demand shocks using disturbances to domestic output growth and inflation of East Asian economies, respectively.

The macro-economy is a high-dimensional system with dynamics and complex feedbacks among the variables. Identification in macroeconomics is difficult and care must be taken to assess the robustness of structural VAR inference. In the structural VAR models, the long-run restrictions imposed possess the merit of being economically sound. However, a drawback with them is that I cannot ensure that the global and regional shocks, represented by disturbances to US and Japan output, are identical across East Asian countries. In order to solve this problem, I need to simultaneously impose block recursive restrictions on the structural shocks.

Given that the external shocks are identical for each East Asian country, one subset of variables in the VAR system is independent of the others. The situation fits the block exogeneity restrictions in that domestic shocks do not affect the external variables either contemporaneously or with lags. Cushman and Zha (1997) are the first paper that uses structural VAR models with block exogeneity, followed by Zha (1999) and Mackowiak (2007). The authors argue that a block of macroeconomic variables external to an emerging market is exogenous to the block of variables in an emerging market. Since the growth of East Asian economies in my sample has no cointegration with output of either US or Japan, I can treat the variables asymmetrically by imposing a block recursive structure.

This chapter makes mainly three contributions to OCA empirical literature. First, I take into account the co-movements of non-stationary series and test for cointegration. Although cointegration does not exist in this study, it is important to check for cointegration for reasons discussed before. Second, I identify various shocks and estimate a series of VAR models. The different specifications of models not only help us grasp more information about macroeconomic shocks, but also act as robustness tests. Third, I impose the long-run restrictions in combination with block exogeneity restrictions. In this way, I can ensure identical external shocks across East Asian countries.

3.2. Empirical Model

The empirical analysis is mainly based on the structural VAR model with long-run restrictions by Blanchard and Quah (1989). Consider a structural VAR system in which the true model can be represented by an infinite moving average (MA) of a vector of n variables X_t and an equal number of shocks ε_t. It should be emphasized that X_t is a vector of variables that are not cointegrated. Using the lag operator L, the structural MA can be written as

$$X_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + A_3\varepsilon_{t-3} \ldots = \sum_{i=0}^{\infty} A_i\, \varepsilon_{t-i} = \sum_{i=0}^{\infty} L^i A_i \varepsilon_t = A(L)\varepsilon_t \quad (1)$$

where the elements of matrix A_i represent the impulse responses of the elements of X_t to changes in the structural shocks. A_0 captures initial impacts of structural shocks, and determines the contemporaneous correlations among elements of X_t. A(1) represents the value of the polynomial A(L) for L=1, and mathematically it is the sum of all lagged coefficients included in A(L). I assume that $\varepsilon_t \sim \text{i.i.d.}(0, I)$ where I is an identity matrix.

In the four-variable model, X_t is made up of first differences in logarithm of global output, regional output, domestic output and domestic price. The endogenous variables are represented by output of the US, Japanese output, output of East Asian countries (excluding Japan), and price of East Asian countries (excluding Japan). Corresponding to the four endogenous variables are structural shocks, ε_t, including global, regional, domestic supply, and domestic demand shocks. I look at one East Asian economy at a time. Eq. (1) becomes

$$\begin{bmatrix}\Delta y_t^g\\ \Delta y_t^r\\ \Delta y_t^d\\ \Delta p_t^d\end{bmatrix} = \sum_{i=0}^{\infty} L^i \begin{bmatrix} a_{11}^i & a_{12}^i & a_{13}^i & a_{14}^i\\ a_{21}^i & a_{22}^i & a_{23}^i & a_{24}^i\\ a_{31}^i & a_{32}^i & a_{33}^i & a_{34}^i\\ a_{41}^i & a_{42}^i & a_{43}^i & a_{44}^i\end{bmatrix}\begin{bmatrix}\varepsilon_t^g\\ \varepsilon_t^r\\ \varepsilon_t^d\\ \varepsilon_t^p\end{bmatrix}$$

$$= \begin{bmatrix} A_{11}(L) & A_{12}(L) & A_{13}(L) & A_{14}(L)\\ A_{21}(L) & A_{22}(L) & A_{23}(L) & A_{24}(L)\\ A_{31}(L) & A_{32}(L) & A_{33}(L) & A_{34}(L)\\ A_{41}(L) & A_{42}(L) & A_{43}(L) & A_{44}(L)\end{bmatrix}\begin{bmatrix}\varepsilon_t^g\\ \varepsilon_t^r\\ \varepsilon_t^d\\ \varepsilon_t^p\end{bmatrix} \tag{2}$$

where y_t and p_t represent the logarithm of output and price, and a_{11}^irepresents the element a_{11} in matrix A_i. $A_{jk}(1)$ is an element of matrix A(1), and $A_{jk}(1) = \sum_{i=0}^{\infty} a_{jk}^i$ (j, k = 1,2,3,4).

To identify this structural model, a finite reduced-form VAR model for observed variables is first estimated. As in any VAR, each element of X_t is regressed on lagged values of all the elements of X_t. Using B_i to represent these estimated coefficients, the reduced-form VAR can be written in a matrix form as

$$\begin{aligned} X_t &= B_1X_{t-1} + B_2X_{t-2} + \cdots + e_t = B(L)X_t + e_t\\ &= [1 - B(L)]^{-1}e_t\\ &= [1 + B(L) + B(L)^2 + \cdots]e_t\\ &= e_t + C_1e_{t-1} + C_2e_{t-2} + \cdots\\ &= \textstyle\sum_{i=0}^{\infty} L^i C_i e_t = C(L)e_t \end{aligned} \tag{3}$$

where e_t represents the reduced-form (observed) residuals from the VAR. $C(L) = [1 -$ BL−1and C0=I by construction. Eq. (1) reveals Xt=A0εt, and Eq.2 implies Xt=C0et=et. So I get the relationship:

$$e_t = A_0\varepsilon_t \tag{4}$$

The reduced-form errors are linear combinations of structural shocks, and have a covariance matrix as follows:

$$E(e_te_t') = A_0E(\varepsilon_t\varepsilon_t')A_0' = A_0A_0' \tag{5}$$

In order to identify the structural shocks ε_t from the reduced-form residuals e_t, I need to identify matrix A_0 which requires choosing n^2 elements of A_0. The first n restrictions are imposed by normalizing the variance of structural shocks to one. An additional $(n^2 - n)/2$ restrictions are needed for complete identification, which means six restrictions in the context of my model since n=4 in my sample.

The conventional way to identify the structural parameter is to impose contemporaneous restrictions on matrix A_0 and solve it by Cholesky decomposition of the reduced-form covariance matrix $E(e_t e_t')$. The triangular (recursive) structure, however, has lack of support from economic theory.

Instead, I use the Blanchard and Quah (1989) approach which imposes restrictions on the matrix of long-term effects of structural shocks on endogenous variables A(1). The restrictions are based on economic theory, and provide a simplified way to orthogonalize the reduced-form errors. Combining Eq. (1), (3), and (4), I obtain the following relationship between the matrix of long-term effects of structural shocks A(1) and the equivalent matrix of reduced-form shocks C(1):

$$A(1) = C(1)A_0 \tag{6}$$

where the matrix C(1) is obtained from the reduced-form estimates and therefore contains known elements. Based on Eq. (6), I can get $A(1)A(1)' = C(1)E(e_t e_t')C(1)'$. The following six identification restrictions are imposed on matrix $A(1)$: (i) Neither regional nor country-specific shocks have long-run effects on global output, $A_{12}(1) = A_{13}(1) = 0$; (ii) Country-specific shocks have no long-run effects on regional output, $A_{23}(1) = 0$; (iii) Demand shocks have no permanent effects on output, $A_{14}(1) = A_{24}(1) = A_{34}(1) = 0$.[8]

In addition to the long-run restrictions, I also impose block exogeneity restrictions that domestic shocks in ε_t^d and ε_t^p do not affect the external variables in Δy_t^g and Δy_t^r, either contemporaneously or with lags. So I assume that $a_{13}^i = a_{14}^i = a_{23}^i = a_{24}^i = 0,$ for each $i = 0,1, \dots, p$. In other words, the long-run restrictions are $A_{13}(1) = A_{14}(1) = A_{24}(1) = A_{34}(1) = 0$ because each element of them is zero.

Given the restrictions, the model is formulated separately for each East Asian economy. The restrictions can uniquely identify the matrix $A(1)$ and therefore A_0 by $A_0 = C(1)^{-1}A(1)$. Thus it is sufficient to recover the structural shocks ε_t, from reduced-form innovations according to $\varepsilon_t = {A_0}^{-1}e_t$. Then I investigate the variance decomposition, correlation of structural shocks as well as the dynamic response of the economy of interest to the structural shocks.

4. Data

Annual data on real gross domestic product (GDP, International dollars) are collected from the Penn World Table (PWT) 7.1. The sample is composed of the United States (US) and 11 East Asian economies –Japan (JP), Mainland China (CN), Hong Kong (HK), Indonesia (IN), South Korea (KR), Malaysia (MA), Philippines (PH), Singapore (SG), Thailand (TH), Taiwan (TW), and Vietnam (VN), spanning 1951 to 2010. The output growth rates are calculated as first difference in log real GDP. Annual data on GDP deflator and inflation based on GDP deflator are obtained from the database of the World Bank, ranging from 1961 to 2010. Price data are not

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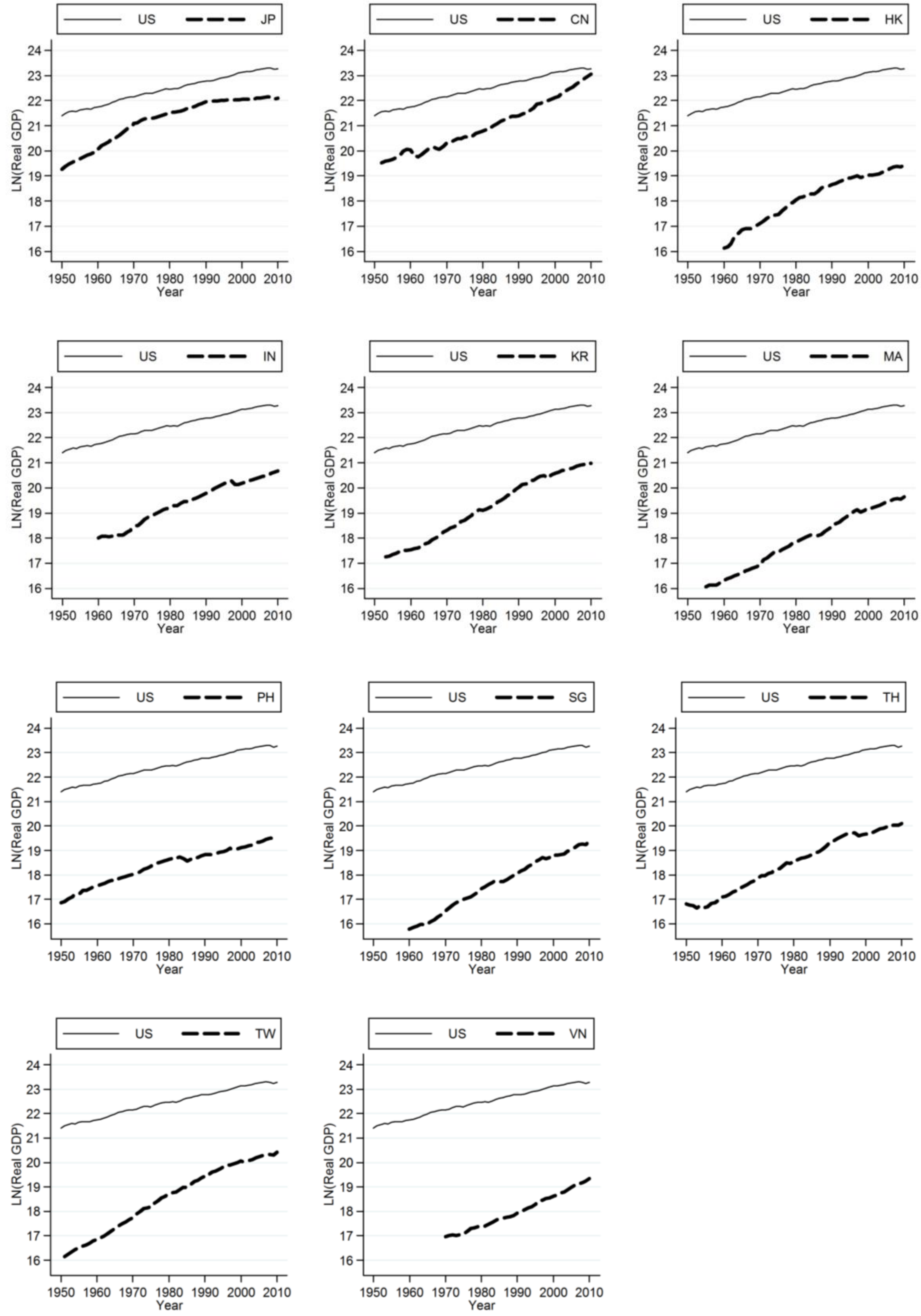
[8] Similarly, the bivariate VAR model is identified by assuming $A(1) = \begin{bmatrix} A_{11}(1) & 0 \\ A_{21}(1) & A_{22}(1) \end{bmatrix}$, while the assumption used in the three-variable VAR models is $A(1) = \begin{bmatrix} A_{11}(1) & 0 & 0 \\ A_{21}(1) & A_{22}(1) & 0 \\ A_{31}(1) & A_{32}(1) & A_{33}(1) \end{bmatrix}$.

available for Taiwan and Vietnam, so they are excluded from the four-variable model. The plots for output and GDP deflator are presented in Figures 1-2.

In Table 1, I summarize the descriptive statistics for output growth and inflation rates. The US output grows at 3%, while other East Asian countries witnessed faster growth. The inflation rates in Japan, Singapore, Malaysia, and China are close to that in US on average, but have higher standard deviation. The inflation rates in other Asian counties are generally higher than that in US. This is especially the case for Indonesia. The hyperinflation in the 1960s makes Indonesia's mean and variance of inflation much higher than other countries. This suggests that I need to be careful about interpreting results using full sample.

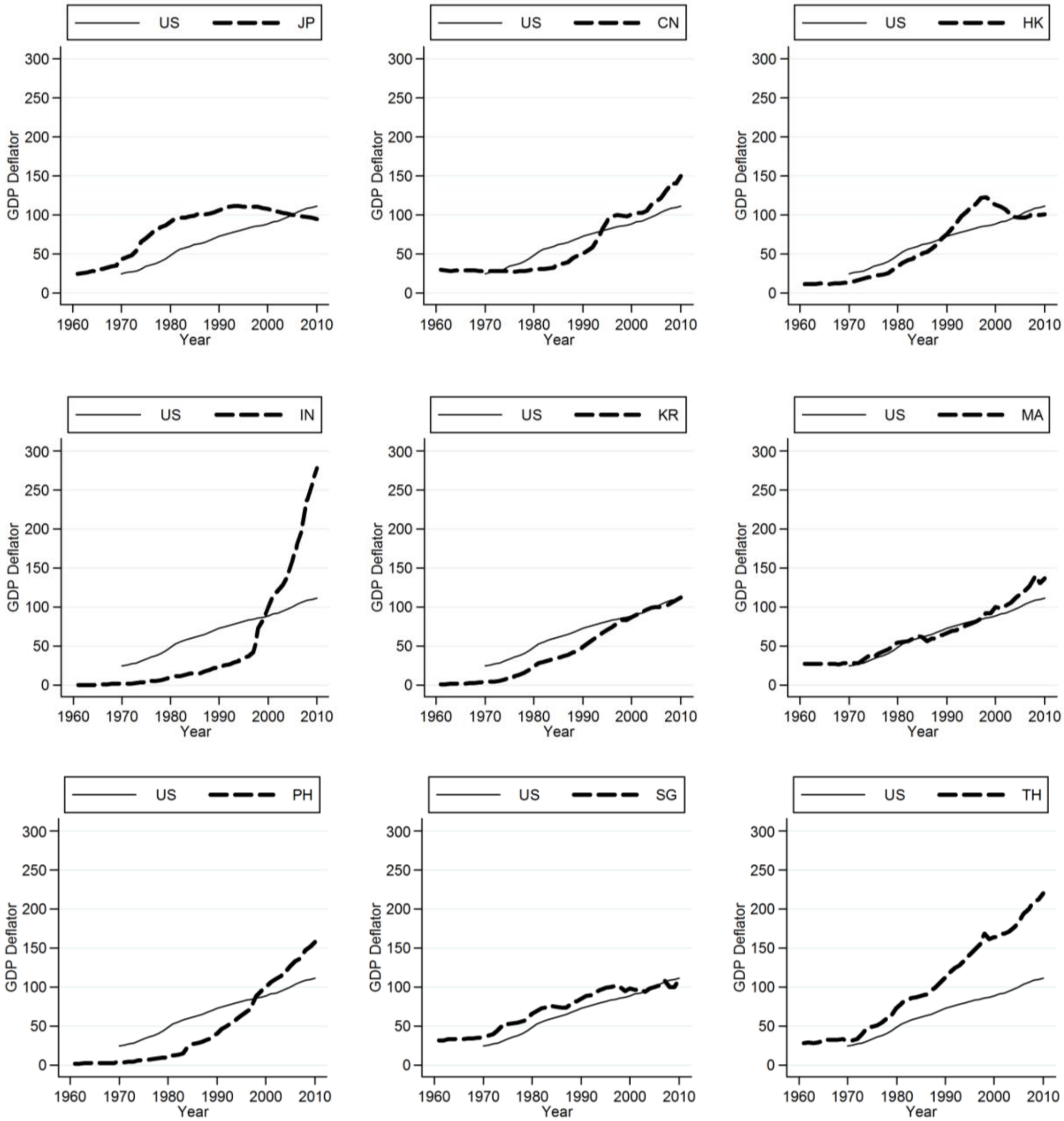
Table 2 reports correlation coefficients between GDP growth and inflation rates. The correlations vary greatly from -0.33 to 0.87. Positive correlation coefficients suggest symmetry of output growth and inflation. Based on the sign of coefficients, a distinctive region displaying symmetry of both output and price have been identified: Hong Kong, Indonesia, South Korea, Malaysia, Singapore, and Thailand. Whether these correlations in output and price are consistent with correlations in underlying disturbances is a question to which I now turn.

Figure 1: Natural Logarithm of Real GDP



Source: Penn World Table 7.1.

Figure 2: GDP Deflator



Source: World Bank’s World Development Indicators.

Table 1: Basic Statistics of Different Countries

Panel A. Output Growth Rates

Country	Sample	Obs	Mean (%)	Std. Dev (%)
US	1951-2010	60	3.11	2.59
Japan	1951-2010	60	4.73	4.19
China	1953-2010	58	6.07	6.02
Hong Kong	1961-2010	50	6.61	5.33
Indonesia	1961-2010	50	5.34	4.33
Korea	1954-2010	57	6.54	4.40
Malaysia	1956-2010	55	6.48	4.60
Philippines	1951-2010	60	4.52	3.62
Singapore	1961-2010	50	7.19	4.67
Thailand	1951-2010	60	5.46	5.20
Taiwan	1952-2010	59	7.26	3.30
Vietnam	1971-2010	40	5.93	3.20

Panel B. Inflation Rates

Country	Sample	Obs	Mean (%)	Std. Dev (%)
US	1961-2010	50	3.66	2.34
Japan	1961-2010	50	3.06	5.04
China	1961-2010	50	3.68	5.02
Hong Kong	1961-2010	50	4.61	5.45
Indonesia	1961-2010	50	15.71	12.68
Korea	1961-2010	50	11.17	8.69
Malaysia	1961-2010	50	3.23	5.09
Philippines	1961-2010	50	9.77	8.45
Singapore	1961-2010	50	2.60	3.95
Thailand	1961-2010	50	4.36	4.53

Notes: Output growth rates and inflation rates are constructed from real GDP and GDP deflator.
Sources: Penn World Table 7.1, World Bank's World Development Indicators.

Table 2: Correlations of Output Growth Rates and Inflation Rates across Different Countries

Panel A. Output Growth Rates (1951-2010)

	US	JP	CN	HK	IN	KR	MA	PH	SG	TH	TW	VN
US	1.00											
Japan	0.53	1.00										
China	-0.08	-0.16	1.00									
Hong Kong	0.39	0.65	-0.03	1.00								
Indonesia	0.05	0.40	0.04	0.56	1.00							
Korea	0.33	0.53	0.01	0.48	0.54	1.00						
Malaysia	0.26	0.44	-0.07	0.59	0.63	0.58	1.00					
Philippines	-0.01	0.19	-0.14	0.44	0.42	0.22	0.41	1.00				
Singapore	0.22	0.43	0.04	0.56	0.45	0.42	0.82	0.45	1.00			
Thailand	0.08	0.49	0.01	0.48	0.63	0.66	0.56	0.24	0.38	1.00		
Taiwan	0.63	0.70	-0.16	0.75	0.39	0.49	0.55	0.28	0.54	0.40	1.00	
Vietnam	0.15	-0.15	0.11	-0.07	-0.07	0.09	0.05	-0.10	-0.04	0.01	-0.09	1.00

Panel B. Inflation Rates (1961-2010)

	US	JP	CN	HK	IN	KR	MA	PH	SG	TH
US	1.00									
Japan	0.71	1.00								
China	-0.32	-0.31	1.00							
Hong Kong	0.62	0.53	0.18	1.00						
Indonesia	0.24	0.40	-0.33	0.16	1.00					
Korea	0.87	0.85	-0.26	0.61	0.33	1.00				
Malaysia	0.28	0.44	-0.07	0.31	0.57	0.36	1.00			
Philippines	0.31	0.45	-0.07	0.42	0.37	0.33	0.32	1.00		
Singapore	0.55	0.64	0.02	0.53	0.28	0.56	0.44	0.25	1.00	
Thailand	0.61	0.79	-0.11	0.59	0.61	0.68	0.61	0.37	0.77	1.00

Notes: Output growth rates and inflation rates are constructed from real GDP and GDP deflator.

Sources: Penn World Table 7.1, World Bank’s World Development Indicators.

The plots imply output and price may be non-stationary, so I undertake unit root tests. To improve robustness of results, I use two tests – Dickey-Fuller GLS test (Elliott et al., 1996) and Augmented Dickey-Fuller test (Dickey & Fuller, 1979). Both unit root tests deliver substantially the same results. Since Elliott et al. (1996) and later studies have shown that DF-GLS test has greater power than the previous version of ADF test, I report the results of DF-GLS test only. Reported in Table 3, all the output and price series present unit roots at any reasonable lags and significance levels. Given the existence of unit roots in levels, unit root tests are then applied to the first differences.

Table 4 reports the DF-GLS test results for the output growth and inflation rates. Both series are stationary at lower lags. Under such circumstances, the real GDP and price are integrated of order one. At lags larger than one, however, the output growths of US, Japan, and Thailand, as well as the inflation rates of Hong Kong and Malaysia contain unit roots. To ensure all the elements in the VAR model are stationary, I will enter output growth and inflation rates as endogenous variables and specify a lag order of one.

Given that both output and price are I(1) series, I need to consider cointegration tests to inspect any long-run co-movements. Since the cointegration test established by Engel and Granger (1987), many statistical methods have been suggested to test cointegrated models. Undoubtedly the VAR- based method advocated by Johansen (1988, 1991) is one of the most popular choices.

Table 3: Dickey-Fuller GLS Tests for Unit Roots on Natural Logarithm of Real GDP and GDP Deflator

Panel A. Natural Logarithm of Real GDP

Country	**Lag=1**	**Lag=2**	**Lag=3**	**Lag=4**
The US	**-1.72**	-1.63	-1.51	-1.73
Japan	-0.54	**-0.70**	-1.08	-1.09
China	-1.75	-1.10	-0.67	**-0.72**
Hong Kong	**-0.60**	-0.49	-0.62	-0.44
Indonesia	-1.61	**-1.87**	-2.05	-2.34
Korea	**-0.97**	-1.08	-1.30	-1.28
Malaysia	**-1.79**	-1.78	-2.21	-1.74
Philippines	**-0.96**	-1.11	-1.25	-1.16
Singapore	**-2.11**	-2.10	-2.13	-2.14
Thailand	-1.35	-1.70	-2.35	**-2.14**
Taiwan	**-0.34**	-0.41	-0.67	-0.65
Vietnam	-1.12	-1.11	-0.53	**-0.15**

Panel B. GDP Deflator

Country	**Lag=1**	**Lag=2**	**Lag=3**	**Lag=4**
China	-0.68	**-0.79**	-0.96	-0.55
Hong Kong	-2.33	**-2.06**	-2.86	-2.80
Indonesia	**-0.18**	-0.98	-1.12	-0.97
Korea	**-0.90**	-1.15	-1.28	-1.19
Malaysia	-0.24	**-0.80**	-1.03	-1.27
Philippines	**-0.09**	-0.56	-0.82	-1.10
Singapore	**-1.86**	-1.68	-1.96	-1.54
Thailand	**-0.64**	-0.93	-1.08	-1.01

Notes:

1. The optimal lag order (bolded) are obtained using Schwarz Bayesian information criterion. The optimal lag varies across countries and ranges from one to four; therefore, I report test statistics at four different lag lengths.
2. All the unit root tests include a linear time trend.
3. ***, **, and * indicate statistical significance at 1%, 5%, and 10% chosen size. The interpolated critical values are constructed in Elliott et al. (1996). Because of slight differences in sample size of different countries, the critical values are not exactly the same.
4. The price levels of US and Japan will not enter any of the VAR models, so the series are not tested by DF-GLS.

Table 4: Dickey-Fuller GLS Tests for Unit Roots on Output Growth Rate and Inflation

Panel A. Output Growth Rates

Country	**Lag=0**	**Lag=1**	**Lag=2**	**Lag=3**
The US	**-3.32*****	-1.91*	-1.29	-0.74
Japan	-2.42**	-1.67*	-0.63	**-0.56**
China	-4.91***	-5.35***	-5.46***	**-4.02*****
Hong Kong	-4.28***	**-5.36*****	-4.50***	-4.50***
Indonesia	-4.86***	**-3.84*****	-3.36***	-2.87***
Korea	-5.37***	-3.44***	-2.42**	**-2.18****
Malaysia	**-6.23*****	-4.46***	-3.07***	-3.45***
Philippines	**-6.13*****	-4.16***	-3.21***	-3.19***
Singapore	**-5.76*****	-4.45***	-3.45***	-3.40***
Thailand	-3.58***	-1.99**	-1.33	**-1.43**
Taiwan	-3.89***	**-2.73*****	-1.65*	-1.42
Vietnam	**-4.31*****	-3.62***	-4.27***	-4.24***

Panel B. Inflation Rates

Country	**Lag=0**	**Lag=1**	**Lag=2**	**Lag=3**
China	-2.39**	**-2.32****	-1.71*	-1.94*
Hong Kong	-2.42**	**-1.86***	-1.48	-1.44
Indonesia	-5.08***	**-3.61*****	-3.01***	-2.56**
Korea	-2.44**	**-2.52****	-2.18**	-1.66*
Malaysia	**-3.91*****	-2.24**	-1.35	-0.94
Philippines	**-4.60*****	-3.84***	-2.60**	-2.10**
Singapore	-4.38***	**-3.76*****	-3.09***	-3.26***
Thailand	-4.17***	**-4.11*****	-3.62***	-3.13***

Notes:
1. The optimal lag order (bolded) are obtained using Schwarz Bayesian information criterion. The optimal lag varies across countries and ranges from zero to three, therefore I report test statistics at four different lag lengths.
2. All the unit root tests include no trend.
3. ***, **, and * indicate statistical significance at 1%, 5%, and 10% chosen size. The interpolated critical values are constructed in Elliott et al. (1996). Because of slight differences in sample size of different countries, the critical values are not exactly the same.
4. The inflation rates of US and Japan will not enter any of the VAR models, so the series are not tested by DF-GLS.

Johansen's approach applies maximum likelihood estimation for reduced rank regression models to isolate common stochastic trends in multiple time series. The method is attractive in that it provides a unified set of tools of estimation and cointegration rank testing, based on the assumption that the error vector is multivariate normal at each period and independent across observations. The distributional assumption for the Johansen test, however, is not suitable for my sample. Because I do not have sufficient confidence to assume the normality of the shocks in my study, the statistical information provided by Johansen test may be inaccurate. By comparison, the Engle-Granger (EG) test has advantage in making fewer distributional assumptions and better fits my data. EG test is a two-step residual-based test. First, one variable is regressed on a constant and the other variables, and the residuals are calculated. Afterwards, first differences of the residuals are regressed on the lagged level of residuals without a constant. EG test, however, fails to pick out more than one cointegrating vector. Therefore, the Johansen test is much more useful for multivariate studies.

Because of the complementary advantages of the Johansen and EG test, I will report results of both. The test statistics of EG tests is the coefficient on the lagged residuals. Rejection of the null hypothesis indicates non-stationary residuals and no cointegration. Since all the output series are trending (or may contain a trend) in Figure 1, a trend is included in the cointegration regression. Moreover, EG test can be augmented by choosing lags to remove any evidence of serial correlation in the residuals. An optimal lag order is chosen based on information criterion procedures.[9] A uniform lag of two is chosen in order to preserve symmetry of specification across economies.

The cointegration test results for three models are presented in Table 5. Throughout the panels, both EG statistics consistently indicate that there are no long-run co-movements among the variables, except the bivariate model. In panel A, the EG test statistics provide evidence of cointegration relationships in US-Japan and US-China pairs at 10% statistical significance level.

[9] Choice of the lag order is critical in that too many lags will increase the error in the forecasts, while too few may leave out relevant information. Three commonly used criteria for lag order selection are Akaike information criterion (AIC), Hannan-Quinn information criterion (HQIC), and Schwartz-Bayes information criterion (SBIC). Ivanov and Kilian (2001) show that in the context of VAR or VEC models, AIC tends to be more accurate with monthly data, HQIC works better for quarterly data on samples over 120. I apply SBIC to my small sample of annual data.

In the right-hand-side columns, I use the trace statistics in Johansen test to detect the number of cointegration relationships. The null hypothesis for a trace test is the number of cointegration vectors from 0 to n-1 against alternatives with a greater number of cointegration vectors, where n is the sample size. Based on the trace statistics, I arrive at the same conclusion as that using EG test statistics. Because cointegration is strongly rejected at 5% size, I have sufficient evidence to estimate the time series variables in the VAR model.

5. Estimation

I estimate three structural VAR models with long-run and block exogenous restrictions. The block exogeneity assumes that external shocks are identical across countries and independent of internal shocks.[10] Therefore, I am more interested in the behavior of domestic shocks.

Specifically, I wish to examine how the variations in output growth and inflation are affected by different shocks, to what extent domestic shocks are correlated across countries, and the impulse responses to shocks. To answer these questions, I will examine forecast error variance decomposition, correlation of structural shocks, size of domestic shocks, and speed of adjustment.

5.1. Forecast Error Variance Decomposition of Disturbances

FEVD analysis is first performed to identify the contribution of individual shocks. FEVD determines the proportion of variability of the errors in forecasting elements of X_t at time t+i based on information available at time t, that is due to variability in the structural shocks ε_t between time t and t+i. The forecast errors in terms of structural shocks are:

[10] Global and regional shocks show perfectly positive correlations under the block exogenous restrictions. Because of missing data in some economies, the coefficients are not exactly one in the entire sampling period. However, within a common sample range when data for all economies are complete, the correlations are strictly at one.

$$\begin{bmatrix} \Delta y^{g}_{t+i} - \Delta y^{g}_{t+i|t} \\ \Delta y^{r}_{t+i} - \Delta y^{r}_{t+i|t} \\ \Delta y^{d}_{t+i} - \Delta y^{d}_{t+i|t} \\ \Delta p^{d}_{t+i} - \Delta p^{d}_{t+i|t} \end{bmatrix} = \begin{bmatrix} a^{0}_{11} & a^{0}_{12} & a^{0}_{13} & a^{0}_{14} \\ a^{0}_{21} & a^{0}_{22} & a^{0}_{23} & a^{0}_{24} \\ a^{0}_{31} & a^{0}_{32} & a^{0}_{33} & a^{0}_{34} \\ a^{0}_{41} & a^{0}_{42} & a^{0}_{43} & a^{0}_{44} \end{bmatrix} \begin{bmatrix} \varepsilon^{g}_{t+i} \\ \varepsilon^{r}_{t+i} \\ \varepsilon^{d}_{t+i} \\ \varepsilon^{p}_{t+i} \end{bmatrix} + \cdots + \begin{bmatrix} a^{i-1}_{11} & a^{i-1}_{12} & a^{i-1}_{13} & a^{i-1}_{14} \\ a^{i-1}_{21} & a^{i-1}_{22} & a^{i-1}_{23} & a^{i-1}_{24} \\ a^{i-1}_{31} & a^{i-1}_{32} & a^{i-1}_{33} & a^{i-1}_{34} \\ a^{i-1}_{41} & a^{i-1}_{42} & a^{i-1}_{43} & a^{i-1}_{44} \end{bmatrix} \begin{bmatrix} \varepsilon^{g}_{t+1} \\ \varepsilon^{r}_{t+1} \\ \varepsilon^{d}_{t+1} \\ \varepsilon^{p}_{t+1} \end{bmatrix}$$

where the forecast error for domestic supply shocks Δy^{d}_{t} is:

$$\Delta y^{d}_{t+i} - \Delta y^{d}_{t+i|t} = \left(a^{0}_{31}\varepsilon^{g}_{t+i} + \cdots + a^{i-1}_{31}\varepsilon^{g}_{t+1}\right) + \left(a^{0}_{32}\varepsilon^{r}_{t+i} + \cdots + a^{i-1}_{32}\varepsilon^{r}_{t+1}\right)$$
$$+\left(a^{0}_{33}\varepsilon^{d}_{t+i} + \cdots + a^{i-1}_{33}\varepsilon^{d}_{t+1}\right) + \left(a^{0}_{34}\varepsilon^{p}_{t+i} + \cdots + a^{i-1}_{34}\varepsilon^{p}_{t+1}\right)$$

Since it is assumed that $\varepsilon_t \sim \text{i.i.d.}\,(0, I)$, the variance of forecast error for domestic supply shocks can be decomposed as:

$$\text{var}\left(\Delta y^{d}_{t+i} - \Delta y^{d}_{t+i|t}\right) = \sigma^2_d$$
$$= \left((a^{0}_{31})^2 + \cdots + \left(a^{i-1}_{31}\right)^2\right) + \left((a^{0}_{32})^2 + \cdots + \left(a^{i-1}_{32}\right)^2\right)$$
$$+ \left((a^{0}_{33})^2 + \cdots + \left(a^{i-1}_{33}\right)^2\right) + \left((a^{0}_{34})^2 + \cdots + \left(a^{i-1}_{34}\right)^2\right)$$

where the proportion of σ^2_d due to global shocks is then:

$$\rho_{d,g} = \frac{(a^{0}_{31})^2 + \cdots + \left(a^{i-1}_{31}\right)^2}{\sigma^2_d}$$

Table 6 reports FEVD of internal shocks in three VAR models. Because of space limitation, FEVD results are reported at the 2nd and 15th year forecast horizons, which are regarded as short-term and long-term effects. For simplicity, the long-term results are discussed first.

In the bivariate model, global shocks explain an average of 14.04% variation in non-global output growth, while non-global shocks contribute more than 85%. Because of the strongly dominant status of non-global shocks, I split them into regional and domestic shocks. In the three-variable model, the percentage contribution of global shocks falls to 12.72%, while the regional and domestic shocks explain an average of 13.86% and 73.43% variation in domestic output growth. The highly dominant domestic shocks are then decomposed into domestic supply and domestic demand shocks. In the four-variable VAR model, global and regional shocks remain dominated, explaining 10.10% and 14.20% variation in domestic output growth. Domestic demand shocks provide the least contribution to the change, whereas domestic supply shocks contribute an average of 69.95% to the fluctuation of domestic output.

The three models give rise to consistent FEVD outcomes, revealing that internal shocks play the most important role in explaining movements of domestic output growth in the long run. The extent of dominance of internal shocks varies across both time horizon and country, which implies the divergence of the East Asian countries' development strategy in terms of timing, resource dependence, and production structure. In sharp contrast, global and regional supply shocks are notably dominated, reflecting that external shocks impose limited influences on economic performances of East Asian countries. Moreover, domestic demand shocks have relatively small contribution in explaining the variation in output growth.

It is found that the short-term impacts of shocks are not essentially different from the long-term influences. However, the minor differences between the short run and the long run provide some implications for the persistence of shocks. On average, both global and regional shocks impose larger influences on domestic output growth in the long term, reflecting the persistent influences of external shocks. Conversely, despite the dominance of domestic supply shocks, they are essentially transitory since their contribution gradually shrinks over time.

5.2. Correlation of Structural Disturbances

FEVD analysis provides information on the shocks' contribution to internal output variation. I find that domestic output fluctuation is mostly subject to internal shocks. In addition to the FEVD analysis, I also examine the symmetry of shocks. Even if internal shocks dominate the variation in domestic output, asymmetry of shocks will undermine the suitability of an East Asian currency union.

Table 5: Engle-Granger and Johansen Tests for Cointegration

		EG Test	Johansen Test		
	Country	Coefficient on lagged residuals	# of cointegration vectors at size of		
			1%	5%	10%
Panel A	Japan	-0.37***	0	0	1
(1951-2010)	China	-0.40***	0	0	1
	Hong Kong	-0.27***	0	0	0
	Indonesia	-0.29***	0	0	0
	Korea	-0.19**	0	0	0
	Malaysia	-0.23***	0	0	0
	Philippines	-0.28***	0	0	0
	Singapore	-0.31***	0	0	0
	Thailand	-0.28***	0	0	0
	Taiwan	-0.28***	0	0	0
	Vietnam	-0.41**	0	0	0
Panel B	China	-0.35***	0	0	0
(1951-2010)	Hong Kong	-0.38***	0	0	0
	Indonesia	-0.42***	0	0	0
	Korea	-0.34***	0	0	0
	Malaysia	-0.35***	0	0	0
	Philippines	-0.36***	0	0	0
	Singapore	-0.36**	0	0	0
	Thailand	-0.37***	0	0	0
	Taiwan	-0.34***	0	0	0
	Vietnam	-0.31**	0	0	0
Panel C	China	-0.37***	0	0	0
(1961-2010)	Hong Kong	-0.39***	0	0	0
	Indonesia	-0.62***	0	0	0
	Korea	-0.47***	0	0	0
	Malaysia	-0.40***	0	0	0
	Philippines	-0.37**	0	0	0
	Singapore	-0.36**	0	0	0
	Thailand	-0.33***	0	0	0

Notes:

1. Panel A-C represent two-, three- and four- variable models respectively. The cointegration tests are performed between the US output and one East Asian economy's output in Panel A, among the US, Japan, and one East Asian economy's outputs in Panel B, and among the output of the US, Japanese output, one East Asian economy's output, and one East Asian economy's GDP deflator in Panel C.
2. There is a linear time trend for all tests.
3. The critical values for the test statistics are reported by MacKinnon (1990, 2010) using response surface regressions. ***, **, and * indicate statistical significance at 1%, 5%, and 10% chosen size. Failure to reject the null hypothesis indicates no cointegration.
4. Coefficient on the lagged residuals in the second step of EG test is reported, whose traditional t-statistics are equal to EG test statistics. ***, **, and * indicate statistical significance at 1%, 5%, and 10% chosen size.

Table 6: Forecast Error Variance Decomposition (1951-2010)

	2nd yr	15th yr	2nd yr	15th yr	2nd yr	15th yr	2nd yr	15th yr
Panel A	**Global Shocks**		**Non-global Shocks**					
Japan	21.72	17.25	78.28	82.75				
China	0.45	3.21	99.55	96.79				
HongKong	14.65	17.81	85.35	82.19				
Indonesia	4.30	5.13	95.70	94.87				
Korea	10.35	12.71	89.65	87.29				
Malaysia	10.47	15.53	89.53	84.47				
Philippines	2.54	2.48	97.46	97.52				
Singapore	2.90	8.10	97.10	91.90				
Thailand	1.36	2.64	98.64	97.36				
Taiwan	27.59	25.20	72.41	74.80				
Vietnam	0.74	44.35	99.26	55.65				
Average	*8.82*	*14.04*	*91.18*	*85.12*				
Median	*4.30*	*12.71*	*95.70*	*87.29*				
Std. Dev.	*9.19*	*12.52*	*9.19*	*12.52*				
Panel B	**Global Shocks**		**Regional Shocks**		**Domestic Shocks**			
China	2.01	3.08	17.24	17.95	98.49	78.97		
HongKong	16.88	19.36	5.73	13.70	77.39	66.94		
Indonesia	3.51	5.60	13.71	16.77	82.77	77.71		
Korea	11.08	13.98	4.21	4.46	84.71	81.56		
Malaysia	10.31	15.88	6.28	7.95	83.41	76.17		
Philippines	2.33	2.39	4.63	6.55	93.03	91.06		
Singapore	2.59	8.70	8.56	11.90	88.85	79.40		
Thailand	1.07	2.02	14.57	17.70	84.36	80.28		
Taiwan	31.95	28.13	6.74	18.23	61.32	53.63		
Vietnam	0.54	28.02	0.38	23.38	99.07	48.60		
Average	*8.23*	*12.72*	*8.21*	*13.86*	*85.34*	*73.43*		
Median	*3.05*	*11.34*	*6.51*	*15.24*	*84.54*	*78.34*		
Std. Dev.	*9.93*	*10.05*	*5.32*	*6.06*	*10.98*	*13.19*		
Panel C	**Global Shocks**		**Regional Shocks**		**Domestic Supply Shocks**		**Domestic Demand Shocks**	
China	0.20	2.61	8.70	8.21	84.33	80.00	6.84	9.17
HongKong	16.36	18.30	8.73	14.61	76.91	65.83	1.25	1.27
Indonesia	2.76	4.22	18.36	22.94	69.77	64.54	9.12	8.31
Korea	10.48	11.04	12.23	14.32	75.46	72.19	1.83	2.45
Malaysia	9.14	17.05	11.93	13.61	77.38	67.60	1.55	1.73
Philippines	6.96	12.82	5.01	5.23	73.32	67.20	14.71	14.75
Singapore	2.31	9.63	8.43	11.32	88.57	78.00	0.69	1.05
Thailand	4.76	5.11	18.13	23.36	70.33	64.27	6.79	7.26
Average	*6.62*	*10.10*	*11.44*	*14.20*	*77.01*	*69.95*	*5.35*	*5.75*
Median	*5.86*	*10.34*	*10.33*	*13.97*	*76.19*	*67.40*	*4.31*	*4.86*
Std. Dev.	*5.27*	*5.85*	*4.76*	*6.39*	*6.55*	*6.12*	*4.95*	*4.94*

Notes:

1. Panel A and B represent two- and three-variable VAR models during 1951-2010. Panel C represents four-variable VAR model during 1961-2010.
2. Reported are the variance decompositions of forecast errors for domestic output growth for East Asia at the 2- and 15-year forecast horizons, which are taken as short-term and long-term effects.

In this part, I will examine the symmetry of shocks by computing the correlations of structural disturbances. If the correlations are statistically significant and positive, the shocks are categorized as symmetric. If the correlations turn out to be negative or statistically insignificant, the shocks are asymmetric.

In order to determine the statistical significance of the correlations, I refer to the critical values of the Pearson product-moment correlation coefficient. My sample pairs of structural disturbances are independent and identically distributed, satisfying the assumptions underlying the Pearson test. The null hypothesis is statistically insignificant correlations against alternatives of statistically significant linear relationships. The degree of freedom is equal to the number of pairs minus two. I will use the two-tail test given no prior expectations about the sign of the correlation coefficients.

Table 7 reports the correlation of structural shocks. Because global and regional shocks are identical and exhibit perfectly positive correlations across countries, I concentrate on the correlation of internal shocks. In the bivariate model, the non-global shocks of East Asian countries except China and Vietnam are statistically significantly inter-correlated. Next I regard Japan as the regional economy representative and look into the correlation of domestic shocks in the rest of East Asia. In the three-variable model, domestic shocks show symmetry across the same group of countries as identified in Panel A. Next, I decompose domestic shocks into demand and supply parts. Because domestic demand shocks are sensitive to macroeconomic policies, I focus on the symmetry of domestic supply shocks. In the four-variable model, the number of symmetric domestic supply shocks is less than that of symmetric domestic shocks in Panel B, reflecting the impact of policy coordination on linking up domestic shocks.

To visualize the symmetry, I describe the symmetric relationships with arrows in Figure 3. Two sub-groups of economies are identified based on the symmetry. The first (interrelated by red arrows) is made up of Hong Kong, South Korea, Malaysia, and Singapore, while the second (associated by blue arrows) includes Indonesia, South Korea, Malaysia, and Thailand. The selected groups are comparable to Bayoumi and Eichengreen (1994), Ling (2001) and Huang and Guo (2005).

Figure 3: Symmetry of Domestic Supply Shocks

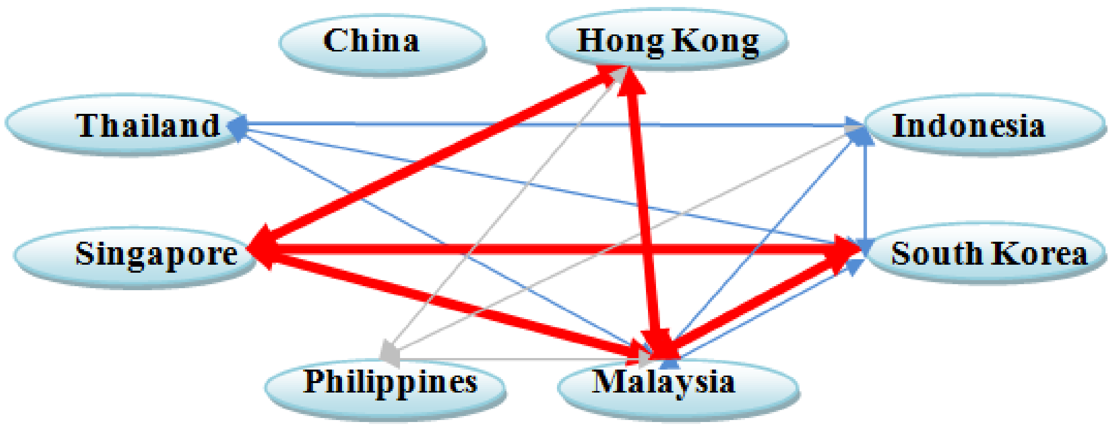


Table 7: Correlation of Structural Disturbances across East Asian Countries

Panel A. Non-global Shocks (1951-2010)

	JP	CN	HK	IN	KR	MA	PH	SG	TH	TW	VN
Japan	1.00										
China	0.19	1.00									
Hong Kong	0.40***	0.19	1.00								
Indonesia	0.14	0.18	0.54***	1.00							
Korea	0.34***	0.12	0.48***	0.63***	1.00						
Malaysia	0.21	0.01	0.58***	0.67***	0.64***	1.00					
Philippines	0.27**	0.10	0.58***	0.39***	0.29**	0.44***	1.00				
Singapore	0.27**	0.14	0.53***	0.37***	0.47***	0.82***	0.44***	1.00			
Thailand	0.49***	0.12	0.44***	0.60***	0.65***	0.50***	0.31**	0.36***	1.00		
Taiwan	0.37***	0.08	0.62***	0.17	0.36***	0.34***	0.32**	0.43***	0.38***	1.00	
Vietnam	0.19	0.04	0.06	0.06	0.08	0.04	0.16	0.07	0.20	0.35***	1.00

Panel B. Domestic Shocks (1951-2010)

	CN	HK	IN	KR	MA	PH	SG	TH	TW	VN
China	1.00									
Hong Kong	0.29**	1.00								
Indonesia	0.33**	0.45***	1.00							
Korea	0.18	0.35***	0.57***	1.00						
Malaysia	0.16	0.54***	0.58***	0.61***	1.00					
Philippines	0.18	0.56***	0.32**	0.22	0.39***	1.00				
Singapore	0.17	0.45***	0.31**	0.35***	0.81***	0.41***	1.00			
Thailand	0.11	0.28*	0.60***	0.60***	0.48***	0.22	0.22	1.00		
Taiwan	0.12	0.55***	0.11	0.28*	0.33**	0.27*	0.35***	0.26*	1.00	
Vietnam	0.09	0.09	0.04	0.21	0.01	0.06	0.11	0.02	0.10	1.00

Table 7 (cont.)
Panel C. Domestic Supply Shocks (1961-2010)

	CN	HK	IN	KR	MA	PH	SG	TH
China	1.00							
Hong Kong	0.27	1.00						
Indonesia	0.10	0.18	1.00					
Korea	0.13	0.29	0.49***	1.00				
Malaysia	0.12	0.36*	0.43**	0.53***	1.00			
Philippines	0.10	0.46**	0.32*	0.23	0.38**	1.00		
Singapore	0.12	0.32*	0.29	0.32*	0.75***	0.31	1.00	
Thailand	0.16	0.27	0.37**	0.42**	0.46**	0.20	0.23	1.00

Notes:
1. Panel A- C represent two-, three-, and four- variable VAR models.
2. Negative correlations coefficients are underlined, and ***, **, and * refers to statistical significance at 1%, 5%, and 10% significance level.
3. At 1% significance level, the critical values of Pearson correlation coefficient are 0.34, 0.35, and 0.48 in Panel A, B, and C. At 5% significance level, the critical values are 0.27, 0.29, and 0.37 in Panel A, B, and C. At 10% significance level, the critical values are 0.22, 0.25, and 0.32 in Panel A, B, and C.

So far, two geographic groups emerge in the statistical sense. The symmetry among each group makes them suitable candidates to join a common currency. One thing that OCA studies should note is that there is no absolute yardstick to decide whether a given currency area is optimal, and hence additional benchmarks are needed. For ease of comparison, I first refer to the average correlation coefficient of aggregate supply for East Asia, which is 0.34 in Bayoumi and Eichengreen (1994). Using 0.34 as an alternative critical value of correlation coefficients, the sub-group identified will incorporate fewer countries. Another natural reference is the EU. Bayoumi and Eichengreen estimate an average correlation coefficient of aggregate supply shocks at 0.53. Based on the criteria, no geographic group in East Asia can be identified. My study is not parallel to Bayoumi and Eichengreen because of the differences in identification of shocks and sampling. However, the comparison reminds us to be cautious in identifying members of a currency union by taking into account both statistical and economic implications.

5.3. Size of Disturbances and Speed of Adjustment

Besides FEVD and correlation analysis, another integral part of structural VAR analysis is structural IRFs. The structural IRFs are plots of a^{i}_{jk} for j, k=1,2,3,4. The plots summarize how unit impulses of the structural shocks at time t impact the level of Δy at time t+i for different values of i. For instance, Eq.(2) can be rewritten as

$$\begin{bmatrix}\Delta y^{g}_{t+i}\\ \Delta y^{r}_{t+i}\\ \Delta y^{d}_{t+i}\\ \Delta p^{d}_{t+i}\end{bmatrix}=\begin{bmatrix}\mu^{g}\\ \mu^{r}\\ \mu^{d}\\ \mu^{p}\end{bmatrix}+\begin{bmatrix}a^{0}_{11} & a^{0}_{12} & a^{0}_{13} & a^{0}_{14}\\ a^{0}_{21} & a^{0}_{22} & a^{0}_{23} & a^{0}_{24}\\ a^{0}_{31} & a^{0}_{32} & a^{0}_{33} & a^{0}_{34}\\ a^{0}_{41} & a^{0}_{42} & a^{0}_{43} & a^{0}_{44}\end{bmatrix}\begin{bmatrix}\varepsilon^{g}_{t+i}\\ \varepsilon^{r}_{t+i}\\ \varepsilon^{d}_{t+i}\\ \varepsilon^{p}_{t+i}\end{bmatrix}+\cdots+\begin{bmatrix}a^{i}_{11} & a^{i}_{12} & a^{i}_{13} & a^{i}_{14}\\ a^{i}_{21} & a^{i}_{22} & a^{i}_{23} & a^{i}_{24}\\ a^{i}_{31} & a^{i}_{32} & a^{i}_{33} & a^{i}_{34}\\ a^{i}_{41} & a^{i}_{42} & a^{i}_{43} & a^{i}_{44}\end{bmatrix}\begin{bmatrix}\varepsilon^{g}_{t}\\ \varepsilon^{r}_{t}\\ \varepsilon^{d}_{t}\\ \varepsilon^{p}_{t}\end{bmatrix}+\cdots$$

where the structural dynamic multiplier $\frac{\partial \Delta y^{d}_{t+i}}{\partial \varepsilon^{g}_{t}} = a^{i}_{31}$ depicts the impact of a unit global shock at time t on domestic output growth i periods later.

The IRFs can be described in two dimensions, namely, the size of shocks and the speed at which the respective economies adjust. Given any cross-country correlations, larger disturbances will have more disruptive effects; hence, more macroeconomic policies are needed to offset the influences. Similarly, when the response of an economy to disturbances gets slower, “the costs of permanently fixing the exchange rate and of forgoing policy autonomy will be larger” (Bayoumi and Eichengreen, 1994, p. 27). In both cases, a common currency is less suitable.

In this part, I define and calculate size of disturbances and speed of adjustment in the same way as Bayoumi and Eichengreen (1992, 1994). Both size and speed of internal shocks are inferred from associated IRFs. The IRFs of global and regional shocks are not studied in this part, because they are mixtures of demand and supply shocks, which are measured differently in Bayoumi and Eichengreen. Therefore, there is no coherent way to define the external shocks. In line with the AD-AS analysis, the size of domestic supply shocks, $\mathrm{Size}^{\mathrm{d}}$, is measured as their long-run effects on domestic output and domestic price and is given by

$$\mathrm{Size}^{\mathrm{d}} = \sum_{i=0}^{15} a_{33}^{i} + \sum_{i=0}^{15} a_{34}^{i}$$

while size of domestic demand shocks, $\mathrm{Size}^{\mathrm{p}}$, is defined as the sum of the first-year impact on both domestic output and price and is as follows

$$\mathrm{Size}^{\mathrm{p}} = \sum_{i=0}^{1} a_{43}^{i} + \sum_{i=0}^{1} a_{44}^{i}$$

The speed of adjustment is summarized by the response in the short-term (the 2nd year) as a share of the long-run effect (the 15th year) and is given by

$$\mathrm{Speed}^{\mathrm{d}} = \frac{\sum_{i=0}^{2} a_{33}^{i} + \sum_{i=0}^{2} a_{34}^{i}}{\sum_{i=0}^{15} a_{33}^{i} + \sum_{i=0}^{15} a_{34}^{i}}, \mathrm{Speed}^{\mathrm{p}} = \frac{\sum_{i=0}^{2} a_{43}^{i} + \sum_{i=0}^{2} a_{44}^{i}}{\sum_{i=0}^{15} a_{43}^{i} + \sum_{i=0}^{15} a_{44}^{i}}$$

Table 8 outlines the size and the speed of individual shocks. Averages for both the entire sample and the selected sub-groups are reported. A natural benchmark for comparison is Bayoumi and Eichengreen (1994), in which the size of domestic supply and demand shocks in East Asia are on average 0.03 and 0.04, and the speeds are 1.16 and 0.93 individually. In my model, however, the size of domestic supply shocks ranges between 0.07 and 0.08, and demand shocks between 0.04 and 0.06. At the same time, the speeds of adjustment are at most 0.86 and 0.84 for domestic supply and demand shocks. The larger size of disturbances and slower adjustment seem to undermine the suitability to form a currency union in East Asia. Nevertheless, by comparing with EU and US, the confidence on a common currency can be reestablished. The average sizes of supply and demand shocks in Western Europe are 0.04 and 0.03, at speeds of 0.68 and 0.42 respectively. Similarly, the sizes in US are 0.06 and 0.14 on average, at speeds of 0.80 and 0.82. Although the sizes of shocks in my sample are larger than those in the EU, the shocks adjust at remarkably higher speeds than those in EU. Besides, the domestic supply shocks in my sample are of similar size and adjustment speed to those of the US, and the domestic demand shocks are of smaller size and slightly higher adjustment speed than those of the US. In order to visualize the countries' size and adjustment speed of domestic supply shocks, I also provide scatter plots in Figure 4. Countries locating at the lower and right part of EU and US refer to optimal candidates for a currency union. The mixed comparison results imply East Asia and the two selected groups may be suitable to join a currency union, because of the high adjustment speed and moderate-sized disturbances.

Table 8: Size of Disturbance and Speed of Adjustment

Country	**Domestic Supply Shocks**		**Domestic Demand Shocks**	
	Size	Speed	Size	Speed
China	0.06	1.10	0.05	0.86
Hong Kong	0.09	0.76	0.04	0.43
Indonesia	0.03	0.35	0.11	0.95
Korea	0.09	0.70	0.06	0.51
Malaysia	0.08	0.95	0.03	0.94
Philippines	0.02	0.33	0.08	0.89
Singapore	0.07	1.04	0.04	1.06
Thailand	0.08	0.91	0.05	0.97
Average	*0.07*	*0.77*	*0.06*	*0.83*
*Average**	*0.08*	*0.86*	*0.04*	*0.74*
*Average***	*0.07*	*0.73*	*0.06*	*0.84*

Notes:
1. The average among Hong Kong, South Korea, Malaysia, and Singapore is indicated by *.
2. The average based on Indonesia, South Korea, Malaysia, and Thailand is represented by ** .

5.4. Stability Test

During the sampling period from 1951 through 2010, the East Asian economies experienced significant economic changes. For instance, the 1997 Asian financial crisis, the 1990 Japanese asset price bubble episode, the rapid economic growth of China since 1978, as well as the 2007-2008 global financial crisis shaped the economic environment in East Asia. The drastically changing economic relationships may make the estimates in the VAR models unstable. In this section, I will examine the stability of the VAR models.

In order to check the stability of the VAR models over time, I will split the sample into halves and re-estimate the VAR models using the second half of the sample. Then I will compare the forecast error variance decomposition (FEVD) with the full-sample VAR models. FEVD is examined since the key statistics reflect the contribution of individual shocks to domestic output growth. If the re-estimated FEVD results are similar to those using the full sample, the models present a reasonable degree of robustness. If the re-estimated FEVD results provide a fair amount of evidence of instability, the robustness of the models is undermined.

Table 9 shows the re-estimation results of FEVD using the second half of the sample. Comparing with the counterparts in Table 6, I find some evidence of instability with the VAR models. The variance decomposition outcome of the two-variable VAR model seems invariant to the sample selected. Although the domestic shocks remain dominant in the three-variable model, the contribution of regional shocks increases to an average of 23.42% which almost triples the 8.21% using the full sample. The four-variable VAR model presents strong evidence of instability, since regional shocks dominate over domestic supply shocks during the time period of 1986-2010.

Despite the presence of instability with my VAR models, I do not have a large dataset so splitting the sample may not be an appropriate approach to check the robustness. Nevertheless, the preliminary stability test suggests that improving the robustness of VAR models with long-run restrictions is an area for future research.

Table 9: Forecast Error Variance Decomposition (1981-2010)

Panel A	**2^{nd} yr**	**15^{th} yr**	**2^{nd} yr**	**15^{th} yr**	**2^{nd} yr**	**15^{th} yr**	**2^{nd} yr**	**15^{th} yr**
(1981-2010)	**Global Shocks**		**Non-global Shocks**					
Japan	28.45	29.30	71.55	70.70				
China	0.42	15.43	99.58	84.57				
HongKong	12.07	12.81	87.93	87.19				
Indonesia	7.06	8.06	92.94	91.94				
Korea	11.11	11.12	88.89	88.88				
Malaysia	7.93	17.35	92.07	82.65				
Philippines	22.34	29.17	77.66	70.83				
Singapore	8.78	23.49	91.22	76.51				
Thailand	0.37	1.23	99.62	98.77				
Taiwan	44.01	41.46	55.99	58.54				
Vietnam	5.24	37.28	94.76	62.72				
Average	*13.43*	*20.61*	*86.56*	*79.39*				
Median	*8.78*	*17.35*	*91.22*	*82.65*				
Std. Dev.	*13.22*	*12.61*	*13.22*	*12.61*				
Panel B (1981-2010)	**Global Shocks**		**Regional Shocks**		**Domestic Shocks**			
China	1.69	11.83	4.33	14.34	93.98	73.83		
HongKong	5.79	6.99	32.35	35.14	61.86	57.87		
Indonesia	9.01	12.98	13.35	13.08	77.64	73.94		
Korea	4.28	4.38	34.58	34.54	61.14	61.08		
Malaysia	2.31	7.99	28.20	27.15	69.48	64.86		
Philippines	26.16	25.61	4.76	10.78	69.08	63.61		
Singapore	3.32	13.88	29.38	27.00	67.31	59.12		
Thailand	2.08	1.90	46.14	53.37	51.78	44.72		
Taiwan	27.88	22.52	37.14	49.32	34.98	28.16		
Vietnam	4.36	40.18	4.01	15.00	91.63	44.82		
Average	*8.69*	*14.83*	*23.42*	*27.97*	*67.89*	*57.20*		
Median	*4.32*	*12.41*	*28.79*	*27.08*	*68.20*	*60.10*		
Std. Dev.	*9.90*	*11.62*	*15.48*	*15.16*	*17.54*	*14.25*		
Panel C	**2^{nd} yr**	**15^{th} yr**	**2^{nd} yr**	**15^{th} yr**	**2^{nd} yr**	**15^{th} yr**	**2^{nd} yr**	**15^{th} yr**
(1986-2010)	**Global Shocks**		**Regional Shocks**		**Domestic Supply Shocks**		**Domestic Demand Shocks**	
China	6.34	8.81	7.69	12.55	79.88	72.28	6.09	6.36
HongKong	7.52	7.83	43.56	43.12	46.68	46.97	2.23	2.08
Indonesia	13.12	28.14	31.38	26.33	52.38	42.44	3.12	3.08
Korea	12.90	14.17	56.71	49.90	0.89	9.76	29.49	26.16
Malaysia	3.52	4.04	59.69	57.85	27.77	28.85	9.01	9.27
Philippines	1.45	17.31	29.92	39.04	36.23	22.98	32.40	20.67
Singapore	6.53	22.30	75.55	54.30	15.50	10.66	2.42	12.73
Thailand	2.21	3.18	29.72	34.80	57.81	52.35	10.26	9.67
Average	*6.70*	*13.22*	*41.78*	*39.74*	*39.64*	*35.79*	*11.88*	*11.25*
Median	*6.44*	*11.49*	*37.47*	*41.08*	*41.46*	*35.65*	*7.55*	*9.47*
Std. Dev.	*4.45*	*8.91*	*21.53*	*15.11*	*25.07*	*21.70*	*12.16*	*8.40*

Notes: 1. Panel A- C represent two-, three-, and four- variable VAR models.

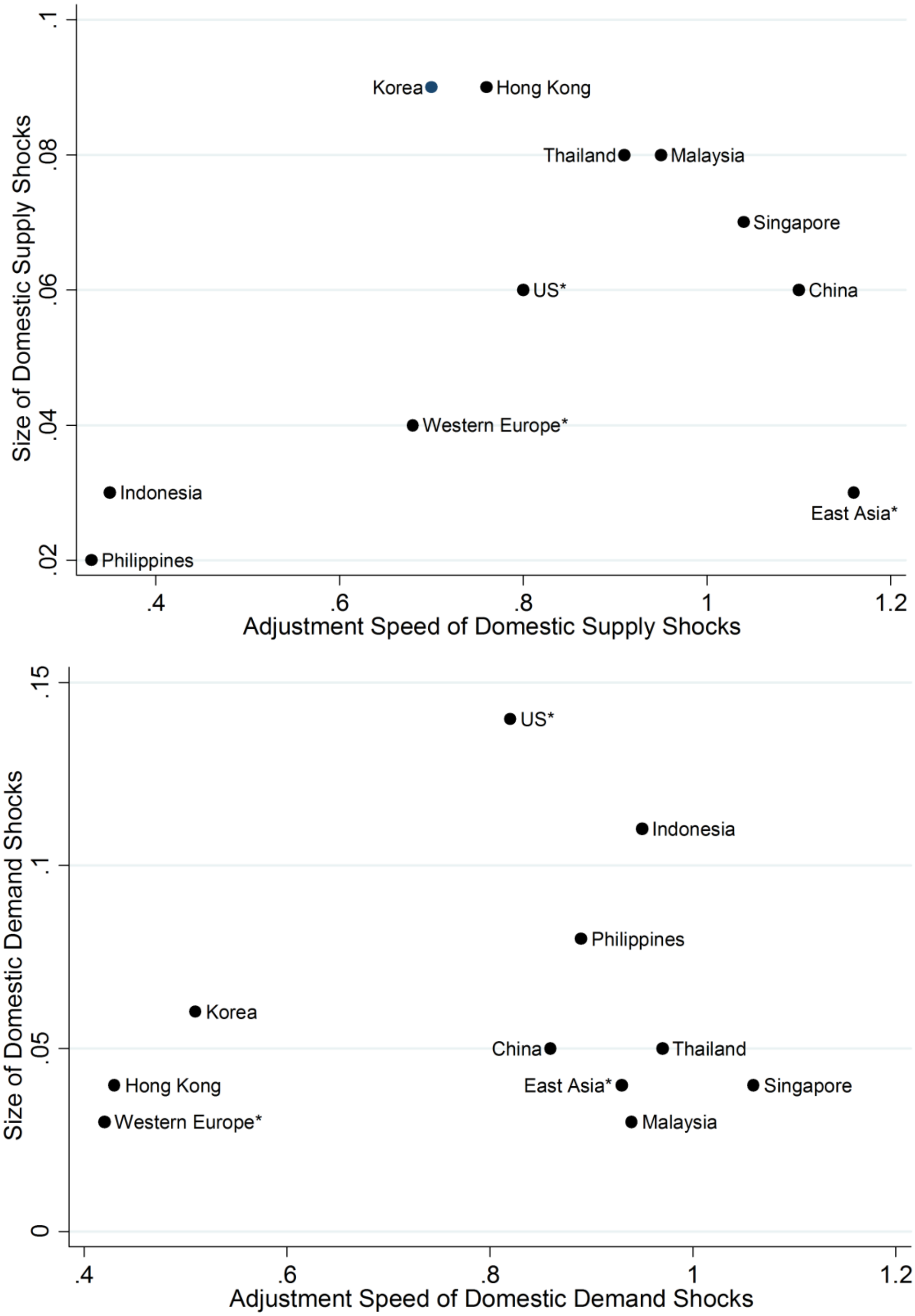
2. Reported are the variance decompositions of forecast errors for domestic output growth for East Asia at the 2- and 15-year forecast horizons, which are taken as short-term and long-term effects.

6. Conclusion

This chapter investigates the nature of macroeconomic shocks in eleven East Asian countries as a way of identifying economies that could form a currency union. I set up a series of structural VAR models incorporating four types of shocks: global, regional, domestic supply as well as domestic demand shocks. Both the long-run restrictions by Blanchard and Quah (1989) and block exogeneity restrictions are imposed to identify the structural shocks.

The forecast error variance decomposition analysis displays dominance of domestic supply shocks in driving domestic output growth, and correlation analysis identifies two geographic groups as exhibiting symmetry in domestic supply shocks. The first group is made up of Hong Kong, South Korea, Malaysia, and Singapore, while the second includes Indonesia, South Korea, Malaysia, and Thailand. The following investigations into the size of domestic shocks and speed of adjustment show that the two groups of economies experience smaller-sized shocks and faster adjustment upon shocks compared with the US and EU, strengthening the suitability for them to establish monetary unification. However, the following stability test suggests that the estimation results are not invariant to time period, which undermines the strength of my conclusion. Because of the small sample size, splitting the sample may not be an appropriate way to examine the robustness. Stability of VAR models, however, is an area that future studies could focus on.

Figure 4: Size of Shocks and Speed of Adjustment



Notes: Economies with asterisk are identified based on estimates in Bayoumi and Eichengreen (1994).

One drawback of the paper is the imposition of the Blanchard and Quah (1989) long-run restrictions. Faust and Leeper (1997) criticize that the structural inferences under the long-run scheme may not be reliable. The reliability of the structural conclusions depend on the quality of the VAR estimates of A(1). However, the estimate of A(1) is very uncertain even in large samples, and “the long-run identification transfers this imprecision to the estimation of other parameters” (p. 345). The authors suggest to impose short-run restrictions and then to use the middle-to-long horizon properties of the model as an informal diagnostic. In addition, Cooley and Dwyer (1998) argue that the model is not based on a specification of underlying preferences and technology and the equilibrium concept is not articulated. Even if none of the underlying demand shocks affects output in the long run, the long-run scheme will mix the underlying demand and supply shocks in both of the estimated disturbances, invalidating the economic interpretation. This is because the underlying model has more sources of shocks than does the estimated model. One solution is to estimate larger-dimensional models with multiple shocks.

While this chapter empirically identifies a collective peg attractive among groups of East Asian economies, realistic issues need to be solved first. To begin with, political commitments are essential to the fulfillment of a monetary union, and East Asia exhibits major weaknesses in political solidarity. The monetary unification became possible in Europe because of their strong political desires to unite, and the build-up of formalized European institutions. However, the political drive to move forward into a common currency is relatively low in East Asia, and “there are no East Asian institutions similar in form or function to those of the European Union – those needed to produce the legislation required to integrate financial markets and set common standards for the supervision of financial institutions” (Kenen & Meade, 2006, p.3). The absence of institutional infrastructure in East Asia determines that it is difficult to create a monetary union in the short term. Another difficulty is that the vulnerable East Asian banking system should be strengthened. Because emerging markets experience immense capital inflows and outflows, financial disturbances become an increasingly prevalent source of asymmetric shocks. Therefore, East Asian emerging economies currently need exchange rate flexibility and monetary independence, both of which are against a common peg.

Chapter Three: Contrasting Effect of Intra- and Inter-Industry Trade on Business Cycle Synchronization

1. Introduction

The theory of Optimum Currency Area (OCA) describes the optimal characteristics for a geographical region to form a monetary union.[11] The theoretical criteria, such as factor (capital and labor) mobility, price flexibility, and financial integration, are preconditions for candidates to join a currency union, so that the benefits of a monetary union can outweigh its costs. These theoretical criteria, however, are commonly difficult to measure unambiguously. Among a large number of empirical studies on the OCA theory, some examine the degree of business cycle synchronization (i.e., cross-country correlation of output growth) and trade intensity. It is generally agreed that the higher degree of business cycle synchronization and the higher trade intensity, the more suitable for the countries to join a monetary union. For example, see Frankel and Rose (1998), Rose (2000), Imbs (2004), Fidrmuc and Korhonen (2006) and Calderón et al. (2007).

Business cycle synchronization and trade intensity, however, are interdependent. Some researchers argue that closer trade ties result in tighter correlation of national business cycles (Canova & Dellas, 1993; Kenen, 2000; Kollman, 2001; Baxter & Kouparitsas, 2005), and therefore better fulfillment of the OCA criteria. However, other scholars find the opposite (Imbs, 1999; Kose & Yi, 2001). In this case, higher trade intensity between countries weakens synchronization and reduces the suitability to join a monetary union. The discrepancy between aggregate trade intensity and business cycle synchronization influences the validity of trade as

[11] For more comprehensive surveys on the OCA criteria, refer to Kawai (1987) and Tavlas (1993).

one of the OCA criteria. In order to further explore the interdependence, Gruben et al. (2002), Shin and Wang (2004), and Fidrmuc (2004) decompose aggregate trade and they find that it is the intra-industry trade, as opposed to aggregate trade intensity, that explains increased business cycle synchronization.[12]

According to previous studies, aggregate trade can be categorized into inter-industry trade and intra-industry trade. The former refers to international exchange of goods in different sectors, such as the import of wines in return for exported natural resources. Economists associate inter-industry trade with the traditional theory of comparative advantage. The comparative advantage comes from either technology in the classic Ricardian model, or relative factor endowments in the Heckscher-Ohlin model (Dornbusch et al., 1977; Aquino, 1978; Leamer, 1995; Bernstein & Weinstein, 2002; Feenstra, 2004).[13] Helpman and Krugman (1987) and Hummels and Levinsohn (1995) maintain that developing countries tend to specialize according to their comparative advantages and hence inter-industry trade dominates bilateral trade between developing countries.

Intra-industry trade, on the other hand, refers to simultaneous imports and exports of similar products in the same sector. Markusen et al (1987, p. 204) maintain that most of the trade in the manufacturing industry among industrialized countries involves intra-industry trade, such as high-technology electronics, automobiles, and consumer durables. Markusen (1984) argues that three factors contribute to the existence of intra-industry trade. The first factor is transport cost. When the transport cost across national borders is lower than that within the same country, intra-industry trade may emerge. For instance, lumber is exported from British Columbia to the state of Washington and simultaneously exported from Maine to Quebec. Two-way trade associated

[12] Gruben et al. (2002) employ intra-industry trade intensity, while Shin and Wang (2004) and Fidrmuc (2004) use the share of intra-industry trade. See literature review for details.

[13] In the Heckscher-Ohlin model, labor-abundant countries tend to export labour-intensive goods, such as clothing, and capital-abundant countries tend to export capital-intensive goods, such as automobiles.

with transport costs is common when localized markets exist across national borders. The second factor is product differentiation. If consumers have heterogeneous preferences over domestic and imported goods, the products are viewed as imperfect substitutes differentiated by style, quality, and services. Intra-industry trade is simply an extension of tastes for variety across borders. The third factor is increasing returns to scale. If each country produces a relatively smaller range of differentiated goods and each good is subject to increasing returns, the combination of product differentiation and returns to scale will lead to economically significant intra-industry trade.

The different nature of intra-industry trade and inter-industry trade implies that increased trade linkage between trading partners may move their business cycles in either direction — towards convergence or divergence. Kenen (1969) argues that closer trade ties can result in countries becoming more specialized in the goods in which they have comparative advantage. The greater specialization induces the countries to be more sensitive to industry-specific supply shocks, tentatively leading to more idiosyncratic business cycles. On the other hand, if common demand shocks dominate or intra-industry trade accounts for most of aggregate trade, business cycles would be more synchronized between trade partners with intensive intra-industry trade. The mechanism through which international trade affects business cycle synchronization can be better revealed when intra- and inter-industry trade effects are accounted for separately. I hypothesize that intra-industry trade increases business cycle synchronization whereas inter-industry trade might lead to less synchronization. At the very least, I expect the effect of intra- and inter-industry trade to differ.

The different nature of intra- and inter-industry trade also provides implications to the validity of aggregate trade as one of the OCA criteria. As one might expect, the components of trade may have different, even contrasting, effects on synchronization. For two countries whose intra-industry trade dominates inter-industry trade, the overall effect of aggregate trade on synchronization is more likely to be positive and hence the countries can better satisfy the OCA criteria. If, however, two countries have exclusive inter-industry trade, aggregate trade may weaken the business cycle synchronization, making the two countries fail to meet the OCA requirements. Studying the interdependence between components of trade and synchronization helps improve scholars' understanding of aggregate trade as one of the OCA criteria.

International trade is one channel through which country or region-specific shocks impact economic interdependence between countries. In general, the greater the interdependence between two countries, the larger the anticipated correlation of their output fluctuations (Kose et al., 2003). Following Otto et al. (2005), I bring in two other transmission channels that may explain business cycle synchronization, international capital movement and national macroeconomic policies. I will elaborate on them below.

The main objective of this chapter is to examine how business cycle comovement has been influenced by intra- and inter-industry trade between 1995 and 2010 among 22 OECD countries. This chapter is a higher-level analysis than the focus on shocks considered in Chapter Two. While less structural than a focus on the underlying disturbances, it has the advantage of allowing me to concentrate on a broad set of influences that relate to business cycle correlation. Using Instrumental Variable (IV) estimation technique, I find evidence that supports an increase in intra-industry trade leads to more synchronized business cycles. Higher inter-industry trade intensity, however, tends to weaken cyclical comovement. When I take into account intra- and inter-industry trade, international capital movement and national macroeconomic policies offer no explanation for synchronization. The analysis sheds light on the prospect and desirability of the eurozone in my sample. The euro area has witnessed increasing intra-industry trade, which may have contributed to a higher degree of business cycle synchronization. Meanwhile, inter-industry trade is growing as trade ties get closer, and it may lead to divergence of business cycles. The effect of aggregate trade on business cycle comovement is uncertain, depending on the relative strengths of intra- and inter-industry trade.

This chapter complements and extends previous studies in the following aspects. In contrast with Canova and Dellas (1993) and Frankel and Rose (1998) who use aggregate trade in the analysis, I decompose aggregate trade into intra- and inter-industry trade, and identify their different roles in driving synchronization. Different from Shin and Wang (2004) and Fidrmuc (2004) who only focus on the share of intra-industry trade, this chapter provides evidence supporting that inter-industry trade intensity also affects business cycle synchronization.[14] Unlike Gruben et al. (2002) who only use OLS models, I investigate the different nature of intra- and inter-industry trade through IV estimations, which better addresses the possible endogeneity issue. More details will be discussed in the literature review part below.

The chapter is organized as follows. Part II presents a selective survey of the relevant literature. Part III describes the data and method employed in the analysis. Part IV reports the analytical results and discusses the key findings. Part V concludes.

2. Literature Review

In this part, I first review the literature on the interdependence between business cycle synchronization and trade intensity. Afterwards, I examine work that examines other channels that may transmit business cycle shocks, namely the financial market linkages and macroeconomic policy coordination.

[14] Fidrmuc (2004) regresses business cycle correlation on aggregate trade intensity and the share of intra-industry trade. The paper implicitly assumes that the share of inter-industry trade and inter-industry trade intensity has no effect on synchronization.

2.1. Trade Intensity and Business Cycle Synchronization

Economic theory does not provide definitive guidance concerning the impact of increased trade on the degree of business cycle synchronization. Empirical studies so far have shown mixed relationships between the two, and the interdependency is moderate. One may attribute the ambiguity of the relationship to the different roles that intra-industry and inter-industry play in stimulating business cycle synchronization, and I will consider each in turn.

2.1.1. Aggregate trade intensity and synchronization

From an intuitive point of view, international trade linkages can lead to more correlated business cycles across countries through spillover effects on the demand side. For example, a consumption boom in one country can generate increased demand for imports, boosting economies abroad. Canova and Dellas (1993), Kenen (2000), Kollman (2001), and Baxter and Kouparitsas (2005) set up a wide range of theoretical models, ranging from multi-sector models with intermediate-goods trade, to one-sector models with either technology or monetary shocks. They theoretically demonstrate that stronger trade links across countries lead to a higher degree of interdependence in business cycles.

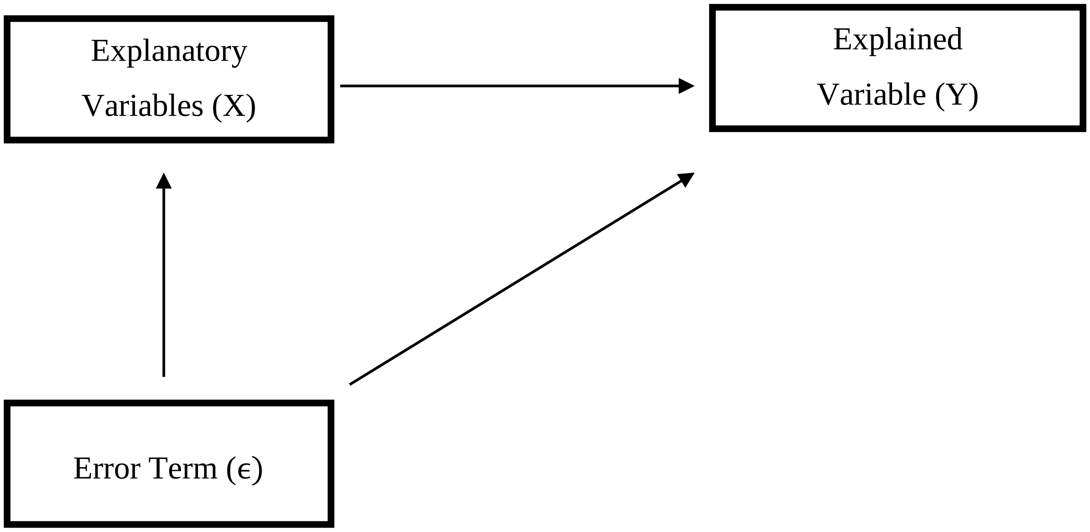
In addition to theoretical support, the statistically significant and positive relationship is confirmed empirically. Frankel and Rose (1998), Clark and van Wincoop (2001) as well as Otto et al. (2005) lend empirical support to a robustly positive relationship between bilateral trade links and cyclical comovement. As the benchmark paper on the interdependence between trade and synchronization, Frankel and Rose will be elaborated on below.

Frankel and Rose (1998) argue that closer trade links result in more correlated business cycles across countries. Using thirty years of data from twenty industrialized countries, they estimate a regression model of synchronization on aggregate trade intensity. Since trade intensity is the only explanatory variable, there may be omitted variables in the error term which influence trade and synchronization at the same time. One example of the omitted variables is the foreign direct investment (Otto et al., 2005). Omitted variables give rise to an endogenous model, in which the explanatory variable is endogenous and jointly determined with the dependent variable.

Figure 5 provides visualization of the endogeneity issue, in which the omitted variables in the error term correlate with the dependent variable both directly and through explanatory variables. To overcome the simultaneous causation problem of omitted variables, Frankel and Rose utilize IV estimations. A set of gravity variables, including logarithm of geographic distance, common border dummy variable, and common language dummy variable, act as instruments on the grounds that they affect synchronization only through trade.

An important step, however, is missing in Frankel and Rose's (1998) analysis. They conjecture "that intra-industry trade accounts for most trade is the more realistic one" (p. 2) and ideally the model "has to involve both inter-sector trade and intra-industry trade" (p. 6), but they do not differentiate the two types of trade. Modeling aggregate trade as the sole independent variable is equivalent to imposing a restriction that intra-industry and inter-industry trade have equal impacts on synchronization. The restriction is inconsistent with the different role that intra- and inter-industry trade may have with respect to synchronization, as implied by economic theories, and may provide misleading information. The potentially different influences of intra-industry and inter-industry trade will also provide dissimilar policy implications. If there exists contrasting effect of intra- and inter-industry trade on business cycle convergence, trade partners who have intensive intra-industry trade are more likely to synchronize their cycles and to form a common currency.

Figure 5: Simultaneous Causation (Endogeneity) Issue



The second critical drawback of Frankel and Rose (1998) is that the instrumental variables used are problematic and result in inflated coefficients. In their model, the IV coefficients are three times larger than those of the corresponding Ordinary Least Square (OLS) estimates. Gruben et al. (2002) maintain that a potential reason of the large difference between OLS and IV estimates is a statistical correlation between the instrumental and omitted variables in the error term. Foreign direct investment (FDI), one candidate of omitted channels of business cycle transmission, may closely correlate with both cyclical synchronization and trade (Imbs, 2004; Garcia-Herrero & Ruiz, 2008) and can be explained by gravity variables (Brenton et al., 1999; Blonigen, 2005; Kleinert, 2010). Because of the endogeneity issue, the instruments that Frankel and Rose use to reflect the influence of trade alone actually capture the effects of all channels of business cycle transmission, overestimating the coefficient of trade.

There are at least three solutions to the second drawback. One way is to find an alternative valid instrument, which is not only exogenous, but also affects the dependent variable only through the variable that is instrumented. Such ideal instruments, however, are hard to acquire.

Another equivalent approach is to specify a simultaneous equation model that coherently explains synchronization, transmission channels of business cycle shocks, and other characteristics that describe the channels, such as Imbs (2000, 2004). The third way is to keep the gravity variables as instruments and incorporate some of the omitted variables as additional explanatory variables. Even in this way, there are other omitted variables which cannot be included in the model and may be correlated with the included variables. Otto et al. (2005) and Shin and Wang (2004) choose the third method, by including financial linkages and similarity in macroeconomic policies as additional explanatory variables. Both studies find that financial integration and macroeconomic policy coordination are statistically significant in explaining synchronization, and the two factors are well explained by gravity variables. The economic implication is that economies that are close in distance, that share common borders, and that use the same languages tend to have closer financial linkages and similar macroeconomic policy.

Contrary to the large body of literature supporting the positive effect of trade on synchronization, there are also studies that give rise to opposite evidence. Imbs (1999) detects that trade intensity can bring about more synchronized business cycles only in Europe, while for other parts of the world the author finds bilateral trade has very little to do with business cycle correlation. Kose and Yi (2001) develop an Armington-aggregator-based international business cycle model, only to find that higher trade intensity is associated with lower business-cycle correlation in a world of fully integrated asset markets. The authors argue that specialization may reduce the diversity of industry structure and weaken cyclical comovement, suggesting that industry-level trade may offer an explanation for the interdependence between aggregate trade and business cycle synchronization.

2.1.2. Intra-industry trade, inter-industry trade and synchronization

Previous studies imply that examining disaggregated trade may help us better understand the interdependence between trade and synchronization. In terms of trade decomposition, Gruben et al. (2002) are closest to my research. The authors run an OLS regression of synchronization on intra- and inter-industry trade intensity. The OLS model also includes Frankel and Rose's (1998) three gravity variables as additional explanatory variables, hoping that they are "adequate proxies for difficult-to-measure factors" (p. 10).

Gruben et al. (2002) provides a more clear understanding of the mechanisms by which international trade influences synchronization, by separating intra-industry trade from inter-industry trade. A minor problem with the study is a potential multicollinearity issue among intra-industry trade and the gravity variables, since Balassa (1986b), Balassa and Bauwens (1987), and Balassa and Bauwens (1988) empirically support the three gravity variables as statistically significant factors in determining intra-industry trade. Without other specification problems, multicollineartiy does not actually bias results; it just produces large standard errors in the related independent variables. However, with other problems which introduce bias, such as omitted variables or measurement errors, multicollinearity can multiply the magnitude of that bias, and the OLS estimation is not capable of delivering consistent parameter estimates (Wooldridge, 2008). Gruben et al. (2002) assume that intra- and inter-industry trade are the only channels through which business cycle shocks transmit, which makes omitted variables possible. The omission together with multicollinearity issue is likely to yield biased and inconsistent OLS estimates. Therefore, one might use IV estimations to control for the endogeneity resulting from omitted variables.

Two similar papers on components of trade and synchronization, Shin and Wang (2004) and Fidrmuc (2004), use aggregate trade intensity and the share of intra-industry trade in aggregate trade as independent variables. They conclude that it is the share of intra-industry trade, instead of bilateral aggregate trade intensity, that induces convergence of business cycles. Specifically, Shin and Wang apply fixed effects models to eliminate unobservable country-specific components. Similar to Gruben et al. (2002), the OLS estimators in Shin and Wang may be biased and inconsistent, because of the collinearity issue in combination with omitted variables that are not country-specific.[15] By comparison, Fidrmuc uses IV estimation with Frankel and Rose's (1998) instruments. Again, IV estimation is justified, because IV estimation can overcome simultaneous causation issue coming from the association of error term with the explanatory variables. Although the IV method by Fidrmuc is preferred, the specification confronts the same problem as Frankel and Rose. In both papers, inter-industry trade intensity is assumed to have no impact on synchronization, which is strongly rejected by Gruben et al. The theoretically different nature of intra- and inter-industry trade motivates us to study them in parallel, and this is the fundamental distinction of my study from others.

To sum up, this chapter can improve previous studies in two ways. First, I study intra-industry trade intensity and inter-industry trade intensity simultaneously, arguing that they have opposite influences on cyclical synchronization. If my hypothesis is true, the finding will pose a challenge to Frankel and Rose (1998) which implicitly assumes that intra- and inter-industry trade impose the same impact on synchronization. Second, I utilize IV estimations, as opposed to the OLS estimations in Gruben et al. (2002) and Shin and Wang (2004). Previous studies on intra- and inter-industry trade commonly suffer from a multicollinearity problem, as evidenced

[15] Balassa and Bauwens (1987, 1988) show that aggregate trade and intra-industry trade are highly correlated, particularly for industrialized countries.

by the high correlation between intra-industry trade, inter-industry trade and aggregate trade. The multicollinearity issue, along with endogeneity (resulting from omitted variables), gives rise to biased and inconsistent OLS estimators. Therefore, I produce more reliable results by conducting IV estimations in a more general model.

2.2. Other Transmission Channels of Business Cycle Shocks

International trade is one of the transmission channels of business cycle shocks through economic interdependence between countries. In addition to trade linkages, there are other transmission channels through which shocks to business cycles pass on. One possible mechanism is through the financial market, and another is through macroeconomic policy making.

2.2.1. Financial integration

Financial integration means that financial markets in two economies are closely linked together in the international capital market. Kose et al. (2003) argue that financial linkages could result in a higher degree of business cycle synchronization between a pair of countries, due to the interdependence of financial markets and the effects that variation in these markets may have on consumption (through wealth effects) and investment (by affecting firms' abilities to raise fund).

Previous empirical studies use various measures of financial integration. One commonly used measure is foreign direct investment (FDI), a direct investment into business in a foreign country either by acquiring business in the target country or by opening multinational enterprises. Baxter (1995) empirically shows that FDI is an important explanatory variable for synchronization. Similarly, Otto et al. (2005) find that FDI linkages are statistically significant in contributing to higher business cycle synchronization when FDI is considered alone. The second measure is equity return spread between two countries, an indicator of international portfolio investments. Smaller equity return spread reflects that financial institutions and individual investors have taken advantage of arbitrage opportunities in bilateral equity market and hence indicates a higher level of financial integration. Otto et al. utilize equity return spread as a second proxy for financial integration, which robustly correlates with synchronization when studied in isolation. Another measure is real interest rate spread between countries on long-term government bonds (usually 10-year maturity). Two countries with highly integrated capital markets are likely to have similar patterns of real bond returns over a period of time (Manganelli & Wolswijk, 2007). Otto et al. find that long-term interest rate spread positively correlates with synchronization when studied in isolation. The three measures provide different information about direct investment, equity investment, and fixed income investment, respectively, and I will use all the three measures in my empirical models as in Otto et al. (2005).

2.2.2. Macroeconomic policy coordination

In addition to trade in goods and financial assets, macroeconomic policy coordination is another possible transmission channel of business cycle shocks. Policy coordination generally means common monetary and fiscal policy shocks. Common monetary policy shocks could lead to a higher degree of business cycle synchronization through monetary aggregates, federal funds rate, real economic activity, and commodity price (Christiano et al., 1996), whereas common fiscal policy shocks can bring higher synchronization through tax and budget spending (Chari et al., 1994; Mountford & Uhlig, 2009).

Earlier empirical studies measure macroeconomic policy coordination using indicators of similarity in both monetary policy and fiscal policy. Clark and van Wincoop (2001) utilize both monetary and fiscal policy similarity to measure policy coordination. The monetary policy indicators include: (1) the standard deviation of the nominal interest rate difference, in annual average overnight money market rates; (2) the correlation of nominal interest rates; (3) the standard deviation of the change in the interest rate differential; (4) the correlation of the changes in interest rates; and (5) the standard deviation of the percent change in the bilateral exchange rate. The fiscal policy indicators include: (1) the standard deviation of the budget deficit differential; and (2) the correlation of the budget deficits. The authors find that policy coordination stays statistically insignificant when trade intensity is accounted for, although a few proxies are marginally significant in simple regressions. Shin and Wang (2004) investigate the effects on synchronization of monetary and fiscal policy coordination, which are measured by the correlation coefficient of M2 growth rates across countries and the correlation coefficient of budget deficit to GDP ratio, respectively. The authors conclude that monetary policy, instead of fiscal policy, offers an explanation for business cycle correlation.

Earlier studies imply that fiscal policy coordination is statistically insignificant in explaining synchronization, and hence later studies concentrate on monetary policy coordination. Otto et al. (2005) investigate the effects of monetary policy similarity by utilizing two measures, namely exchange rate deviation and short-term interest rate spread. Exchange rate deviation is a good indicator of exchange rate regime and monetary policy. Two countries with fixed or strictly managed exchange rates generally share similar monetary policies and have synchronized business cycles. Short-term interest rates are the main monetary policy instrument used by central banks. When central banks in two economies both expand (or contract) their monetary base, short-term interest rates in the two countries move closely together and bilateral interest rate spread gets lower. The common monetary policy shocks are also anticipated to lead to similar real activity and increase business cycle synchronization across countries. Using cross-sectional data on 17 OECD countries, the authors find that lower exchange rate deviation and lower interest rate spread correlates with business cycle convergence. Similarly, Artis and Zhang

(1999) identify a negative relationship between exchange rate volatility and business cycle correlation in OECD countries. Because of the empirical success of using exchange rate deviation and interest rate spread to measure monetary policy coordination, I will use both variables in the following estimation.

2.3. Instruments and Transmission Channels

The above discusses three transmission channels of business cycle shocks, including trade intensity, financial integration, and macroeconomic policy coordination. The channels act as explanatory variables for business cycle synchronization in my empirical models. In spite of my efforts to include multiple explanatory variables and utilize more appropriate measures, there may remain omitted regressors and there may also be mis-measurement problems. For example, industry structure is one of the potential explanatory variables. Imbs (2000, 2004) sets up a simultaneous equations system to deal with the complex interactions among transmission channels of cyclical comovement. The author empirically finds that industry structure, which reflects the similarity of sector-level production, indirectly promotes business cycles synchronization through international trade and financial integration. However, industry structure is notoriously difficult to measure and leads to disputable conclusions. Clark and van Wincoop (2001) use the absolute value index in Krugman (1991) to measure industry structure, only to find it statistically insignificant. Measuring sector structure in the same way, Otto et al. (2001) and Baxter and Kouparitsas (2005) find the industrial structure variable individually significant, but its statistical significance disappears in a multivariate regression framework. These findings indicate that the conclusions of Imbs which stress the importance of industrial structure are fragile, and therefore I do not include industrial structure in my empirical models. Notwithstanding the difference of opinion, the sector structure variable may remain an explanatory variable for business cycle synchronization, if measured more appropriately. Omitting the variable of sector structure may make the OLS estimators biased and inconsistent. Therefore, I use IV for the abovementioned reasons and test for endogeneity in the following estimations. Literature to date substantiates gravity variables as instruments for the transmission channels, assuming that the instruments influence business cycle synchronization only through the intra- and inter-industry trade, financial integration, and monetary policy coordination.

2.3.1. Gravity variables and trade

The gravity model of trade describes trade flows between a pair of countries as being proportional to their national income and negatively correlated with their geographic distance. Economists have found a wide range of economic theories in support of this model (Anderson, 1979; Helpman, 1987; Bergstrand, 1989, 1990; Deardorff, 1998). It has also been regarded as "one of the great success stories in empirical economics" (Feenstra et al., 2001, p. 431). In addition to national income and distance, later empirical studies (Frankel & Rose, 2002, 2005; Glick & Rose, 2002; Rose & van Wincoop, 2001; Rose, 2004) identify other gravity variables that explain trade, such as population, per capita income, common border, common language, colonial relationship, common currency, and indicators of trade agreements among others.[16]

Gravity variables may also provide an explanation for industry-level trade. Balassa (1986a, 1986b) and Balassa and Bauwens (1987, 1988) quantitatively find that the extent of intra-industry trade increases with the level of economic development, economic size, common border, common language, and geographic proximity.

[16] I initially included common currency as one of the gravity variables, since there is empirical evidence that common currency is positively correlated with aggregate trade intensity (Frankel & Rose, 2002, 2005; Clark & van Wincoop, 2001) and intra-industry trade (Balassa & Bauwens, 1987, 1988). However, common currency turns out to be an invalid instrument due to its direct influence on synchronization. Artis and Zhang (1999) and Rose and Engel (2002) use the data for the eurozone and find that a common currency can directly lead to synchronization of business cycles controlling for gravity dummies and other indirect channels. Moreover, I am using the standard deviation of the nominal exchange rate which captures similar information as the common currency dummy variable.

2.3.2. Gravity variables and other channels

Similar to the gravity model of trade, previous studies also offer theoretical and empirical support for a gravity model of FDI. The motivations driving FDI are considered as the theoretical foundation for the gravity model of FDI. Markusen (1984) proposes that increasing returns, imperfect competition, and transport costs explain multinational firms locating affiliates abroad, whereas Helpman (1984) argues that multinational firms locate according to the comparative advantages of countries differing in their production stages. Markusen and Venables (1998) synthesize these two motivations for FDI and contend that the gravity model, which relates FDI between two countries to their economic size, geographic distance, and a set of variables accounting for relative costs, is theoretically consistent with both arguments. A large number of empirical studies (Brenton et al., 1999; Wei, 2000; Otto et al., 2005; Bénassy-Quéré et al., 2007) find that the gravity model fits cross-country data of bilateral FDI reasonably well, and that FDI flow increases with average economic size, geographic proximity, common language, and institutional similarity such as similar accounting standards.

3. Data and Methodology

3.1. Data

My analysis examines bilateral cross-country relationships. The annual data I use for each country ranges from 1995 to 2010, and includes 22 OECD countries for which I can obtain a consistent set of data: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and the United States. This provides 231 country pairs, which form the basis of my analysis.

The dependent variable in my model is a measure of business cycle synchronization. I transform the variable in two steps. The first procedure is to take natural logarithms of real GDP and de-trend so as to focus on business cycle fluctuations. The real GDP data come from the OECD database. Full details are provided in Appendix A. Given the importance of de-trending and the lack of consensus about optimal de-trending techniques, I employ three different procedures. First, I take first difference of the logarithm of real GDP, and the resulting variable $\Delta \ln y_{it}$ will be the annual GDP growth rate for country i at time t. The business cycle synchronization is defined as the cross-country correlation of GDP growth, $\rho_{ij\tau} = \mathrm{corr}\,(\Delta \ln y_{it}, \Delta \ln y_{jt})$. i and j denotes countries in my sample (i ≠ j), corr stands for the correlation function, and τ refers to the sampling time period. Second, I de-trend the logarithm of real GDP using the Hodrick-Prescott (HP) filter (Hodrick & Prescott, 1997). Following Baxter and King (1999), I use the value of 10 for the HP filter smoothing parameter. The correlation of real GDP de-trended by HP filter between two countries will be $\rho_{ij\tau} = \mathrm{corr}\,(\ln y_{it}^{HP}, \ln y_{jt}^{HP})$. Third, I de-trend by using the Baxter-King (BK) band-pass filter (Baxter & King), which allows suppression of both the low- and high-frequency trend components in a series. Following Baxter and King, I use the cycle length between 2-8 years with moving average length of three for annual data. The BK filtered cyclical correlation will be $\rho_{ij\tau} = \mathrm{corr}\,(\ln y_{it}^{BK}, \ln y_{jt}^{BK})$.

The second step is to transform $\rho_{ij\tau}$. Without the transformation, the dependent variable lies between -1 and 1, and the error terms in a regression model are unlikely to be normally distributed. Following Otto et al. (2005, p. 10), I transform $\rho_{ij\tau}$ into a new dependent variable $\ln\frac{1+\rho_{ij\tau}}{1-\rho_{ij\tau}}$. The transformed regression model will be

$$\ln\frac{1+\rho_{ij\tau}}{1-\rho_{ij\tau}} = X_{ij\tau}\beta + \epsilon_{ij\tau}$$

The error term follows a normal distribution, i.e., $\epsilon_{ij\tau} \sim N(0, \sigma^2)$. $X_{ij\tau}$ is the set of explanatory variables I will introduce as follows, and β is the set of coefficient parameters.

Table 10 provides an overview of the measures of business cycle synchronization. Panel A provides descriptive statistics of the three measures of business cycle synchronization. The mean synchronization for a pair of countries is around 0.60, which is twice the value of 0.33 in Otto et al. (2005). Because the sample of countries and de-trending methodology are exactly the same, the difference may be due to the respective samples. Their sample ranges between 1972 and 2000, while my analysis focuses on 1995-2010, a period during which the extent of globalization and regional cooperation has been more intense. The different sample statistics strongly suggests that the business cycle synchronization, modelled in these studies, is not stable and robustness checks are needed. The summary statistics also provide evidence of considerable variation around the mean, as is seen from the standard deviation of bilateral correlation, with the minimum correlation being -0.44 (Australia and South Korea) and the maximum 0.95 (Denmark and Finland). For all three de-trending measures, the sample statistics of the bilateral correlation are similar, particularly for the BK and HP filters.

Panel B presents the correlation coefficients between de-trending methods. The high correlation coefficients suggest that the three de-trending methods will provide similar conclusions. Following Otto et al. (2005), I focus on just one measure, the BK filter, to make the analysis manageable and use the other two measures in the robustness checks.

Panel C lists the top and bottom twenty correlations and the corresponding country pairs. The country pairs that are most highly correlated are European Union member states, which are closely integrated in trade, investment and monetary policies.[17] In all cases of the weakly

[17] The monetary policies of the eurozone members, part of the European Union members, are implemented and governed by the European Central Bank.

correlated country pairs, three countries take responsibility: Korea, Australia, and New Zealand. It is likely that the three countries experienced a unique set of business cycle shocks that dominate other influences over the period.

Figure 6 provides visualization of the distribution of the three de-trending measures. It is evident that the distributions of the three de-trending methods are highly similar. All the distributions are asymmetrical and are located between -0.5 and 1. A large number of occurrences lie between 0.6 and 1, and a longer tail stretches to the left.

The explanatory variables of primary interest are intra- and inter-industry trade. In order to construct intra- and inter-industry trade intensity, I first need a measure of aggregate trade intensity. Following Frankel and Rose (1998) and Otto et al. (2005), I construct this measure as bilateral trade flows, sum of exports and imports, normalized by aggregate trade flows:[18]

$$T_{ij\tau} = T^{-1} \sum_{t} \frac{X_{ijt} + M_{ijt}}{X_{it} + M_{it} + X_{jt} + M_{jt}}$$

$T_{ij\tau}$ is then the time-averaged bilateral trade intensity between country i and j, τ refers to the time interval in my sample, and T is the time length (T = 16). $X_{ijt}(M_{ijt})$ is the bilateral nominal exports (imports) from country i to country j at time t, and $X_{it}(M_{it})$ is the total nominal exports (imports) from country i. I extract bilateral and aggregate trade data from the United Nations Conference on Trade and Development database (UNCTAD, see full details in Appendix A).

[18] An equivalent way to measure trade intensity is to normalize bilateral trade by total nominal GDP. The two measures give rise to highly similar estimation results.

Table 10: Overview of Business Cycle Synchronizations, 1995-2010

Panel A. Descriptive Statistics of Business Cycle Synchronizations

	Growth	**HP**	**BK**
No. Obs.	231	231	231
Mean	0.63	0.59	0.61
Std. Dev.	0.24	0.30	0.29
Minimum	-0.18	-0.42	-0.44
Country pair	Switzerland: New Zealand	Australia: Korea	Australia: Korea
Maximum	0.95	0.95	0.93
Country pair	Denmark: Finland	Denmark: Finland	Netherlands: Switzerland

Panel B. Correlation between Methods

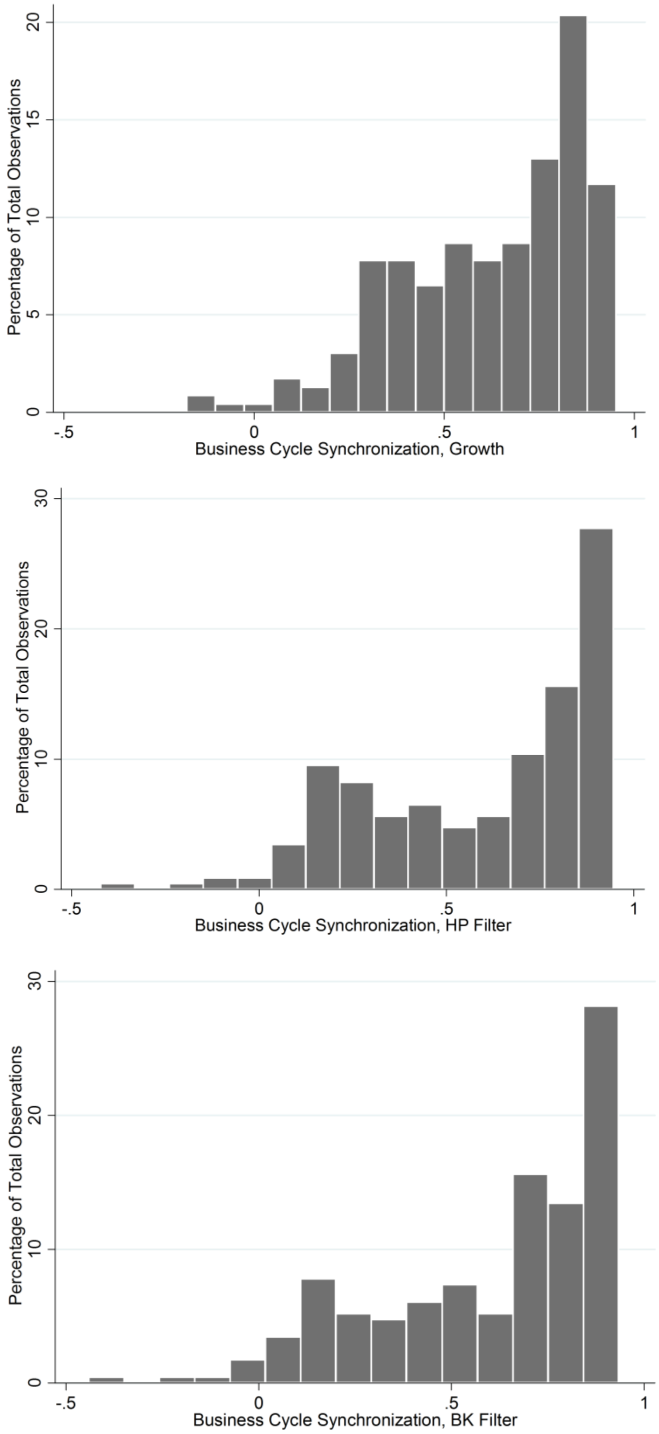
	Growth	HP	BK
Growth	1.00		
HP	0.88	1.00	
BK	0.78	0.90	1.00

Panel C. Selected Country Pairs and Business Cycle Correlations

Top Twenty	**Correlations**	**Bottom Twenty**	**Correlations**
Netherlands: Switzerland	0.93	Australia: Korea	-0.44
Germany: Sweden	0.93	Portugal: New Zealand	-0.19
Austria: Netherlands	0.93	Switzerland: New Zealand	-0.14
Austria: Finland	0.93	Netherlands: New Zealand	-0.07
Germany: Switzerland	0.93	Canada: Australia	-0.05
Austria: Spain	0.93	Belgium: Australia	-0.03
Germany: Netherlands	0.93	Germany: New Zealand	0.01
Austria: France	0.92	Italy: Australia	0.02
Germany: Italy	0.92	Switzerland: Australia	0.02
France: Spain	0.92	Japan: Australia	0.03
France: Sweden	0.92	Portugal: Australia	0.06
Finland: Spain	0.91	Netherlands: Australia	0.08
Denmark: Ireland	0.91	Norway: New Zealand	0.08
Sweden: Canada	0.91	Portugal: Korea	0.09
Austria: Switzerland	0.91	Austria: New Zealand	0.09
France: Canada	0.91	Germany: Australia	0.11
Germany: Finland	0.91	Norway: Australia	0.11
Netherlands: Portugal	0.90	France: Australia	0.12
Austria: Germany	0.90	Denmark: Australia	0.12

Notes:
1. Growth, HP, and BK stand for de-trending methods using first log difference, HP filter, and BK filter.
2. Following Baxter and King (1999), I use the value of 10 for the HP filter smoothing parameter.
3. For the BK filter, Baxter and King (1999) recommend the cycle length between 2-8 years with moving average length of three for annual data.
4. Panel C shows selective country pairs using BK filtered correlation.

Figure 6: Histogram of Business Cycle Correlations



Notes:

1. Growth, HP, and BK stand for de-trending methods using first log difference, HP filter, and BK filter.
2. Following Baxter and King (1999), I use the value of 10 for the HP filter smoothing parameter.
3. For the BK filter, Baxter and King (1999) recommend the cycle length between 2-8 years with moving average length of three for annual data.

Next, I construct an intra-industry trade index (IIT) developed by Grubel & Lloyd (1975) to measure the proportion of intra-industry trade in bilateral aggregate trade:

$$\mathrm{IIT_{ijt}} = 1 - \frac{\sum_k \left|\mathrm{X_{ijkt}} - \mathrm{M_{ijkt}}\right|}{\sum_k \left|\mathrm{X_{ijkt}} + \mathrm{M_{ijkt}}\right|}, \text{and } \mathrm{IIT_{ij\tau}} = \mathrm{T^{-1}} \sum_t \mathrm{IIT_{ijt}}$$

$\mathrm{IIT_{ijt}}$ is the intra-industry trade index between country i and j at time t, and $\mathrm{IIT_{ij\tau}}$ is the time-averaged intra-industry trade index between country i and j. k is an index of industry classes. $\mathrm{X_{ijkt}}(\mathrm{M_{ijkt}})$ is the sector-k exports (imports) from country i to j at time t, which I obtain from the UNCTAD database (see full details in Appendix A). In practice, I only use reported imports (i.e., use $\mathrm{M_{ji}}$ instead of $\mathrm{X_{ij}}$), following Feenstra (2004) and Gruben et al. (2002) which argue that trade data are more reliable for imports than exports. An index value of zero indicates complete specialization on different products for each country in a pair, while an index value of one means complete intra-industry trade between two countries. A related variable, the degree of inter-industry trade, is obtained by subtracting the intra-industry trade index from one.

In constructing the intra-industry trade index, an important consideration is the level of detail used in the classification of industries. The disaggregated bilateral trade data are classified according to the Standard International Trade Classification system (SITC). SITC classifies commodities into ten general sectors. When I measure trade in more homogenous sectors, disaggregation into more sectors increases the risk of missing data and the risk of shrinking the intra-industry trade index to zero. To reduce the risk, I generate the IIT index using industry disaggregation at the one-digit level, which is also the norm in previous studies (Gruben et al., 2002; Shin & Wan, 2004; Fidrmuc, 2004). It should be noted that the measure of intra-industry trade index is imperfect, since there might be mis-measurement that is inter-industry trade in nature but attributes positive effects to intra-industry trade.

The last step of constructing intra-industry trade intensity, $\text{Intra}_{ij\tau}$, is to take natural logarithms of intra-industry trade index multiplied by aggregate trade intensity. It is conventional to take natural logarithms of trade intensity (and FDI intensity as below), because trade intensity (and FDI) is generally skewed and it becomes normally distributed in the logarithm form. Similarly, the inter-industry trade intensity, $\text{Inter}_{ij\tau}$, is the natural logarithm of inter-industry trade index multiplied by aggregate trade intensity:

$$\text{Intra}_{ij\tau} = \ln\left(\text{IIT}_{ij\tau} \times \text{T}_{ij\tau}\right), \text{and } \text{Inter}_{ij\tau} = \ln\left((1 - \text{IIT}_{ij\tau}) \times \text{T}_{ij\tau}\right)$$

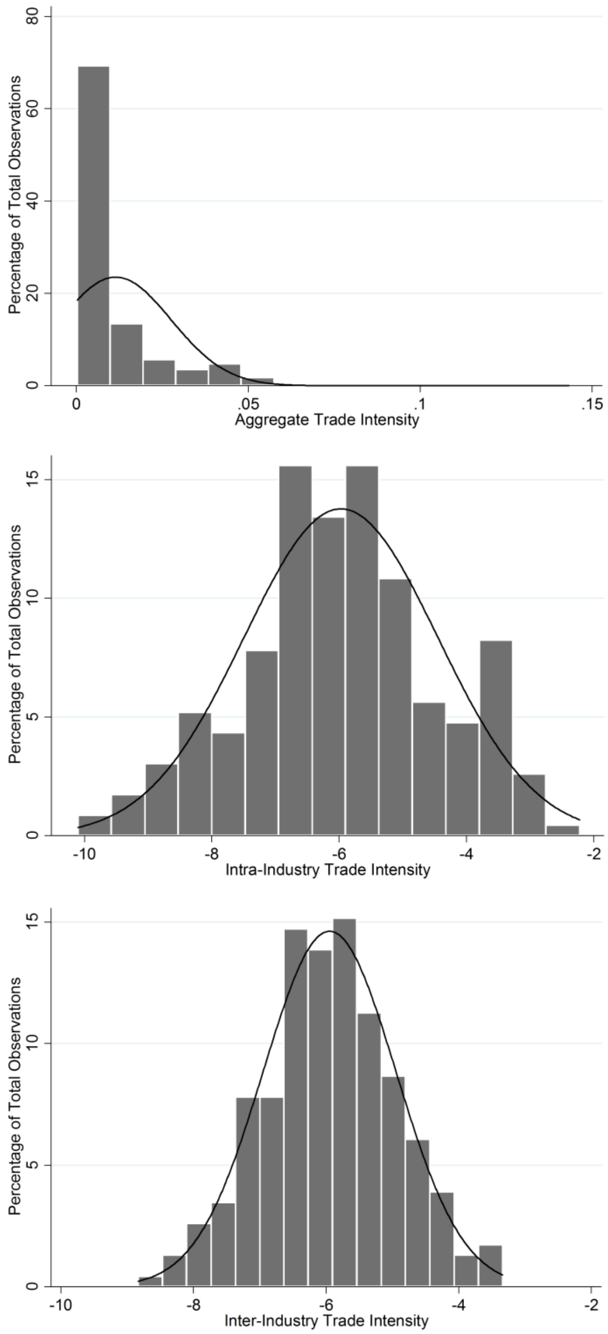
Figure 7 shows the histograms of aggregate trade intensity, as well as intra- and inter-industry trade intensity, and a normal distribution is added for comparison of distributions. The aggregate trade intensity ($\text{T}_{ij\tau}$) appears to be skewed, while intra- and inter-industry trade intensities ($\text{Intra}_{ij\tau}$ and $\text{Inter}_{ij\tau}$, in the logarithm form) are close to normal distributions. With longer tails at both sides of the mean, the distribution of intra-industry trade is more scattered than that of inter-industry trade.

The other transmission channels that I control for are financial integration and monetary policy integration. Following Otto et al. (2005), I construct three variables — FDI, equity return spread, and long-term interest rate spread — to measure financial integration. In the same way as trade intensity, I measure FDI intensity by normalizing bilateral FDI flows by aggregate FDI flows:[19]

$$\text{FDI}_{ij\tau} = \ln\left(\text{T}^{-1}\sum_{t}\frac{\text{FI}_{ijt} + \text{FO}_{ijt}}{\text{FI}_{it} + \text{FO}_{it} + \text{FI}_{jt} + \text{FO}_{jt}}\right)$$

[19] Two equivalent ways to measure FDI intensity are to normalize bilateral FDI positions by either total FDI positions or total nominal GDP, and these measures give rise to nearly the same estimation results.

Figure 7: Histogram of Aggregate Trade Intensity, Intra-Industry Trade Intensity, and Inter-Industry Trade Intensity



Notes:
1. A normal distribution line is added to each histogram.
2. Aggregate trade intensity is bilateral trade flows, sum of exports and imports, normalized by aggregate trade flows.
3. Intra-industry trade intensity is the natural logarithm of aggregate trade intensity multiplied by intra-industry trade index, and inter-industry trade intensity is the natural logarithm of aggregate trade intensity multiplied by inter-industry trade index (one minus intra-industry trade index).

where $FDI_{ij\tau}$ is the FDI intensity between country i and j during the sampling period τ. FI_{ijt} (FO_{ijt}) is the inward (outward) FDI flows of country i from j at time t, and FI_{it} (FO_{it}) is the aggregate inward (outward) FDI flows for country i. I obtain the bilateral and aggregate FDI flow data from the UNCTAD database. Full details are provided in Appendix A.

The second measure of financial integration is the real interest rate spread between countries on long-term bonds. The greater is financial integration, the lower the spread is expected to be. The real long-term interest for country i (r_{it}^{LR}) is computed using nominal long-term interest rate (i_{it}^{LR}) and consumer price indices ($CPI_{i,t}$), both of which are obtained from the OECD database (see full details in Appendix A). The bilateral measure of long-term bond return spread ($LR_{ij\tau}$) is the natural logarithm of time-averaged real interest rate spread:

$$r_{it}^{LR} = i_{it}^{LR} - 100 \times \ (CPI_{i,t+1} - CPI_{i,t})/CPI_{i,t}, \text{and } LR_{ij\tau} = \ln\left(T^{-1}\sum\nolimits_{t}\left|r_{it}^{LR} - r_{jt}^{LR}\right|\right)$$

The third measure of financial integration is the equity return spread. The real equity return (s_{it}) is calculated using consumer price indices ($CPI_{i,t}$) and nominal equity market indices($S_{i,t}$), which I extract from the World Bank (see full details in Appendix A). Similar to long-term interest rate spread, the bilateral measure of equity return spread ($EQ_{ij\tau}$) is the natural logarithm of mean absolute spread:

$$s_{it} = 100 \times \frac{S_{i,t}/CPI_{i,t} - S_{i,t-1}/CPI_{i,t-1}}{S_{i,t-1}/CPI_{i,t-1}}, \text{and } EQ_{ij\tau} = \ln\left(T^{-1}\sum\nolimits_{t}\left|s_{it} - s_{jt}\right|\right)$$

The last category of transmission channel is through monetary policy coordination. Following Otto et al. (2005), I construct two measures of monetary policy similarity, namely the short-term interest rate spread and exchange rate deviation. When bilateral interest rate spread gets lower, the bilateral cyclical correlation is expected to be higher. I obtain nominal short-term interest rates (i_{it}^{SR}) from the OECD database (see full details in Appendix A), build up real short-term interest rates (r_{it}^{SR}) according to the Fisher Equation, and construct short-term interest rate spread ($SR_{ij\tau}$) in the same way as long-term interest rate spread:

$$r_{it}^{SR} = i_{it}^{SR} - 100 \times \frac{CPI_{i,t+1} - CPI_{i,t}}{CPI_{i,t}}, \text{and } SR_{ij\tau} = \ln\left(T^{-1} \sum_{t} \left| r_{it}^{SR} - r_{jt}^{SR} \right|\right)$$

Exchange rate deviation is another measure of monetary policy. When exchange rate deviation gets lower, synchronization is expected to be higher. Exchange rate deviation is defined as the natural logarithm of the standard deviation of first difference in nominal bilateral exchange rates:

$$ER_{ij\tau} = \ln\left(\sigma\left(\Delta \ln e_{ijt}\right)\right)$$

$ER_{ij\tau}$ is the exchange rate deviation and $\sigma(\cdot)$ denotes the standard deviation. e_{ijt} is the bilateral nominal exchange rate between country i and j at time t, which I retrieve from the OECD database. Full details are provided in Appendix A.

Table 11 provides an overview of the explanatory variables. Panel A reports the descriptive statistics of the explanatory variables. The country pair with the highest intra-industry trade intensity is US and Canada. It is likely that consumers in the two countries have different taste towards differentiated goods, and they simultaneously export and import goods in the same sectors. In contrast, the country pair with highest inter-industry trade is US and Japan, reflecting the expect to which two countries specialize in producing distinct goods in which they hold comparative advantages.

Panel B shows the correlation coefficients between explanatory variables. There are evident correlations between the explanatory variables, especially among intra-industry trade, inter-industry trade, and FDI. Measures of intra- and inter-industry trade intensity are highly correlated because they are both made up of the intra-industry trade index and aggregate trade intensity. The multicollinearity problem poses difficulties for OLS estimation, because potential omitted variables in combination with this multicollinearity issue will make OLS estimates inconsistent and biased (Wooldridge, 2008). Therefore, I use IV estimation which is expected to address the endogeneity issue.

Table 11: Summary Statistics of Explanatory Variables, 1995-2010

Panel A. Descriptive Statistics of Explanatory Variables

	Intra	**Inter**	**FDI**	**EQ**	**LR**	**SR**	**ER**
No. Obs.	231	231	193	210	190	190	231
Mean	-5.97	-5.95	-5.82	2.85	0.18	0.46	0.07
Std. Dev.	1.52	1.00	1.83	0.33	0.34	0.41	0.04
Minimum	-10.10	-8.83	-10.76	1.69	-0.55	-0.50	-8.50
Country pair	Portugal: New Zealand	Canada: Greece	Spain: New Zealand	UK: Netherland	Belgium: Germany	Denmark: Germany	Austria: Germany
Maximum	-2.22	-3.33	-2.28	3.58	1.04	1.27	-1.86
Country pair	US: Canada	US: Japan	US: UK	Austria: Finland	Ireland: New Zealand	Ireland: New Zealand	Italy: Korea

Panel B. Correlations between Explanatory Variables

	Intra	Inter	FDI	EQ	LR	SR
Inter	0.83					
FDI	0.77	0.65				
EQ	-0.39	-0.32	-0.48			
LR	-0.23	-0.12	-0.12	0.13		
SR	-0.42	-0.25	-0.26	0.03	0.77	
ER	-0.39	-0.30	-0.24	0.06	0.32	0.60

3.2. Methodology

The objective of this study is to investigate the contrasting effect of intra- and inter-industry trade on business cycle synchronization, controlling for two other channels, financial integration and monetary policy coordination. Because economic theory does not provide systematic guidance on the determination of business cycle correlation, I will run a series of regression models to better understand the cross-section variation in bilateral cyclical comovement. At the beginning, I focus on individual transmission channels. For instance, I initially concentrate on intra- and inter-industry trade:

$$\ln\frac{1+\rho_{ij\tau}}{1-\rho_{ij\tau}} = \beta_0 + \beta_1 \mathrm{Intra}_{ij\tau} + \beta_2 \mathrm{Inter}_{ij\tau} + \epsilon_{ij\tau} \qquad (1)$$

The error term $\epsilon_{ij\tau}$ is assumed to be independently and identically distributed with mean zero. When I augment Eq. (1) with other channels, the general empirical model will be:

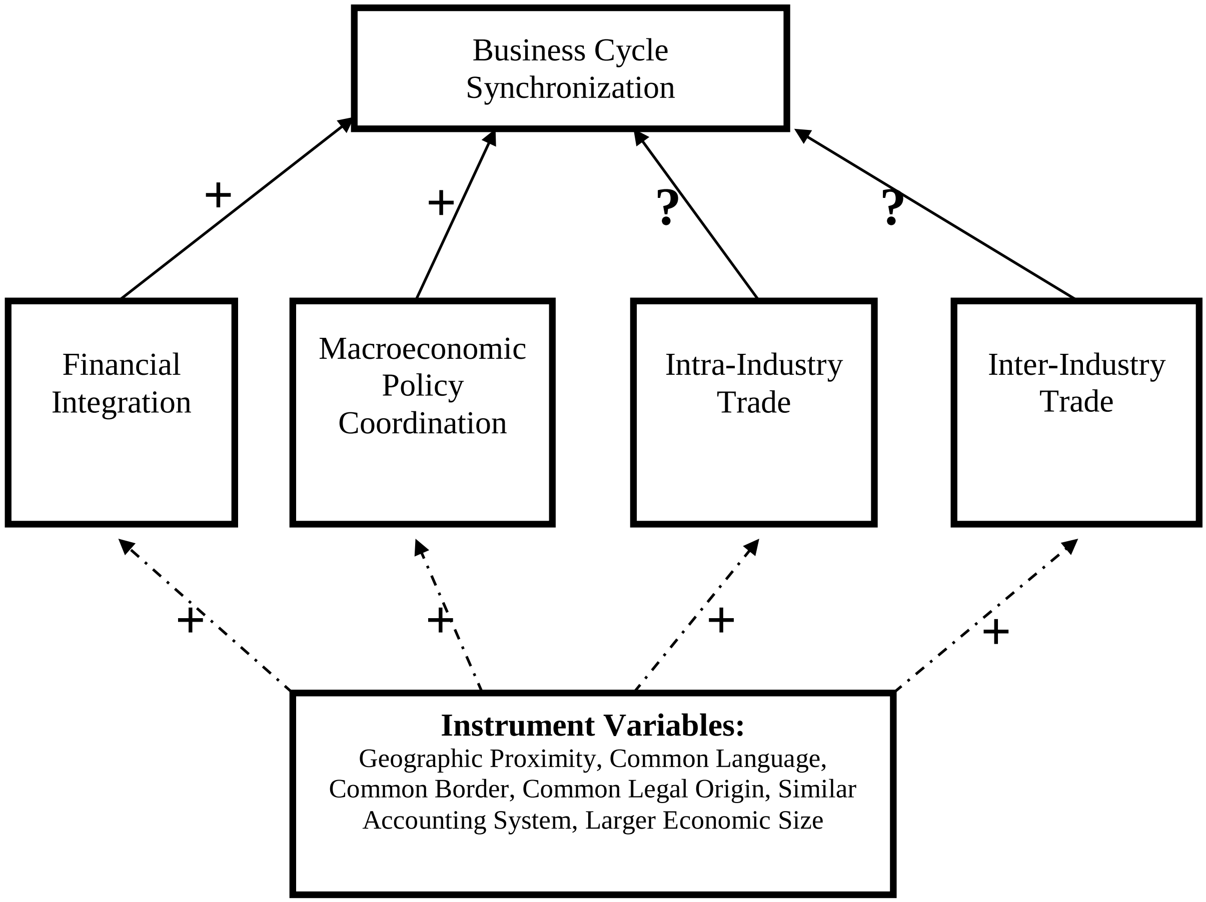
$$\ln\frac{1+\rho_{ij\tau}}{1-\rho_{ij\tau}} = \beta_0 + \beta_1 \mathrm{Intra}_{ij\tau} + \beta_2 \mathrm{Inter}_{ij\tau} + \beta_3 \mathrm{FDI}_{ij\tau} + \beta_4 \mathrm{LR}_{ij\tau} + \beta_5 \mathrm{EQ}_{ij\tau} + \beta_6 \mathrm{SR}_{ij\tau} + \beta_7 \mathrm{ER}_{ij\tau} + \epsilon_{ij\tau} \qquad (2)$$

In both Eq. (1) and (2), each explanatory variable is instrumented by a set of instrument variables. I am assuming that the instrument variables do not directly affect the dependent variable, but do explain the endogenous dependent variables. To put it another way, the instrument variables are assumed to satisfy two properties simultaneously: they are uncorrelated with the error term, but correlated with the endogenous variables. Following Otto et al. (2005), my instrument set is comprised of six bilateral variables: geographic distance, common border, common language, common legal origin, accounting standards, and economic size. Geographic distance is defined as the natural logarithm of bilateral geographic distance between two countries. Common border and common language are dummy variables which are equal to one if a country pair shares similarity in these characteristics; otherwise, they are zero. Common legal origin is a dummy variable for legal system, according to La Porta et al. (1998) which classify the legal systems of various countries into four categories – English, French, German and Scandinavian – based on the origin of the country's legal system and laws. The variable of accounting standards is measured as averaged accounting standard indices of two countries, and the bilateral measure of economic size refers to the logarithm of mean real GDP products. Full details are provided in Appendix A.

In Eq. (2), the parameters of primary interest to us are β_1 and β_2, which describe the effects of intra-and inter-industry trade on business cycle synchronization. I hypothesize that β_1 is positive, indicating that intra-industry trade explains convergence of cycles. I also conjecture that β_2 is negative, suggesting that higher inter-industry trade brings divergence of business cycles.

Figure 8 provides visualization of the structure of the underlying model and summarizes the relationships implied by earlier studies. The first row refers to the dependent variable in my model. The four variables in the second row act as endogenous variables in the IV estimations. Solid arrows with question marks denote the individual impacts of intra- and inter-industry trade on business cycle synchronization, and they are the relationships I will concentrate on. Solid arrows with positive signs indicate that integrated capital markets and similar monetary policies are expected to bring about more synchronized cyclical comovement. The positive signs on dashed arrows mean that geographic proximity, common language, common border, common legal origin, similar accounting standards, and larger pair-wise economic size are supposed to boost trade ties, financial market integration and policy coordination.

Figure 8: Structure of the Underlying Model



4. Estimation

4.1. Single Transmission Channel

Table 12 presents the univariate regressions of business cycle correlation on each of the transmission channel variables identified in Eq. (2), using the BK filtered data for the period 1995-2010. All models are estimated by IV using the instrument set identified earlier. The IV estimates are reported with White heteroskedasticity robust standard errors (MacKinnon & White, 1985). Heteroskedasticity seems to be a potential problem because of the construction of the bilateral data in country pairs. In addition, I report some diagnostic statistics. They include: a Sargan's (1958) chi-squared test for the over-identifying (OI) restrictions, a Durbin-Wu-

Hausman (DWH) test for endogeneity (Durbin, 1954; Wu, 1974; Hausman, 1978), the correlation coefficient between the predicted and actual bilateral correlation as a measure of goodness of fit, and the standard deviation of the regression residuals measured by root mean square error.To measure instrument quality (IQ), I use Shea's (1997) partial sample squared correlation statistic for each endogenous variable.[20]

The results in Table 12 are encouraging. All the transmission channels are statistically significant when studied alone, providing evidence that these channels may offer some explanations for synchronization. Further, the instrument quality is generally good, particularly for FDI and exchange rate deviation. In all the models, I reject the DWH test, indicating that there is a statistical difference between the IV and OLS estimations. Therefore, I will continue to use IV estimations as I expect that the explanatory variables are endogenous.

The measures of intra- and inter-industry trade intensity fit the data reasonably well; the correlation coefficient between the actual and predicted business cycle synchronization is 0.46. This provides some evidence to support both intra- and inter-industry trade as explanations for business cycle correlation. Both measures are statistically significant. As implied by economic theory, intra-industry trade explains more synchronized business cycles while inter-industry trade brings about business cycle divergence. The major concern with intra- and inter-industry trade is their relatively low instrument quality, which may be a consequence of the multicollinearity issue.

The FDI estimates are similar to those of intra- and inter-industry trade. The coefficient on FDI is positive and statistically significant. Moreover, the fit is as good as that for intra- and inter-industry trade variables. Nevertheless, another two financial market integration measures –

[20] For a single endogenous variable, this is equivalent to the R^2 from the first stage regression. The partial R^2 measure of instrument relevance is particularly useful to improve the consistency and precision of IV estimates in multivariate models.

long-term interest rates spread and equity market returns – have relatively poor fit. Both are negatively signed, indicating the greater the spread on asset returns the smaller the correlation between two countries' business cycles. The monetary policy measures I employ, bilateral spread on short-term interest rates and exchange rate deviation, are both of negative signs. Although each of these channels is statistically significant, only the short-term interest rate spread and equity return spread can provide as good an explanation as do intra- and inter-industry trade, based on the correlation between predicted and actual business cycle correlation.

The results in Table 12 provide some evidence to support the channels as explanations for business cycle correlation: intra- and inter-industry trade, financial market linkages, and monetary policy linkages. These models, however, are clearly not adequate. In each model, the over-identifying restrictions are strongly rejected, implying either that the instrument variables are invalid or that the models are mis-specified (Davidson & MacKinnon, 1993). Therefore, I will proceed to look at models with more than one transmission channel.

4.2. Two Transmission Channels

Table 13 reports results for models that include two transmission channels. In each column, I estimate a model that includes intra- and inter-industry trade and one of the other channel variables identified in Eq. (2). The first three columns use indicators of financial integration, and the last two columns include measures of monetary policy similarity.

From the five models, a number of results emerge. First, the fit — as measured by the correlation between predicted and actual business cycle synchronization and the standard deviation of the residuals — seems reasonable. The bivariate models do a better job of explaining the data than the simple models with only one transmission channel in Table 12. Second, the measures of intra- and inter-industry trade intensity remain statistically significant in most cases, and the coefficients are comparable to those reported in Table 12. Introducing other transmission channels does not dramatically alter the effect of intra- and inter-industry trade intensity on business cycle correlation. Third, the coefficients on FDI and long-term interest rate spread change substantially in both statistical significance and sign. Although both coefficients are statistically significant when considered in isolation (Table 12), they turn statistically insignificant when intra- and inter-industry trade are accounted for. Given their statistical insignificance, I drop these two variables in the following analysis. Fourth, three other channels remain significantly important while considering intra- and inter-industry trade: the equity market returns, the short-term interest rate spread, and the extent of exchange rate variation. In the latter two cases, the negative coefficients suggest that the smaller the short-term interest rate spread and the less the variation in bilateral exchange rates, the greater the correlation of business cycles. The sign of the equity measure, however, is surprisingly positive. Greater equity market integration, as measured by the closeness of equity returns, is expected to increase the extent of business cycle correlation. This could be a consequence of weak instrument variable problem.

The major concern with the five models of Table 13 remains instrument quality and the over-identification test. Even though financial integration and policy coordination variables exhibit good instrument relevance in simple regressions, their instrument quality falls dramatically in the two-transmission-channel models. It is likely a consequence of the multicollinearity issue. In addition, the over-identifying restrictions are strongly rejected for the last three columns. This suggests that either the instrument variables are invalid or that the models are mis-specified. The rejection of the over-identification test leads us to be skeptical about these two-transmission-channels models, therefore I consider more complex versions.

Given the relatively strong instrument quality and statistical significance of the equity variable, short-term interest rate variable, and exchange rate variation, I will augment them with additional variables in the following section.

4.3. Multiple Transmission Channels

I proceed to estimate more general models with multiple transmission channels. Given the statistical significance of equity return spread, short-term interest rate spread, and exchange rate variation in Table 13, I now control for at least two of the three channels. Table 14 reports estimates with multiple transmission channels. The first three columns show results for models that include intra- and inter-industry trade as well as two of the other channels, and the fourth column reports estimates with all of the three channels.

A number of important results emerge. First, my previous concern with over-identifying restrictions is lessened. Except the model in column (3), I do not reject the over-identifying restrictions at standard significance levels. This implies that models with multiple transmission channels are more reasonable than those in Table 13. Second, the model fit — evidenced by the correlation between predicted and actual synchronization and standard error of regression residuals — is no better than those in Table 13. This suggests incorporating multiple transmission channels does not better explain my data. Third, the measures of intra- and inter-industry trade intensity generally remain statistically significant with the same signs as those reported in Table 13. Intra-industry trade explains more synchronized cyclical comovement, while inter-industry trade contributes to de-synchronization of business cycles. Moreover, their coefficients get larger in absolute value than those in Table 13, indicating that introducing multiple transmission channels substantively increase the importance of intra- and inter-trade intensity for business cycle correlation.

Table 12: Single-Transmission-Channel IV Estimations

Dependent variable: A non-linear transformation of BK filtered business cycle correlation

	(1)	(2)	(3)	(4)	(5)	(6)
Intra	1.54***					
	(0.31)					
Inter	-2.03***					
	(0.55)					
FDI		0.42***				
		(0.04)				
EQ			-2.85***			
			(0.56)			
LR				-3.42***		
				(0.82)		
SR					-3.01***	
					(0.34)	
ER						-0.79***
						(0.10)
Constant	-1.21	4.21***	9.91***	2.44***	3.14***	-0.72**
	(1.49)	(0.26)	(1.58)	(0.16)	(0.19)	(0.29)
No. Obs.	231	193	210	190	190	231
OI	0.02	0.00	0.00	0.00	0.00	0.00
DWH	0.00	0.00	0.00	0.00	0.00	0.00
σ	1.32	1.30	1.24	1.34	0.96	0.86
Correlation	0.46	0.41	0.08	0.12	0.64	0.60
IQ (Intra)	0.07					
IQ (Inter)	0.05					
IQ (FDI)		0.51				
IQ (EQ)			0.25			
IQ (LR)				0.13		
IQ (SR)					0.32	
IQ (ER)						0.51

Notes:

1. All models are estimated using instrumental variables. The set of instrument variables includes logarithm of distance, common border, common language, a bilateral index of accounting standards, common legal origin, and mean real GDP dummy variables.
2. The numbers in parentheses are White heteroskedasticity-robust standard errors (MacKinnon & White, 1985). ***, **, and * denotes statistical significance at 1%, 5%, and 10% size.
3. OI refers to the marginal significance level for the over-identifying test, which is Sargan's (1958) chi-squared test for my 2SLS estimator.
4. DWH denotes the marginal significance level for a Durbin-Wu-Hausman test (Durbin, 1954; Wu, 1974; Hausman, 1978)
5. σ is the standard deviation of the regression residuals, which is the reported root mean square error.
6. Correlation is the correlation between actual and predicted bilateral correlation.
7. IQ is the measure of instrument quality, which is Shea's (1997) partial sample squared correlation statistic for each endogenous explanatory variable.

Table 13: Two-Transmission-Channel IV Estimations

Dependent variable: A non-linear transformation of BK filtered business cycle correlation

	(1)	(2)	(3)	(4)	(5)
Intra	1.76***	1.90***	1.44***	0.09	0.59**
	(0.63)	(0.43)	(0.27)	(0.30)	(0.29)
Inter	-2.51***	-2.21***	-1.77***	0.05	-0.54
	(0.85)	(0.66)	(0.45)	(0.45)	(0.49)
FDI	0.02				
	(0.63)				
EQ		3.05**			
		(1.52)			
LR			1.44		
			(1.06)		
SR				-2.40***	
				(0.66)	
ER					-0.43***
					(0.12)
Constant	-2.63	-8.65**	-0.47	3.67	0.69
	(2.24)	(4.11)	(1.28)	(1.20)	(0.98)
No. Obs.	193	210	190	190	231
OI	0.16	0.43	0.02	0.00	0.00
DWH	0.00	0.00	0.00	0.01	0.00
σ	1.52	1.48	1.09	0.83	0.72
Correlation	0.44	0.54	0.57	0.70	0.69
IQ (Intra)	0.05	0.06	0.11	0.05	0.03
IQ (Inter)	0.04	0.06	0.08	0.05	0.02
IQ (FDI)	0.02				
IQ (EQ)		0.06			
IQ (LR)			0.05		
IQ (SR)				0.07	
IQ (ER)					0.17

Notes:

1. All models are estimated using instrumental variables. The set of instrument variables includes logarithm of distance, common border, common language, a bilateral index of accounting standards, common legal origin, and mean real GDP dummy variables.
2. The numbers in parentheses are White heteroskedasticity-robust standard errors (MacKinnon & White, 1985). ***, **, and * denotes statistical significance at 1%, 5%, and 10% size.
3. OI refers to the marginal significance level for the over-identifying test, which is Sargan's (1958) chi-squared test for my 2SLS estimator.
4. DWH denotes the marginal significance level for a Durbin-Wu-Hausman test (Durbin, 1954; Wu, 1974; Hausman, 1978)
5. σ is the standard deviation of the regression residuals, which is the reported root mean square error.
6. Correlation is the correlation between actual and predicted bilateral correlation.
7. IQ is the measure of instrument quality, which is Shea's (1997) partial sample squared correlation statistic for each endogenous explanatory variable.

Table 14: Multiple-Transmission-Channel IV Estimations

Dep. Var	BK				HP	Growth	BK
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intra	2.22**	2.32*	0.24	2.15**	1.64***	0.79***	2.46***
	(0.94)	(1.20)	(0.26)	(0.96)	(0.36)	(0.21)	(0.59)
Inter	-2.76**	-2.78*	0.04	-2.65*	-1.74***	-0.74**	-3.11***
	(1.34)	(1.65)	(0.38)	(1.38)	(0.57)	(0.34)	(0.91)
EQ	2.87**	3.69		2.70*	2.85**	0.86	3.37*
	(1.29)	(2.65)		(1.47)	(1.28)	(0.67)	(1.95)
SR	0.69		-0.13	0.86			
	(1.48)		(0.93)	(1.61)			
ER		0.16	-0.51***	-0.07			
		(0.40)	(0.16)	(0.31)			
Constant	-9.82*	-10.89	1.83	-9.40	-6.88	-0.33	-12.45**
	(5.76)	(8.01)	(1.17)	(5.85)	(3.52)	(1.92)	(5.47)
No. Obs.	171	210	190	171	210	210	210
OI	0.48	0.44	0.00	0.24	0.27	0.12	0.75
DWH	0.00	0.00	0.00	0.00	0.00	0.00	0.00
σ	1.64	1.84	0.76	1.57	1.26	0.68	2.01
Correlation	0.53	0.51	0.77	0.53	0.53	0.60	0.50
IQ (Intra)	0.03	0.02	0.05	0.02	0.06	0.06	0.06
IQ (Inter)	0.03	0.02	0.05	0.02	0.06	0.06	0.06
IQ (EQ)	0.11	0.03		0.07	0.06	0.06	0.06
IQ (SR)	0.06		0.04	0.06			
IQ (ER)		0.11	0.19	0.15			

Notes:

1. All models are estimated using instrumental variables. The set of instrument variables includes logarithm of distance, common border, common language, a bilateral index of accounting standards, common legal origin, and mean real GDP dummy variables.
2. The numbers in parentheses are White heteroskedasticity-robust standard errors (MacKinnon & White, 1985). ***, **, and * denotes statistical significance at 1%, 5%, and 10% size.
3. OI refers to the marginal significance level for the over-identifying test, which is Sargan's (1958) chi-squared test for my 2SLS estimator.
4. DWH denotes the marginal significance level for a Durbin-Wu-Hausman test (Durbin, 1954; Wu, 1974; Hausman, 1978)
5. σ is the standard deviation of the regression residuals, which is the reported root mean square error.
6. Correlation is the correlation between actual and predicted bilateral correlation.
7. IQ is the measure of instrument quality, which is Shea’s (1997) partial sample squared correlation statistic for each endogenous explanatory variable.

Comparing Table 13 and Table 14 shows that the model in the second column of Table 13 seems to be a reasonable specification and is the one I will consider in the following sections. The model displays good fit (as evidenced by the correlation between actual and predicted business cycle synchronization). The over-identifying test and endogeneity test statistics are both favorable. The coefficients on intra- and inter-industry trade are both statistically significant, although the equity return is surprisingly positively signed. Suppose we have an average country pair which has a predicted correlation of 0.61(mean of BK filtered synchronization, see Table 10). This country pair sees an increase in intra-industry trade of 10% which sources from closer trade ties, then the best-fit model predicts a reduction in the synchronization between these two countries of 3.1% (1.9*0.1-2.21*0.1).

As a final robustness check, I substitute the first difference and HP filtered measures for the BK filtered measure in the benchmark model (the second column of Table 13), and report the estimation results in the fifth and sixth column of Table 14. In addition, I employ the BK filtered measure using data from 1995 to 2007 only, because the financial crisis of 2008-2010 may be unduly influencing the estimation in the best-fit model. The re-estimation is reported in the seventh column of Table 14.

In comparison to the benchmark model which I believe to be reasonable, replacing measures of business cycle synchronization does not materially alter conclusions about the influences of intra- and inter-industry trade on synchronization. The model fit, instrument quality, over-identification test statistics, and endogeneity test statistics are similar to those with BK filtered correlation in the full sample. This suggests that my results are robust across de-trending methods and sampling period. Because of the very high correlation between BK and HP filtered measures, the estimates for intra- and inter-industry trade are similar in terms of statistical significance, sign, and size. The coefficients of trade intensities in the case of growth synchronization, however, are roughly half of what they are with the BK filtered synchronization. Using the sample before 2008, the estimates for intra- and inter-industry trade are slightly larger than those in the full sample. Because there is no substantial change in the effects of intra- and inter-industry trade upon the 2008 global financial crisis, and the financial crisis is an important event which merits inclusion in my data, I will continue to focus on the BK-filtered measure in the full sample.

Consistent with Gruben et al. (2002), intra-industry trade robustly explains increased business cycle synchronization, whereas inter-industry trade brings about de-synchronization of business cycles. And consistent with Otto et al. (2005), I find that interest rate spread and exchange rate variation offer no explanation for cyclical synchronization when trade is simultaneously taken into account.

The coefficients of intra- and inter-industry trade provide economic implications with regard to the interdependence of trade and synchronization. Country pairs with higher intra-industry trade intensity tend to experience more synchronized cycles. Consider a country pair which has a very close trade ties. If they specialize in the industries in which they have comparative advantage, the considerable share of inter-industry trade is likely to decrease their business cycle synchronization. In other words, larger aggregate trade intensity may not explain increased synchronization if inter-industry trade constitutes a sufficiently large proportion.

The economic implication is also substantial for the eurozone enlargement and formation of monetary unions in other parts of the world. In line with the conclusions of previous studies on intra- and inter-industry trade (Gruben et al., 2002; Shin &Wang, 2004; Fidrmuc, 2004), intra-industry trade increases the degree of business cycle comovement, which makes it more suitable and feasible for the countries to join a monetary union. My result is challenging the conclusions made by Frankel and Rose (1998) that higher bilateral trade intensity increases the extent of business cycle synchronization. Even for country pairs who have intense bilateral trade, it is likely that the de-synchronizing effects of inter-industry trade on business cycles dominate over the converging impacts of intra-industry trade on business cycles. In such circumstances, the overall trade may lead to de-synchronization of business cycles and less suitability to form a common currency.

4.4. Further Investigations

My empirical models have identified the contrasting effect of intra- and inter-industry trade intensity on a measure of cross-section variation in business cycle synchronization among OECD nations. What is not apparent, however, is how the extent of intra-industry trade directly influences business cycle synchronization. In order to explore this relationship, I will take advantage of the estimates from the benchmark model (the second column of Table 13) and provides visualization of how the degree of intra-industry trade, captured by the intra-industry trade index $IIT_{ij\tau}$, relates to the cyclical correlation $\rho_{ij\tau}$. It is worth noting that using estimates from other models produces substantively the same relationship.

According to the benchmark model, I can rewrite Eq. (2) as

$$\ln\frac{1+\rho_{ij\tau}}{1-\rho_{ij\tau}} = \hat{\beta}_0 + \hat{\beta}_1 \ln\left(IIT_{ij\tau} \times T_{ij\tau}\right) + \hat{\beta}_2 \ln\left(\left(1 - IIT_{ij\tau}\right) \times T_{ij\tau}\right) + \hat{\beta}_5 EQ_{ij\tau} \quad (3)$$

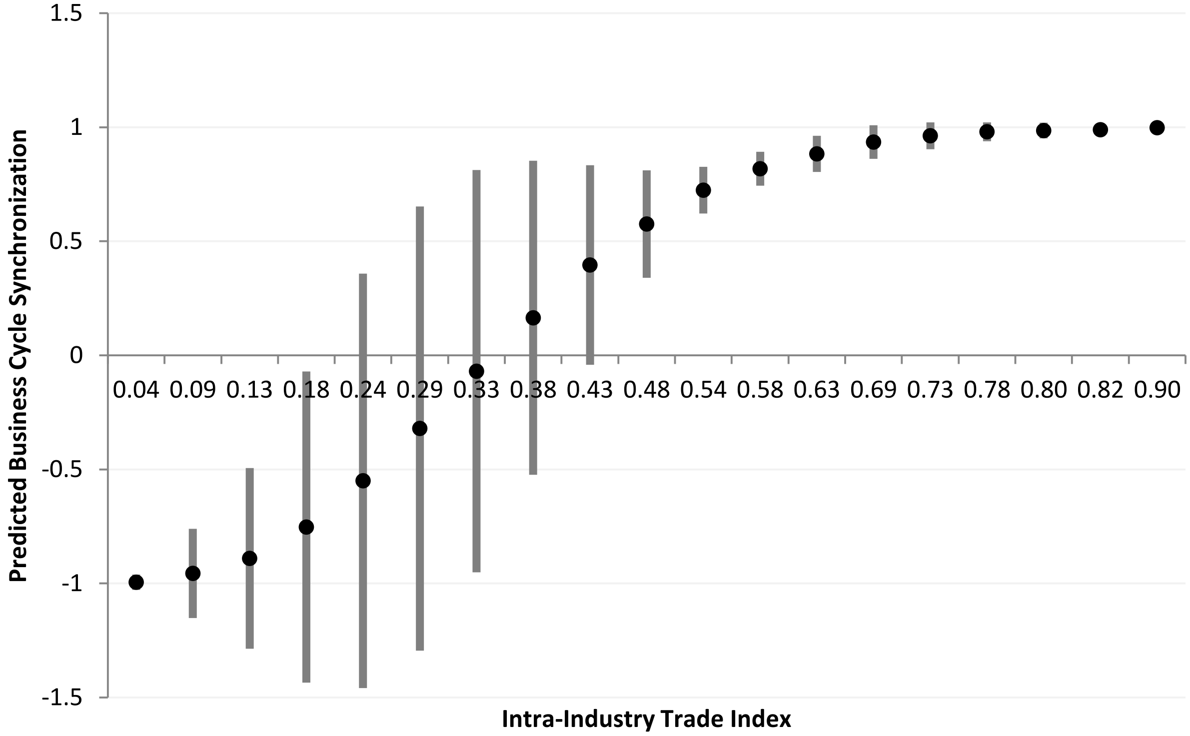
The vector of $\hat{\beta}$ refers to the estimated coefficients. I substitute the estimated coefficients in my benchmark model ($\hat{\beta}_0 = -8.65$, $\hat{\beta}_1 = 1.90$, $\hat{\beta}_2 = -2.21$, and $\hat{\beta}_5 = 3.05$) for the parameters in Eq. (3) and write $\rho_{ij\tau}$ as a univariate function of $IIT_{ij\tau}$:

$$\rho_{ij\tau} = 1 - 2/\left[e^{-8.65+1.90*\ln\left(IIT_{ij\tau}\right)-2.21*\ln\left(1-IIT_{ij\tau}\right)-0.31*\ln\left(\overline{T_{ij\tau}}\right)+3.05*\overline{EQ_{ij\tau}}} + 1\right] \quad (4)$$

$IIT_{ij\tau}$ ranges between 0 and 1 in theory, and the variables with a bar on the top refer to the sample means. Because Eq. (4) takes a non-linear form which is difficult to plot, I select several values of intra-industry trade index $IIT_{ij\tau}$ in my sample (the explanatory variable) and obtain discrete $\rho_{ij\tau}$ (the dependent variable) according to Eq. (4).

The scatter plot in Figure 9 demonstrates the relationship between business cycle synchronization $\rho_{ij\tau}$ and the intra-industry trade index $IIT_{ij\tau}$. The grey lines show the 95% confidence interval at each prediction. The scatter plot has an evidently upward trend, suggesting that a higher level of intra-industry trade increases synchronization. For smaller values of intra-industry trade index (lower than 0.45), the points in the figure are statistically insignificant. The synchronization-promoting effect of the intra-industry trade index is more salient when intra-industry trade constitutes more than 45% of aggregate trade, as evidenced by the confidence interval of the points in the scatter plot.

Figure 9: Higher Business Cycle Synchronization by Intra-Industry Trade Index



Notes: The scatter plot represents the predicted business cycle synchronization, and the grey line shows the 95% confidence interval at each prediction.

5. Conclusion

The different nature of intra-industry trade and inter-industry trade imply that they may impact business cycle comovement in different ways. Greater specialization, or a higher degree of inter-industry trade, induces two countries to be more sensitive to industry-specific supply shocks and tentatively leads to more idiosyncratic business cycles. On the other hand, if intra-industry trade takes a majority share of aggregate trade, common demand shocks may bring about more synchronized business cycles between trade partners. Given the nature of the two types of trade, I hypothesize that intra-industry trade explains convergence of cyclical comovement, while inter-industry trade contributes to divergence of business cycles.

This study uses a series of IV estimations to investigate the effects of intra- and inter-industry trade on business cycle synchronization, controlling for financial market linkages and monetary policy making. My empirical analysis shows that intra-industry trade explains increased business cycle synchronization, whereas inter-industry trade brings about divergence of business cycles. The conclusion is robust to de-trending methods. In addition, financial integration and policy coordination are statistically significant in stimulating synchronization when studied in isolation. When intra- and inter-industry trade are taken into account, nevertheless, the statistical significance of financial integration and policy coordination variables disappears. In further detail, I investigate the direct relationship between the measure of business cycle correlation and the share of intra-industry trade. The relationship is non-linear, and the synchronization-promotion effect of intra-industry trade index is more apparent when intra-industry trade takes over 45% of aggregate trade.

The fundamentally different effects of intra- and inter-industry trade on synchronization are helpful in explaining the inconsistent relationship between aggregate trade and business cycle synchronization (Canova & Dellas, 1993; Baxter and Kouparitsas, 2005; Imbs, 1999; Kenen, 2000; Kollman, 2001; Kose & Yi, 2001). For industrialized countries whose intra-industry trade takes a greater share, the overall effect of trade on synchronization is more likely to be positive. In other words, the synchronization-stimulating effect of intra-industry trade dominates. While in developing countries which are in the process of deeper specialization, the majority share of inter-industry trade may lead to a lower degree of cyclical comovement. According to the OCA theory, this provides economic implication for the eurozone enlargement and other monetary unions as well. It is the country pairs with higher intra-industry trade intensity, instead of aggregate trade intensity, that are more likely to experience synchronized business cycles and to join a monetary union.

While this study has provided a number of preliminary results, more rigorous estimation methods and more accurate measurement of variables are needed to improve my understanding of the interdependence between trade and business cycle synchronization. First, my estimation suffers from a multicollinearity issue. In particular, the measures of intra- and inter-industry trade are closely linked with a correlation coefficient of 0.82. The multicollinearity might explain the low instrument quality for intra- and inter-industry trade, as well as the statistical insignificance of financial integration and policy similarity. It is optimal if I could measure inter-industry trade with the degree of specialization and describe intra-industry trade using the extent of product differentiation and increasing returns to scale. In this way, the measures of intra- and inter- industry trade are detached from each other and the multicollinearity issue is addressed. Second, additional important transmission channels of business cycle shocks could be included and they are supposed to improve the explanatory power of the model. Although I control for transmission channels through financial market and monetary policy making, most of the factors turn statistically insignificant when intra- and inter-industry trade are accounted for. This suggests that I may be omitting other relevant explanatory variables. In future studies, I will identify other statistically and economically significant factors which may improve the model fit.

Chapter Four: Structural Equivalence and Intra-Industry Trade

1. Introduction

Intra-industry trade is defined as the simultaneous export and import of goods in the same industry. Intra-industry trade has an important impact on the national economy and the global economic network. For instance, Falvey (1981) maintains that intra-industry trade correlates inversely with the level of trade restrictions and influences domestic production through commercial policies. Melitz (2003) argues that intra-industry trade boosts aggregate industry productivity growth. The important role of intra-industry trade leads scholars to examine the underlying determinants. This chapter, following from the third chapter on industry structure and business cycle synchronization, explores how the characteristics of global trade networks influence intra-industry trade volume between countries.

The conventional way of studying determinants of bilateral trade is the gravity model, in which bilateral trade volume is explained by two countries' economic development level and geographical distance between them (Anderson, 1979; Helpman, 1987; and Deardorff, 1998). It has been regarded as "one of the great success stories in empirical economics" (Feenstra et al., 2001, p.431). Similar to aggregate trade, empirical studies on intra-industry trade find that intra-industry trade also follows a basic gravity model (Balassa, 1986b; Balassa & Bauwens, 1987, 1988; Bergstrand, 1989, 1990). In addition to national income and geographic distance, later empirical studies (Greenaway et al., 1994, 1995; Fontagne & Freudenberg, 1997; and Stone & Lee, 1995) identify other variables in explaining intra-industry trade, such as common language, colonial relationship, common currency, and indicators of trade agreements, to name a few.

Despite the popularity and empirical success of the gravity model in explaining bilateral trade, the approach is subject to many criticisms. One of the criticisms is that the gravity model focuses exclusively on bilateral features of country pairs, neglecting how bilateral trade can be affected by their relationships with other countries in the global trade network. This narrow bilateral perspective has been criticized by some studies which find network structures also contribute to explain bilateral trade (Kim & Shin, 2002; Kim & Skvoretz, 2010, 2013; Zhou & Park, 2012).

Within the global trade network, country pairs with common trade partners are likely to compete in the market of their common trade ties and know of business opportunities in each other's markets (Kim & Skvoretz, 2010; Zhou & Park, 2012). Availability of more information reduces the information barrier in international trade, thereby facilitating the establishment of closer trade ties between countries. Imperfect information in the international market makes this channel of information flow particularly important (Rauch & Watson, 2004). When two countries share more structural similarities in the trade network, there are more such information transmission channels, generating more trade opportunities between the two countries.

Structural equivalence, the level of structural similarities between individual actors within a network (Lorrain & White, 1971), is the conventional measure used to capture this network effect. Zhou and Park (2012) and Kim and Skvoretz (2010, 2013) robustly support the trade-promoting effect of structural equivalence in the context of aggregate trade. There have been, however, no studies on the relationship between structural equivalence and trade at the industry level. Intra -industry trade, primarily motivated by product differentiation and increasing returns to scale (Markusen, 1984), tends to associate with more information uncertainties (Kim &

Skvoretz, 2013). This implies that information transmitted through common trade partners is likely to be important for the establishment of intra-industry trade relationships.

This chapter is a first attempt to bring structural equivalence into the study of intra-industry trade. The main contribution of this chapter is the incorporation of social network analysis into the gravity model of intra-industry trade. The chapter extends Zhou and Park (2012), which studies the effect of structural equivalence on aggregate trade, in that I examine the effect of structural equivalence on intra-industry trade and its variation across sectors. Controlling for standard gravity variables, I find evidence supporting an effect of structural equivalence on encouraging intra-industry trade varies across industries. Moreover, the effect of structural equivalence on intra-industry trade is increasingly important over time.

This chapter is organized as follows. Part 2 presents a survey of the existing empirical literature on intra-industry trade. Part 3 describes the data and method employed in the analysis. Part 4 reports the estimation results and discusses the key findings. Part 5 concludes.

2. Existing Literature on Intra-Industry Trade

In order to examine how the similarity of trade partners affects intra-industry trade, I need to control for other factors that explain intra-industry trade. Therefore, a comprehensive literature review on the determinants of intra-industry trade is necessary. In this section, I first discuss various measures of intra-industry trade and justify my measurement. Then I review the literature on the theoretical and the empirical gravity models of intra-industry trade. Finally, I elaborate on a potential determinant of intra-industry trade suggested by the social network literature, namely structural equivalence.

2.1. Measures of Intra-Industry Trade

The conventional gravity model of trade uses aggregate trade volume as the dependent variables. Existing studies on industry-level trade, however, most construct an intra-industry trade index for the dependent variable, the construction of which is usually open to criticism. In this section, I will first introduce various measures used in previous studies and then discuss my measure of intra-industry trade.

The first intra-industry trade index (IIT), $\mathrm{IIT_{ijt}} = \frac{\sum_k |X_{ijkt} - M_{ijkt}|}{\sum_k |X_{ijkt} + M_{ijkt}|}$ and $\mathrm{IIT_{ij\tau}} = T^{-1} \sum_t \mathrm{IIT_{ijt}}$, is proposed by Balassa (1986a), which measures the degree of trade overlap. k is an index of industry classes, and X_{ijkt} and M_{ijkt} are sector-k exports and imports from country i to j at time t. Though the index captures the essence of intra-industry trade, the simultaneous export and import of goods within an industry, an index that reflects pure intra-industry trade at value of zero is not intuitive. That is why Grubel & Lloyd (1975) develop an alternative index $\mathrm{IIT_{ijt}} = 1 - \frac{\sum_k |X_{ijkt} - M_{ijkt}|}{\sum_k |X_{ijkt} + M_{ijkt}|}$ and $\mathrm{IIT_{ij\tau}} = T^{-1} \sum_t \mathrm{IIT_{ijt}}$. This index assigns pure intra-industry trade a value of one and pure inter-industry trade a value of zero (See Chapter Three for full details).

Both Balassa and Gruben-Lloyd index have been criticized for suffering from subgroup aggregation issues. In constructing the indexes, I need to disaggregate industries when I want to measure subgroups of commodities. However, the intra-industry trade index will shrink and eventually become zero. Another problem with the Gruben-Lloyd index is that it fails to explicitly differentiate one-way from two-way trade. Any commodity that has a Grubel-Lloyd index greater than zero will be regarded as two-way trade. To identify two-way trade, Abd-el-Rahman (1991), and Fontagne and Freudenberg (1997) argue that notable two-way trade exists within a commodity classification when the value of the minority value flow of trade represents at least γ percent of the majority value flow of trade. That is, $\frac{\mathrm{Min}(X_{ijkt}, M_{ijkt})}{\mathrm{Max}(X_{ijkt}, M_{ijkt})} > \gamma$.

After differentiating one-way from two-way trade, Fontagne and Freudenberg (1997) move on to differentiate horizontal from vertical intra-industry trade. They argue that products differ in terms of quality even for a given commodity that experiences two-way trade. Within the framework of intra-industry trade, horizontal intra-industry trade is characterized by trade of products with similar quality levels, while vertical intra-industry trade is defined as trade of goods with remarkably different quality levels. Assuming that unit values (UV) represent quality even under imperfect information, Fontagne and Freudenberg set up criteria to disentangle intra-industry trade: $\frac{1}{1+\alpha} \leq \frac{UV^X}{UV^M} \leq 1 + \alpha$ for horizontal intra-industry trade; otherwise, $\frac{UV^X}{UV^M} > 1 + \alpha \ or \ \frac{UV^X}{UV^M} < \frac{1}{1+\alpha}$ for vertical intra-industry trade. UV is defined as the value of trade divided by the quantity traded, and α is the threshold value which lies between 0.15 and 0.25.[21]

Although the abovementioned intra-industry trade indexes sometimes act as the dependent variable in the gravity model, I will use bilateral trade volume in the same sub-sectors rather than the indexes for two reasons. First, it is conventional to use aggregate trade volume as the dependent variable in gravity models of trade. As its counterpart, the use of volume of intra-industry trade is more intuitive. Using intra-industry trade volume in a gravity model also allows for comparison with Rose (2004) and Zhou and Park (2012) which use aggregate trade volume. Second, characteristics of intra-industry trade are not the focus of my analysis. Instead, my major interest is the determinants of the volume of intra-industry trade. Hence, it is not necessary to distinguish between one-way from two-way trade, or between horizontal and vertical intra-

[21] Empirical studies on vertical and horizontal intra-industry trade are not sensitive to the threshold number chosen.

industry trade. For these two reasons, I will use bilateral trade volume in the same sectors as my measure of intra-industry trade.

2.2. Theoretical Studies on the Gravity Model of Intra-Industry Trade

2.2.1. Theoretical justification of the gravity model of aggregate trade

The basic gravity model of trade draws an analogy with Newton's law of gravitation. A mass of goods supplied at the origin country is attracted to a mass of demand for goods at the destination country, but the potential trade flow is reduced by the distance between them. Tinbergen (1962) is the first to use gravity to explain trade flows.

Starting from 1979, theoretical rationales for the gravity model of trade emerged, which are mostly based on general equilibrium frameworks. The theoretical support for the gravity model can be divided into two categories. The first approach, proposed by Anderson (1979) and Bergstrand (1985), assumes that each country specializes completely in the production of its own good, and there is one good for each country produced exogenously. Using the market-clearing condition that one country's production equals the volume of exports and domestic consumption, they derive the basic gravity model of trade.[22]

Another theoretical rationale for the gravity model of trade relies on the roles of technology and market structure. This approach is more closely tied to prevailing theories of trade, where production functions and market structure are explicit. The three most prominent theories under this category are: (1) the Ricardian approach (Dornbusch et al., 1977), which emphasizes labor-productivity differentials; (2) the Heckscher-Ohlin approach, which attributes trade flows to relative-factor-endowment differentials; and (3) the Helpman-Krugman monopolistic

[22] When frictions of trade and heterogeneous consumer preference are accounted for, the relationship is much more complicated. Detailed explanation about the model is beyond the scope of this chapter. See Anderson and van Wincoop (2004) for a comprehensive survey on the theoretical foundations of gravity model.

competition approach (Krugman, 1979; Helpman and Krugman, 1987), which regards economies of scale and tastes for variety as the source of trade.

As the gravity model of trade has been used extensively for over 50 years, a large number of recent studies identify an augmented gravity model of trade, whose specifications are based upon rigorous theoretical and econometric foundations. These augmented gravity variables include, but are not limited to, economic integration agreements (Ghosh & Yamarik, 2004; Baier & Bergstrand, 2007), infrastructure (Francois & Manchin, 2007), currency unions (Rose, 2000), and political and institutional factors (Grigoriou, 2007; Shepherd & Wilson, 2007).

2.2.2. Theoretical analysis of the gravity model of intra-industry trade

Unlike the extensive general equilibrium theoretical foundations for the gravity model of aggregate trade, there has been no theoretical justification provided for intra-industry trade flows. However, there are two important facts implicitly supporting the use of the gravity equation for modeling intra-industry trade flows. First, the empirical specification most frequently used in the study of economic determinants of intra-industry trade flows is the gravity equation (See empirical studies in the next section). Second, theoretical justification for using the gravity model of intra-industry trade has been usually used by analogy to aggregate trade flows (Balassa & Bauwens, 1987; Bergstrand, 1990; Greenaway et al., 1994). In fact, the gravity model has also been used extensively for understanding the determinants of bilateral foreign direct investment and migration flows, although the theoretical foundations were not provided until recently and are not yet complete (Markusen, 2002; Bergstrand & Egger, 2007; Head & Ries, 2008).

Anderson and van Wincoop (2004) argue that the gravity model provides the main link between trade costs and trade flows. Trade costs can be decomposed into two main sources, namely natural trade costs and policy-based trade costs. Natural trade costs include geographic distance, fuel cost, the level and quality of communications between countries, and being landlocked, while policy-based trade frictions are associated with tariffs and non-tariff barriers. Trade costs to intra-industry trade are also prominent and play an important role in explaining the levels of such flows (Lancaster, 1980; Bergstrand, 1990; Markusen & Venables, 1998). Therefore, it is reasonable to use the gravity model to describe the effects of trade costs on intra-industry trade flows.

As discussed above, although there has been no theoretical explanation for the gravity model of intra-industry trade, the importance of trade costs to intra-industry trade as well as a sensible analogy between aggregate trade and intra-industry trade motivates the use of gravity variables to explain intra-industry trade. Nevertheless, more rigorous theoretical analysis on the gravity model of intra-industry trade is still needed.

2.3. Empirical Studies on the Gravity Model of Intra-Industry Trade

In addition to GDP and geographic distance, earlier empirical studies have identified a large number of augmented gravity variables of intra-industry trade, which will be elaborated in this section. These gravity variables primarily include economic size, geographic proximity, economic performance, economic integration, and other national characteristics. These gravity variables are commonly used in existing studies, and are found to be robustly correlated with intra-industry trade. Following the convention, I incorporate them into my empirical models.

Economic size is one of the basic gravity variables. It reflects the market value of goods and services produced within a country, and is expected to be positively correlated with intra-industry trade volume. Larger economic sizes have the potential to encourage a higher degree of product differentiation (Krugman, 1979; Lancaster, 1980), because larger markets can be segmented into more target markets to attract consumers with different tastes. Larger economic size also provides a greater possibility to achieve economies of scale by producing more units of output. All studies so far use GDP to measure economic size, as in the basic gravity model of trade. Balassa (1986b), Balassa and Bauwens (1987, 1988), Bergstrand (1990), Greenaway et al. (1994, 1995), Fontagne and Freudenberg (1997), and Stone and Lee (1995) empirically support the positive effect of GDP on intra-industry trade.

Geographic proximity is the other basic gravity variable, and is expected to encourage intra-industry trade. Usually, geographic proximity is captured by a dummy variable for a common border or by a measure of geographic distance between the countries. Two geographically close countries tend to have lower transport costs and similar natural resource endowments, which may promote intra-industry trade. Balassa (1986b), Balassa and Bauwens (1987, 1988), Bergstrand (1990), and Fontagne and Freudenberg (1997) provide empirical support for the important role that closer distance and common border play in promoting intra-industry trade.

Economic performance is one of the variables in the augmented gravity model of intra-industry trade. Better economic performance is expected to promote intra-industry trade, because highly developed countries have stronger research and development capability, and generally greater potential to design differentiated products. In the meantime, consumers in developed countries are more likely to demand highly differentiated products. The most commonly used variable to describe economic performance is GDP per capita. Balassa (1986b), Balassa and Bauwens (1987, 1988), Fontagne and Freudenberg (1997), and Stone and Lee (1995) use average GDP per capita as independent variables and find a positive relationship between GDP per capita and intra-industry trade.

It should be noted that better economic performance of a country pair may arise from two highly developed economies or from one very highly developed economy and a developing economy. In the former case, I will expect a larger intra-industry trade volume. While in the latter case, better economic development may not contribute to more intra-industry trade. Begstrand (1990) uses both economic development and its difference between countries as independent variables, and the analysis identifies the statistically significant effect of the difference but not economic development. This implies that it is necessary to include a variable that captures the difference of economic performance between a pair of countries. Generally, one can expect a negative relationship between intra-industry trade and inequality in economic development within a country pair. The most common measure of economic inequality is the absolute value of difference of GDP per capita between a pair of countries. Helpman (1987), Bergstrand (1990), Greenaway et al. (1994), and Fontagne and Freudenberg (1997) provide empirical support for a negative relationship between economic inequality and intra-industry trade.

Economic integration, another variable in the augmented gravity model of intra-industry trade, is expected to promote intra-industry trade, because country pairs with greater economic integration tend to eliminate trade barriers and reduce transactions costs of trade. The variable is usually represented by a dummy variable with for a regional trade agreement (RTA) or monetary union. An RTA removes tariff and non-tariff barriers to trade (including quota, subsidies and trade licenses) and promotes establishment and enlargement of free trade areas. Joining a monetary union eliminates currency risk associated with international trade and thus promotes trade among union members. Balassa (1986b), Balassa and Bauwens (1988), Bergstrand (1990), Greenaway et al. (1994), and Fontagne and Freudenberg (1997) find evidence supporting the positive relationship between economic integration and intra-industry trade.

There are some other national characteristics, mainly language and colonial relationships, which act as gravity variables in applied work. Sharing common characteristics is expected to promote intra-industry trade. Countries that speak the same languages or have had colonial relationships tend to have lower barriers of trade and have similar tastes towards products. The similarity of these characteristics may promote intra-industry trade. Balassa and Bauwens (1987, 1988), Hu and Ma (1999), Kandogan (2003), and Blanes (2005) find that common language and previous or current colonial relationships contribute to higher intra-industry trade.

2.4. Structural Equivalence from Social Network Analysis

The abovementioned literature on gravity variables of intra-industry trade concentrates on characteristics of country pairs identified in the gravity model of trade. An implicit assumption underlying the gravity model of trade is that bilateral trade is independent of the country pair's relationship to other countries within the global trade network. In other words, country pairs are examined in isolation from the network of global trade in which they are embedded. This narrowly bilateral perspective ignores possibly important network effects that may help explain bilateral trade (Kim & Shin, 2002; Kim & Skvoretz, 2010, 2013; Zhou & Park, 2012).

2.4.1. Structural equivalence

Structural equivalence is conceptualized as the level of structural similarities between individual actors within a network (Lorrain & White, 1971). When applied to the global trade network, it measures the degree of similarity in two countries' trading relationship with other countries. In practice, structural equivalence is calculated by the Pearson correlation of a pair of countries' trade relations with other countries (Zhou & Park, 2012).

To illustrate how structural equivalence is constructed and what it measures, I use a simple hypothetical example of an international trade network made up of five countries (countries A-E).

The number of countries in the example is small enough to be manageable and large enough to clarify the construction of structural equivalence. In order to measure the similarity in Country A and Country B's trade relations with other countries in the network, I construct structural equivalence between A and B:

$$\mathrm{SE_{AB}} = \mathrm{corr}(\mathrm{V_A}, \mathrm{V_B})$$

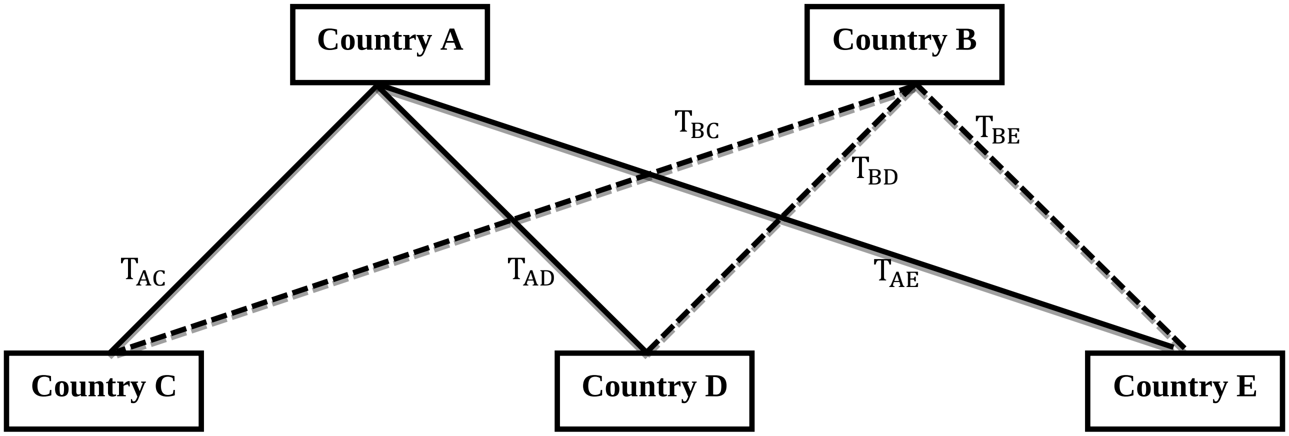
$\mathrm{SE_{AB}}$ denotes the degree of structural equivalence between A and B, and corr refers to correlation. $\mathrm{V_A} = (\mathrm{T_{AC}}, \mathrm{T_{AD}}, \mathrm{T_{AE}})'$ and $\mathrm{V_B} = (\mathrm{T_{BC}}, \mathrm{T_{BD}}, \mathrm{T_{BE}})'$. $\mathrm{V_A}$ is the vector composed of all the values of bilateral aggregate trade that A has with all other countries except B (e.g., $\mathrm{T_{AC}}$ denotes the bilateral aggregate trade value between A and C, which is the average of bilateral trade between the two countries). Similarly, $\mathrm{V_B}$ is the vector of all the values of bilateral trade that B has with all other countries except A. I use the measure of structural equivalence based on aggregate trade. In terms of information flow, there is a spillover effect which indicates that the information beneficial for the trade in one sector may benefit another sector's trade. The effects exists because most of the business information that firms seek for is common to all the sectors, including labour force characteristics, environmental standards, business code, regulations and laws, consumers' wealth and preference, productivity, as well as research and development. Therefore, I base structural equivalence on aggregate trade to capture the comprehensive information transmission. If industry-specific information transmission is investigated in future studies, I will build up structural equivalence based on intra-industry trade.

Figure 10 provides visualization of the structure of the hypothetical trade network. The solid lines represent A's bilateral trade relations, and the dashed lines denote the bilateral trade relations that country B has. Structural equivalence between A and B is based on the comparison of their trade relations with other countries, not the trade relationship between themselves.

Structural equivalence ranges between -1 and 1 in theory. Structural equivalence at the value of one indicates perfect structural equivalence in that the two countries have exactly the same trade partners and each trade relation has exactly the same relative weight in total trade. Perfect structural equivalence rarely exists in the real trade network. However, some country pairs are close to perfectly structural equivalence. Two country pairs (Canada - Mexico and Japan - South Korea) have structural equivalence with values of 0.999 and 0.991, respectively. (See Table 1 in Zhou & Park, 2012).

I further demonstrate the calculation of SE_{AB} using hypothetical values of trade in the two vectors V_A and V_B . Table 15 shows the five scenarios when structural equivalence equals -1, -0.5, 0, 0.5, and 1, respectively. It should be emphasized that there are a large number of V_A and V_B that give rise to the same value of structural equivalence. These scenarios are only selected for the purpose of illustration. It is also worth noting that non-positive structural equivalence is rare in reality. Major countries such as the US, China, and other large economies, have a large volume of trade with most countries in the world. Any pair of countries would have relatively large amount of trade with these major countries, thereby making non-positive structural equivalence unlikely.

Figure 10: Hypothetical Trade Network



Notes:
1. The solid lines represent A's bilateral trade relations, and the dashed lines denote the bilateral trade relations that country B has.
2. T refers to bilateral trade value. For example, T_{AC} denotes the trade value between A and C.

Table 15: Examples of Structural Equivalence Calculation

Example	V_A			V_B			SE_{AB}
	T_{AC}	T_{AD}	T_{AE}	T_{BC}	T_{BD}	T_{BE}	
(1)	0	0	20	20	20	0	-1
(2)	0	20	20	20	0	20	-0.5
(3)	20	40	30	20	20	20	0
(4)	20	40	30	40	50	30	0.5
(5)	20	40	20	40	80	40	1

Notes: SE_{AB} is the structural equivalence of country A and B. V_A is the vector composed of all the values of bilateral trade that A has with all other countries except B (e.g., T_{AC} denotes the trade value between A and C). V_B is the vector of all the values of bilateral trade that B has with all other countries except country A.

2.4.2. Trade-promoting effect of structural equivalence

Earlier studies argue that information flow is the main mechanism through which structural equivalence promotes bilateral trade (Burt, 1987; Mizruchi, 1993; Kim & Skvoretz, 2010; Zhou & Park, 2012). Search for trade partners is costly for firms in international markets, and information about potential trading partners is almost always incomplete and lacking (Baker, 1984).[23] Even though many trade opportunities are potentially available, lack of information remains a great barrier to international trade in spite of advancement of information and communication technologies (Rauch & Watson, 2004; Kim & Skvoretz, 2013; Petropoulou, 2011). Firms when seeking to develop new markets or sources of supply are constrained by access to information on potential business opportunities. Because of these constraints, networks developed through trading relationships may provide important information flows that further shape trade patterns.

In reality, availability of more information reduces the searching cost, thereby facilitating the establishment of closer trade ties between countries. Rauch and Trindade (2002) and Frankel and Wei (1993) find that immigration ties and common languages play an important role in facilitating the transmission of business information and thus boost bilateral trade. Similarly, country pairs with a high level of structural equivalence tend to have more information about each other, because they are more likely to meet in the market of their common trading partners and know of business opportunities in each other's markets (Kim & Skvoretz, 2010; Zhou & Park, 2012). Imperfect information in the international market makes this channel of information flow particularly important. This information transmission process can be illustrated by the previous five-country example in Table 15. When A trades with C, information about A also flows to C. If B also trades with C, then B can get this information about A through C. This is a typical information transmission process in social and economic networks. As a result of this information flow, A and B are likely to establish more trade among themselves (Easley &

[23] Countries rarely exchange commodities with one another, but individual firms and governments within the countries do. Firms with some assistance perhaps from government choose trade partners to import and export. Since aggregate correlations cannot be substitutes for individual correlations, it is difficult to explain individual firm's behavior (Kim & Skvoretz, 2010). In this chapter, I examine structural equivalence which may influence opportunities for the interaction between countries, but I do not specify which firms in the countries take the opportunities.

Kleinberg, 2010). As defined above, a higher level of structural equivalence implies the existence of more such information transmission channels, and thus creates more trade opportunities between the two countries.

To get a more practical sense as to how structural equivalence promotes bilateral trade, consider two emerging markets such as South Korea and Vietnam. Intensive trade occurs between South Korea and Japan, as well as between Vietnam and Japan. Because of their common ties to firms in Japan, firms in South Korea and Vietnam are likely to know more about each other. Firms from these countries tend to obtain more information in the Japanese market and can observe the details of the exchanges between the other country and Japan. The common ties with Japan provide South Korea and Vietnam with information about each other such as market demands and supply, consumer tastes and preferences, pricing, product or service related standards, labor standards, legal regulations, institutional environments, and even the manners of doing business. Hence, the shared ties with Japan are conducive to more trade opportunities between South Korea and Vietnam. More common trade partners like Japan, thus a higher level of structural equivalence, provide more such information transmission channels and promote more bilateral trade between South Korea and Vietnam.

Although theories suggest that structural equivalence promotes bilateral trade, there is a potential problem of reverse causality. Two countries may develop similar trade networks as their bilateral trade increases. Rauch (2001) and Rauch and Watson (2004) argue that trading with a network intermediary, a firm who sells access to its network typically for a commission on the value of the transaction realized, may help develop a trade network similar to that of the network intermediary. For instance, firms in Hong Kong connected Chinese firms to the rest of the world in the early 1990s. After a peak in 1993 (61.3%), the percentage of Chinese goods that were re-exported through Hong Kong declined to 45.4% in 1998 (Feenstra, 2004). China and the rest of the world eventually established direct trade ties to eliminate the brokerage fees charged by Hong Kong. This example implies that bilateral trade may sometimes increase the degree of structural equivalence. In order to mitigate such endogeneity issue, I use lagged structural equivalence in the empirical models so as to establish the temporal order.

2.4.3. Structural equivalence and intra-industry trade

The trade-promoting effect of structural equivalence has been tested in the context of aggregate trade (Kim & Skvoretz, 2010, 2013; Zhou & Park, 2012), but it is still an open question whether it also applies to trade at the industry level. Intra-industry trade is primarily motivated by product differentiation and increasing returns to scale (Markusen, 1984).[24] This implies that the exchange of goods within the same sector requires information on consumer tastes, differentiated products, as well as market demand and supply structure. As discussed above, such information can be transmitted through common trade ties, and countries can obtain the information in their common markets. It is reasonable to hypothesize that structural equivalence promotes intra-industry trade. In contrast, inter-industry trade is closely associated with countries' comparative advantages in natural endowment or technology, according to the classic Ricardian or Heckscher-Ohlin model. Existing studies mostly assume that inter-commodity differences are more observable, making information search less a problem (Aquino, 1978; Ricci, 1999).

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[24] Product differentiation and the associated information uncertainty is my rationale for the higher importance of structural equivalence in sectors of heterogeneous products. I am not, however, using a measure of product differentiation in the empirical models. None of the measures of product differentiation robustly influences intra-industry trade in early studies (Hufbauer, 1970; Caves, 1981; Toh, 1982; Hughes, 1993). Moreover, I examine only two sectors in the following empirical analysis and estimate the sectors separately. If product differentiation does not vary over time, it is captured by the constant term. If product differentiation varies over time, it is captured by the fixed year effects. In addition, economic size is regarded as a measure of product differentiation (Krugman, 1979; Lancaster, 1980), and I use a measure of economic size in the models. For abovementioned three reasons, I do not include product differentiation in my estimations.

Given that intra-industry trade is likely to be particularly dependent on information transmitted through common trade ties, I am interested in how structural equivalence influences intra-industry trade. There have been no empirical studies that examine the role of structural equivalence in explaining intra-industry trade. In this chapter I will bridge the structural equivalence from the social network theory and the gravity model of intra-industry trade.

Borrowing the measure of structural equivalence in Zhou and Park (2012), I examine the effect of structural equivalence in two sectors: crude materials and final products. For reasons stated above, I hypothesize that structural equivalence promotes intra-industry trade, but the trade-promoting effect may vary with sectors. Rauch (1999) and Kim and Skvoretz (2013) maintain that similarity of trade network, such as structural equivalence, is more important for the exchange of differentiated goods which vary drastically in price, quality, and design. Rauch and Trindade (2002) find that ethnic Chinese networks increase bilateral trade more for differentiated than for homogeneous products. Final products are mostly differentiated commodities, which are likely to have higher information uncertainty and require more costly information search than the homogenous commodities in the raw material sector. In the absence of perfect information, search for trade in differentiated goods is more dependent on previous contacts and network information. It is sensible to hypothesize an economically significant trade-promoting effect of structural equivalence in the final product sector, while it may not be the case in the raw material sector.

I further hypothesize that the trade-promoting effect of structural equivalence on intra-industry trade increases over time. This hypothesis is similar to the conclusion in Zhou and Park (2012) that structural equivalence is getting more important in boosting aggregate trade. The effect of structural equivalence is expected to become more salient over time as the structure of global trade networks becomes more complex. Within increasingly diverse and complex global trade networks, the search cost for information and trade opportunities is increasing too. Consequently, the business information transmitted through common trade partners becomes more valuable. Firms in two countries increasingly take advantage of the information transmitted through their common trade partners and establish more intensive bilateral trade relations. In other words, structural equivalence is likely to play a more and more important role in boosting bilateral trade over time.

3. Data and Methodology

3.1. Data

I use panel data, which consist of annual data from 1962 through 2000 for 182 countries. The dependent variable is the bilateral industry-level trade organized by the one-digit Standard International Trade Classification (SITC), Revision 1.[25] SITC classifies commodities into ten general sectors, from which I extract two sectors for analysis. They are (1) SITC 2: Crude materials, inedible and except fuel; and (2) SITC 7: Machinery and transport equipment. The one-digit sectors chosen represent raw materials and final products separately.

All the disaggregated bilateral trade data come from the United Nations Commodity Trade (UN Comtrade) database. Bilateral trade in the industry level and all the other measures are in US dollars. To generate nominal intra-industry trade volume, I use the average of bilateral imports in one of the two sectors, as Gruben et al. (2002), Feenstra (2004), and Feenstra et al. (2005) contend that trade flows reported by the importing country, whenever they are available, are more accurate than reports by the exporters, suggesting that import data is usually considered

[25] I use one-digit trade data as opposed to two-, three-, and four-digit data, because there are more missing observations in more disaggregated data. In order to retrieve data back to the 1960s, I employ the most comprehensive version of the disaggregated trade data.

of higher quality.[26] Following Rose (2004) and Zhou and Park (2012), I deflate nominal intra-industry trade by the US Consumer Price Index (1982-1984=100) from United States Bureau of Labor Statistics.[27] It is conventional to take natural logarithms of real trade volume in empirical models. The unit of the observations is a given pair of countries in a given year. The country pairs in my sample are exactly the same for each sector, so that the effects of structural equivalence are comparable across sectors.

Figure 11 provides an overview of the real bilateral trade in SITC 2 and SITC 7. The distributions of real intra-industry trade in the two sectors are similar. The summary statistics also provide evidence of considerable variation around the mean, as is seen from the standard deviation of intra-industry trade.

The measure of structural equivalence (SE), the variable of primary interest, is taken from Zhou and Park (2012). This measure is based on aggregate trade, which makes my results comparable to Zhou and Park. It describes the degree of similarity in two countries' trade relationship with other countries in the global trade network. Structural equivalence was constructed using the UCINET software, which is the Pearson correlation coefficient of a pair of countries' trade relations with other countries.[28] The value of structural equivalence varies across country pairs and over time.

Figure 12 presents the distribution of structural equivalence in the first year and last year of my data, respectively. A number of results emerge. First, the figure shows that my panel data is unbalanced. There are 517 country pairs in the year of 1962, and 3731 country pairs in 2000.

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[26] Rose (2004) constructs an alternative measure of bilateral trade by taking an average value of all the four possible trade between two countries (imports into j from i, exports from i to j, imports into j from i, and exports from j to i). I do not anticipate any significant differences between the two approaches. Exclusively using import data is also the way that Zhou and Park (2012) construct bilateral trade, which makes our studies more comparable.

[27] An alternative and potentially better way is to deflate nominal trade by GDP deflator. In order to be comparable with Rose (2004) and Zhou and Park (2012), I use the CPI index to deflate intra-industry trade.

[28] UCINET is a software package for the analysis of social network data. It was developed by Borgatti et al. (2002).

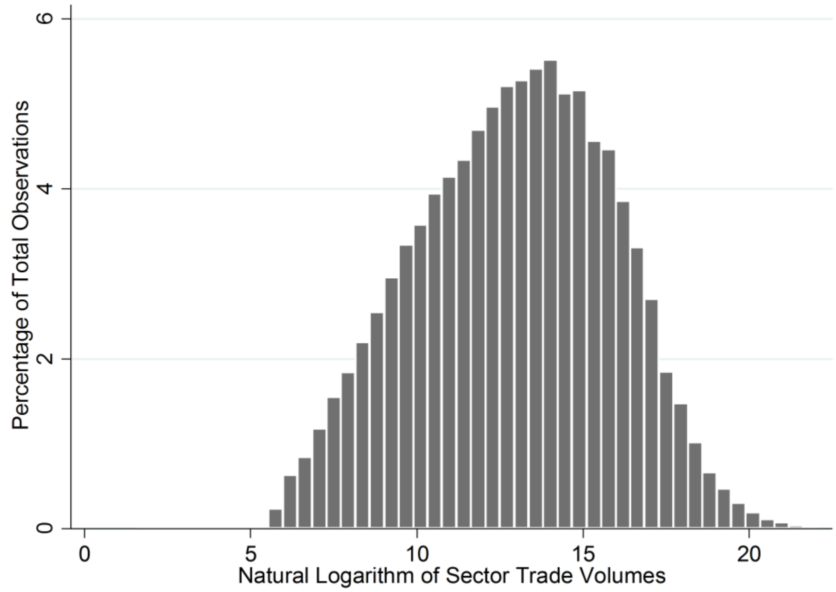
Second, structural equivalence is seldom negative in the real world of trade, which is consistent with my prior expectation. Third, structural equivalence is somewhat negatively skewed in 1962, but it turns positively skewed in 2000. The fact that structural equivalence is generally higher in 1962 is likely a reflection of global trade network complexity. The number of trade partnerships in the 1960s is much smaller than that in 2000, implying a higher likelihood of common trade partners and thus a higher level of structural equivalence in earlier years.

Table 16 lists the country pairs that have the highest and lowest degrees of structural equivalence in 1962 and 2000, respectively. Canada and Mexico are identified with the highest structural equivalence in 2000. Both countries have intensive trade with the US, which is likely to contribute to the almost perfect structural equivalence. Belarus appears in all of the country pairs with the lowest degrees of structural equivalence in 2000. This can be explained by Belarus' almost exclusive trade with Russia which distinguishes it from other economies in terms of similarity of trade relationships within the global trade network.

As a first look at the data, I also consider a scatter plot of the contemporaneous relationship between real intra-industry trade and structural equivalence. Figure 13 presents the scatter plots for both sectors in 1962 and 2000, respectively. A linear fit line and its 95% confidence intervals are provided in each graph. In 1962, real intra-industry trade does not obviously increase with higher structural equivalence, as the fit lines in the first two panels are close to horizontal. In 2000, however, the fit lines are apparently upwards trending, suggesting that structural equivalence promotes intra-industry trade in both sectors. The preliminary descriptive statistics seem supportive of my prior hypothesis that the trade-promoting effect of structural equivalence grows over time.

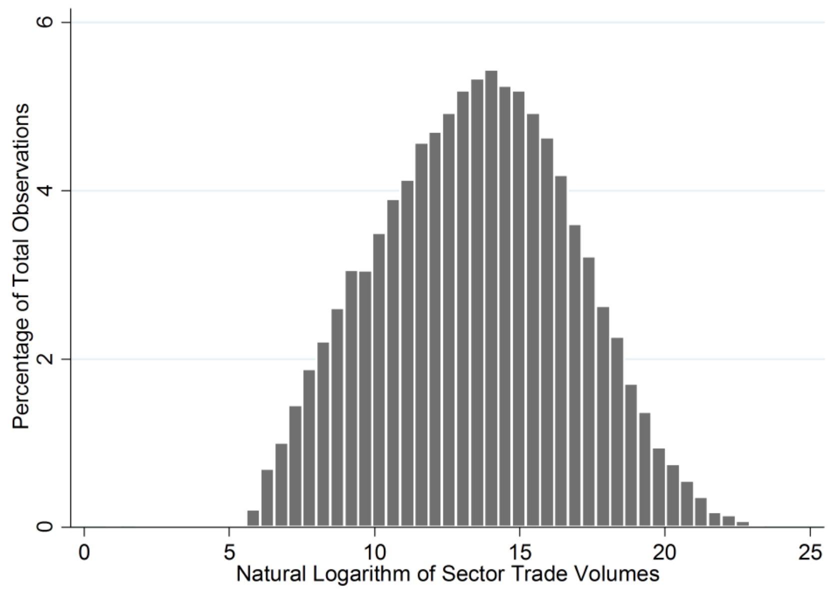
Figure 11: Descriptive Statistics of Real Intra-Industry Trade
Panel A. Distribution of Real Intra-Industry Trade (SITC 2)

No. Obs.	58544
Mean	12.918
Std. dev.	2.985
Minimum	1.622
Maximum	22.068



Panel B. Distribution of Real Intra-Industry Trade (SITC 7)

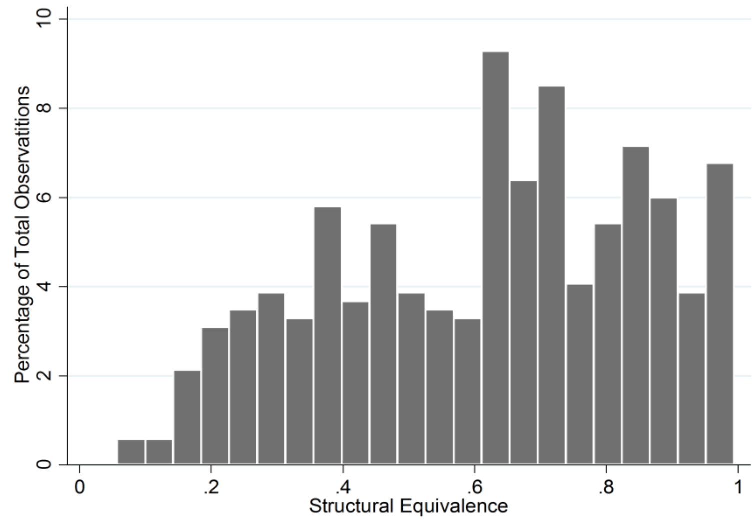
No. Obs.	58544
Mean	13.471
Std. dev.	3.335
Minimum	0.771
Maximum	23.405



Note: Real intra-industry trade is nominal intra-industry trade (average of bilateral imports) deflated by the US Consumer Price Index.
Sources: UN Comtrade database.

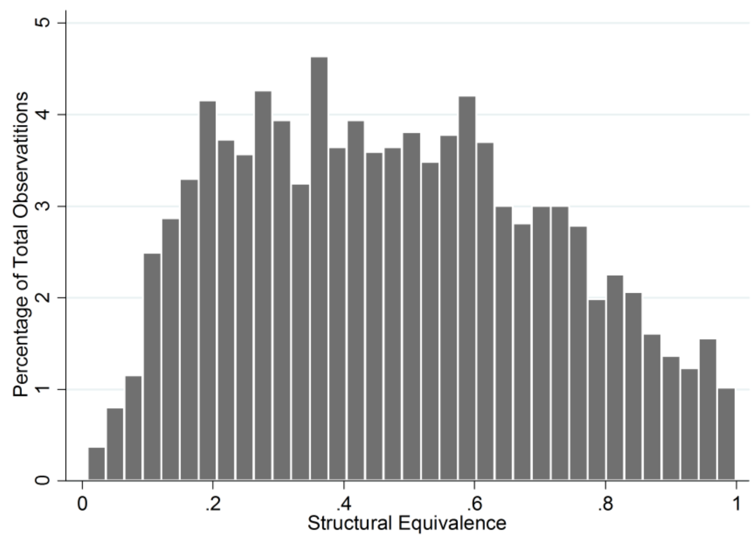
Figure 12: Descriptive Statistics of Structural Equivalence
Panel A. Distribution of Structural Equivalence, Year 1962

No. Obs.	517
Mean	0.615
Median	0.644
Std. dev.	0.235
Minimum	0.057
Maximum	0.994



Panel B. Distribution of Structural Equivalence, Year 2000

No. Obs.	3731
Mean	0.477
Median	0.464
Std. dev.	0.237
Minimum	0.008
Maximum	0.999



Sources: Zhou and Park (2012).

Table 16: Country Pairs with Highest and Lowest Structural Equivalence

Panel A. Country Pairs with Highest and Lowest Structural Equivalence, Year 1962

Top five pairs	Score	Bottom five pairs	Score
Ecuador and Costa Rica	0.994	Indonesia and Myanmar	0.057
Madagascar and Algeria	0.993	Japan and Hungary	0.075
Algeria and Senegal	0.992	Japan and Bulgaria	0.080
Costa Rica and Columbia	0.992	Brazil and Vietnam	0.122
Mexico and Columbia	0.987	Madagascar and Mauritius	0.122

Panel B. Country Pairs with Highest and Lowest Structural Equivalence, Year 2000

Top five pairs	Score	Bottom five pairs	Score
Canada and Mexico	0.999	Belarus and Indonesia	0.008
Honduras and Canada	0.997	Belarus and Philippines	0.010
Mexico and Honduras	0.997	Belarus and Canada	0.014
Japan and Korea	0.991	Belarus and Mexico	0.014
Columbia and Venezuela Rep.	0.986	Belarus and Chile	0.019

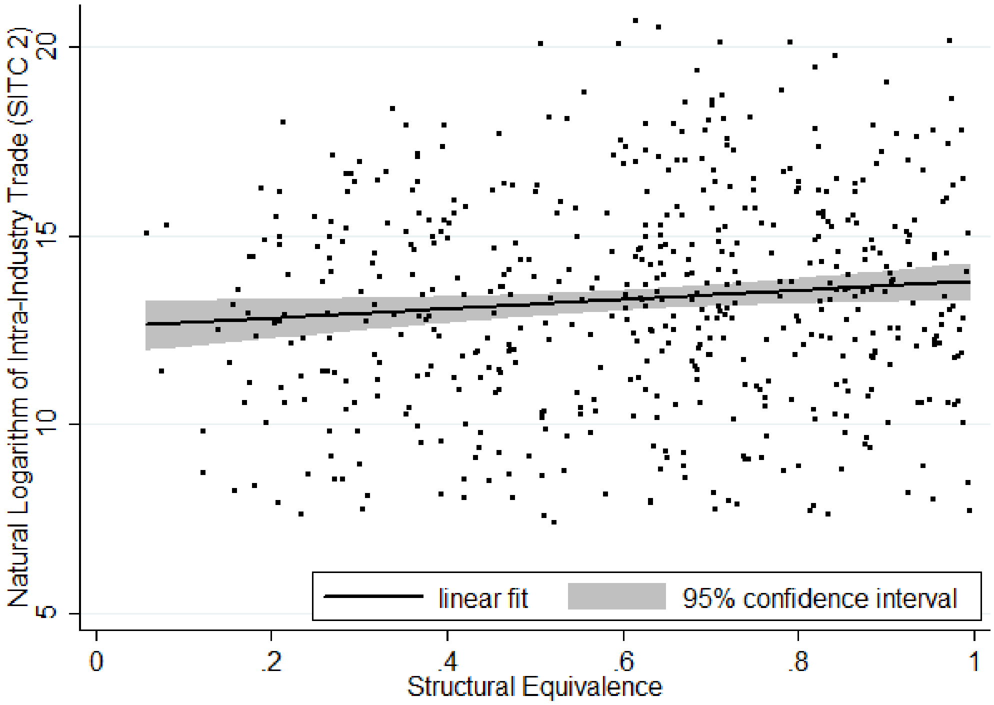
Sources: Zhou and Park (2012).

Except structural equivalence, all the other independent variables are from Rose (2004) whose dataset is constructed from the IMF's Direction of Trade Statistics, Penn World Table, and World Bank's World Development Indicators. These time-varying variables include real GDP, population, difference of GDP per capita, and two dummy variables indicating whether the country pairs are in any regional trade arrangements (RTA) and whether they have a common currency (CU).

Table 17 provides an overview of my dataset. Panel A presents the summary statistics of the explanatory variables. Structural equivalence falls between -0.048 and 1. Panels B and C show the correlation coefficients among the variables for each sector. Intra-industry trade volume is positively correlated with national income, population, regional trade agreements, lower economic inequality, and structural equivalence. The correlations are consistent with what earlier studies suggest. In addition, all the correlation coefficients are relatively small, indicating no serious multicollinearity problems.

Figure 13: Contemporaneous Relationship between Real Intra-Industry Trade and Structural Equivalence

Panel A. Real Intra-Industry Trade by Structural Equivalence in SITC 2 sector, Year 1962



Panel B. Real Intra-Industry Trade by Structural Equivalence in SITC 7 sector, Year 1962

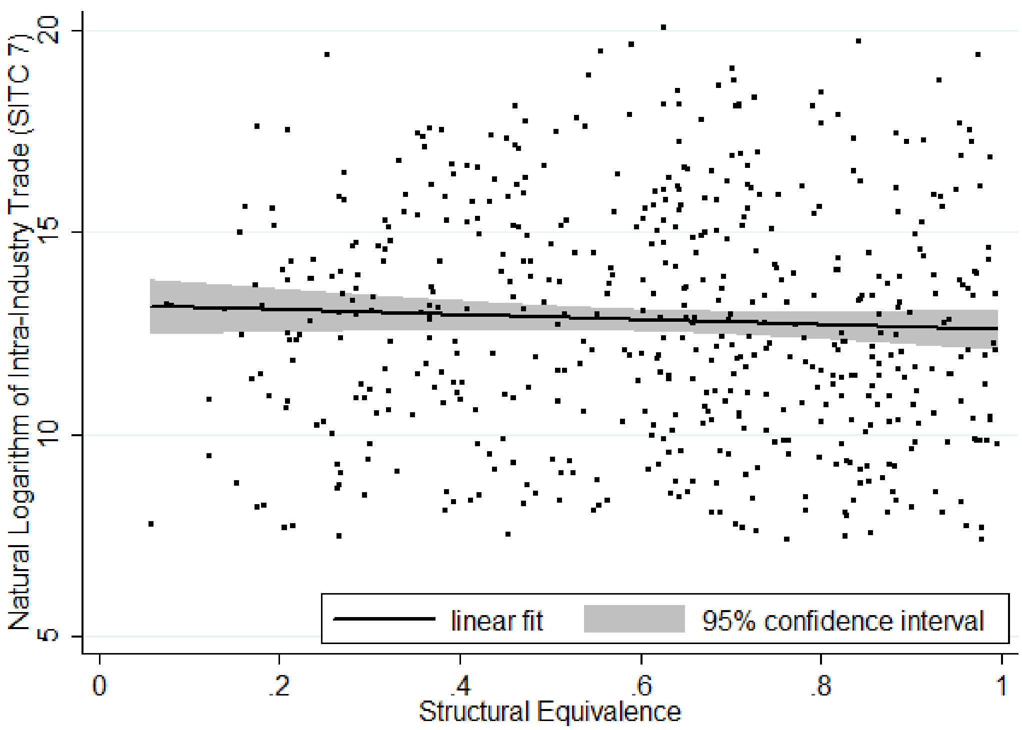
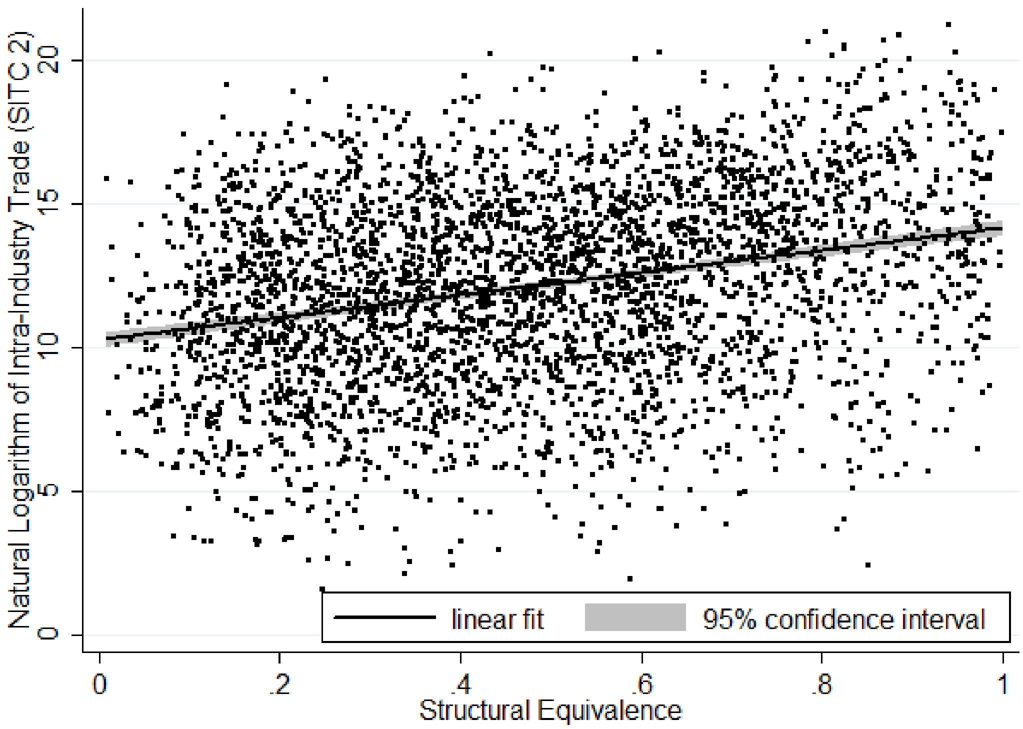


Figure 13 (cont.)
Panel C. Real Intra-Industry Trade by Structural Equivalence in SITC 2 sector, Year 2000



Panel D. Real Intra-Industry Trade by Structural Equivalence in SITC 7 sector, Year 2000

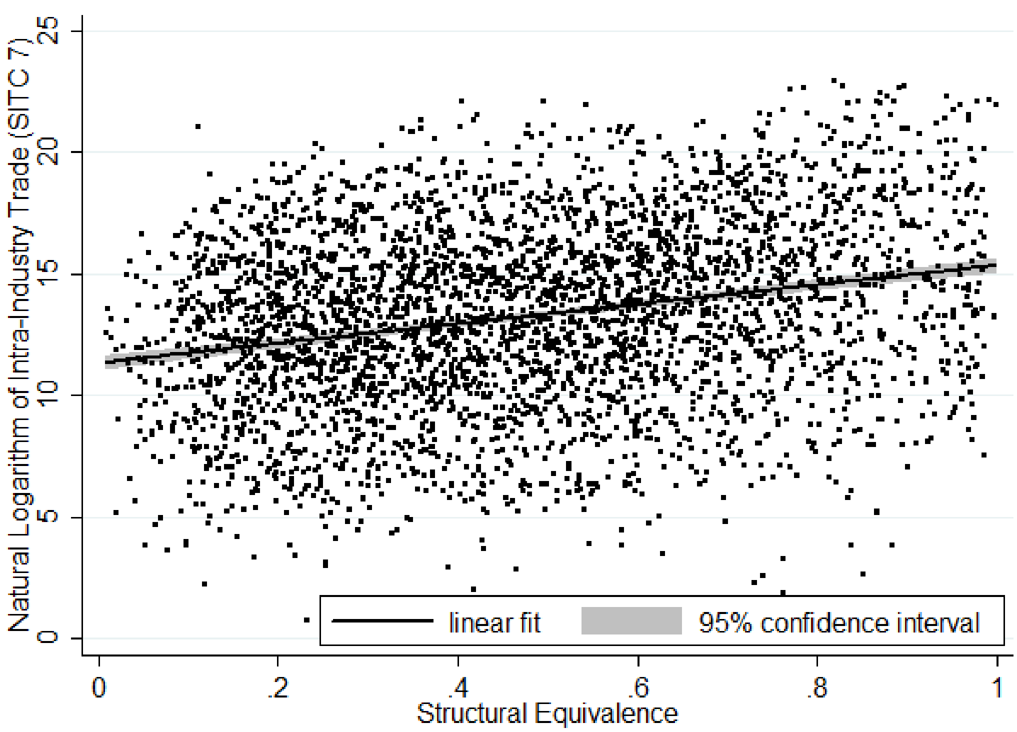


Table 17: Description of Data

Panel A. Summary Statistics of Explanatory Variables

	Log(GDP)	**Log(POP)**	**Inequality**	**RTA**	**CU**	**SE**
No. Obs.	54614	54782	54614	58544	58544	58544
Mean	17.539	18.813	1.117	0.032	0.013	0.544
Median	17.653	18.865	0.955	0.000	0.000	0.540
Std. Dev.	1.319	2.250	0.842	0.176	0.113	0.232
Minimum	11.812	8.001	0.000	0.000	0.000	-0.048
Maximum	20.892	26.483	4.927	1.000	1.000	1.000

Panel B. Correlation of Dependent Variable and Independent Variables (SITC 2)

	Log(trade)	Log(GDP)	Log(POP)	Inequality	RTA	CU
Log(GDP)	0.239					
Log(POP)	0.368	-0.232				
Inequality	-0.109	-0.257	0.115			
RTA	0.078	0.070	-0.167	-0.113		
CU	-0.040	-0.185	-0.117	-0.043	0.038	
SE	0.228	-0.062	0.011	-0.163	0.211	0.109

Panel C. Correlation of Dependent Variable and Independent Variables (SITC 7)

	Log(trade)	Log(GDP)	Log(POP)	Inequality	RTA	CU
Log(GDP)	0.410					
Log(POP)	0.255	-0.232				
Inequality	-0.168	-0.257	0.115			
RTA	0.101	0.070	-0.167	-0.113		
CU	-0.069	-0.185	-0.117	-0.043	0.038	
SE	0.137	-0.062	0.011	-0.163	0.211	0.109

Notes: Log(trade) is the natural logarithm of real intra-industry trade, Log(GDP) is the natural logarithm of the product of real GDP for two countries, Log (POP) is the natural logarithm of the product of population, Inequality is the absolute difference of natural logarithm of real GDP per capita, RTA and CU are dummy variables which are at the value of one if two countries belong to a regional trade agreement or a monetary union, and SE is the degree of structural equivalence.
Sources: UN Comtrade database, Rose (2004), and Zhou and Park (2012).

3.2. Methodology

The principal difference from Zhou and Park (2012) is the focus on intra-industry trade. I construct an industry-level gravity model that includes conventional gravity variables and structural equivalence. I use lagged structural equivalence in the estimation, in contrast to Zhou and Park (2012). While this may limit my ability to identify the full relationship or the role for structural equivalence, it avoids endogeneity problem arising from the potential for reverse causality.

In addition, I pursue a different econometric method. For panel data, the conventional method is either fixed effects or random effects estimators (Rose, 2004; Zhou & Park, 2012). The fixed effects model is advantageous in that it allows explanatory variables to be correlated with country-pair specific unobserved variables. Random effects models, however, assume that the explanatory variables are not correlated with the error terms. In the current context, this assumption of random effects models is likely a poor one. Because I cannot control for all the variables that explain intra-industry trade, the omitted variables are included in the error term and they may correlate with the explanatory variables, violating the assumption of random effects models. Therefore, I employ the fixed effects model in my analysis.[29] Since I use fixed effects models, the coefficients of time-invariant variables such as geographic distance and common language are not estimated.

To test the abovementioned two hypotheses, I set up two models. One model controls for year dummies, and the other includes a trend variable. The two variables are used for different purposes.

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[29] Hausman test is also conducted to examine which model is appropriate, and the estimation results strongly suggest a fixed effects model. The outcome is available upon request.

To study the overall effect of structural equivalence, I use fixed year effects to allow for common global events, such as the contraction of global trade in the 2008 financial crisis. In contrast, a trend variable cannot control for a sudden drop of global trade as well as allowing for the ongoing growth in global trade. Therefore, I use year dummies to control for fixed year effects, and the first model is specified as follows.

$$\ln\left(X_{ijt}\right) = \beta_0 + \beta_1 \ln\left(Y_i Y_j\right)_t + \beta_2 \ln\left(POP_i POP_j\right)_t + \beta_3 INEQ_{ijt} + \beta_4 RTA_{ijt} + \beta_5 CU_{ijt} + \beta_6 SE_{ij,t-1} + vYear + \varepsilon_{ijt} \qquad (1)$$

i and j denote trading partners, and t denotes time. X_{ijt} refers to intra-industry trade volume between i and j at time t in constant US dollars. Y_i denotes real GDP of country i in constant US dollars. POP_i is the population of country i. The measure of economic inequality, $INEQ_{ijt}$, is the absolute difference of the natural logarithm of real GDP per capita between i and j. RTA_{ijt} and CU_{ijt} are dummy variables which are one if i and j are in the same regional trade arrangement or belong to a currency union at time t. $SE_{ij,t-1}$ is the degree of one-year lagged structural equivalence between i and j at time t-1, which is of primary interest. Year is the set of 38 year dummy variables, one for each year. v' is a 38×1 vector. ε_{ijt} is the error term. Because there may be evidence of autocorrelation in the residuals, I use fixed effects models with AR(1) disturbances:

$$\varepsilon_{ijt} = \rho\varepsilon_{ij,t-1} + \eta_{ijt}$$

$|\rho| < 1$ and η_{ijt} is independent and identically distributed (i.i.d.) with mean zero and variance σ_η^2.

The estimated coefficient of structural equivalence, β_6, is of main interest. β_6 represents the overall effect of structural equivalence on intra-industry trade. If the hypothesis that structural equivalence promotes intra-industry trade is true, β_6 will be statistically significant and positive.

To test my second hypothesis about the effect of structural equivalence over time, I need to interact the measure of structural equivalence with either year dummies or a trend variable. Interacting structural equivalence with 38 year dummies results in the loss of too many degrees of freedom and substantially reduces estimation efficiency. In contrast, using the trend variable in the interaction neatly reveals the general linear trend of the changing effect of structural equivalence over time. Instead of 38 interaction terms, I only need one if the trend variable is used for the interaction. Thus, my second model is:

$$\ln(X_{ijt}) = \beta_0 + \beta_1 \ln(Y_i Y_j)_t + \beta_2 \ln(POP_i POP_j)_t + \beta_3 INEQ_{ijt} + \beta_4 RTA_{ijt} + \beta_5 CU_{ijt} + \beta_6 SE_{ij,t-1} + \beta_7 (SE_{ij,t-1} * t) + \beta_8 t + \varepsilon_{ijt} \quad (2)$$

where t=1,2,…,39. The marginal effects of structural equivalence on logarithm of real intra-industry trade are $\frac{\partial \ln(X_{ijt})}{\partial SE_{ij,t-1}} = \beta_6 + \beta_7 * t$. If β_7 is statistically significant and positive, the partial derivative gets higher over time. In order to provide more sensible interpretations, I will provide structural equivalence elasticity of intra-industry trade and present the confidence intervals at each point in time. See estimation section for full details.

4. Estimation

Table 18 shows the overall effect of structural equivalence on intra-industry trade in the SITC 2 and SITC 7 sector, based on Eq. (1). I use within-group R^2 to indicate the goodness of fit for my fixed effects models. The reported R^2 in my model, 0.24 and 0.19 for the two sectors, are slightly larger than that in Zhou and Park (2012) with the value of 0.16.[30] Testing the hypothesis of ρ=0 in a first-order autoregressive process produces test statistics with extremely complicated

[30] I am comparing my model in Table 18 with Model 4 of Table 2 in Zhou and Park (2012). Both models include year dummies to investigate the overall effect of structural equivalence. It is worth noting that the comparison is not exact as samples and model specifications differ.

distributions (Bhargava et al., 1982; Baltagi & Wu, 1999). However, Wooldridge (2002, 282-283) derives a simple test for autocorrelation in panel data models, in which the null hypothesis is no first-order autocorrelation. Drukker (2003) provides simulation results showing that the test has good size and power properties in reasonably sized samples. I conduct the Wooldridge F-test to examine the existence of autocorrelation, and the statistically significant F-statistics suggest autocorrelation does exist.

As opposed to Zhou and Park (2012) which find that structural equivalence promotes aggregate trade, my estimation results show that the overall effect of structural equivalence varies across the two sectors. Structural equivalence is not salient in affecting intra-industry trade in the SITC 2 sector, whereas it plays an important role in promoting intra-industry trade in the SITC 7 sector. In support of my first hypothesis, structural equivalence is more important for the exchange of differentiated goods in the final product sector than homogenous commodities in the raw material sector.

The marginal effects of structural equivalence on natural logarithm of real intra-industry trade are captured by $\frac{\partial \ln(X_{ijt})}{\partial SE_{ij,t-1}} = \beta_5$. One can further derive the structural equivalence elasticity of intra-industry trade volume: $\frac{\partial \ln(X_{ijt})}{\partial \ln(SE_{ij,t-1})} = \frac{\partial \ln(X_{ijt})}{\partial SE_{ij,t-1}} * \overline{SE}_{ij,t-1} = \beta_5 * \overline{SE}_{ij,t-1}$, where $\overline{SE}_{ij,t-1}$ denotes the sample median.[31] Structural equivalence has its median at 0.54 and standard deviation at 0.23. When structural equivalence increases from its median by one standard deviation, or 42.59%, the real intra-industry trade in the SITC 7 sector will increase by 10.58% (=0.46*0.54*42.59) according to the elasticity.

[31] Using the sample mean gives substantively the same result. This is because median and mean of structural equivalence are very close (See Table 17).

Table 18 also suggests that the gravity model specification is not the same across sectors. The gravity variables are of anticipated signs in the SITC 2 sector, while population, regional trade agreement, and currency union cannot explain intra-industry trade in the SITC 7 sector. Population is negatively signed, suggesting that population growth may actually decrease intra-industry trade in the SITC 7 sector. Moreover, the trade-promoting effect of common currency seems sensitive to sectors. My analysis shows that joining a currency union contributes to closer trade ties of the homogeneous products in the crude material sector, but not the heterogeneous products in the final product sector. The heterogeneous effects of common currency on sector trade volumes are consistent with earlier studies (Flam & Nordstrom, 2006a, 2006b; Baldwin et al., 2005). All these studies report that the euro's effect on trade varies with sectors, and the size of the euro's effect correlates to sector characteristics.[32] Although Rose (2000) and Frankel and Rose (2002) conclude that common currency robustly promotes aggregate bilateral trade, the heterogeneous impacts of common currency on sector trade suggests that aggregating at the country level actually cancels out the heterogeneous behaviors.

I proceed to examine the effect of structural equivalence on intra-industry trade over time based on Eq. (2). Table 19 reports the change of the effect of structural equivalence over the years. The reported R^2 in my model, 0.24 and 0.19 for the two sectors, are larger than that in Zhou and Park (2012) with the value of 0.10.[33] This suggests my model has a better fit. The Wooldridge F-statistics are statistically significant, implying the validity of assuming AR(1) process.

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[32] Baldwin et al. (2005) show a correlation between the size of euro's effect and a measure of sector characteristics, including the degree of imperfect competition and increasing returns to scale, the fixed costs of entering a new market and differences in firms' marginal production costs.

[33] I am comparing my model in Table 19 with Model 2 of Table 3 in Zhou and Park (2012). Both models include the interaction term of a trend variable with structural equivalence to capture the over-time behavior of structural equivalence.

Similar to Table 18, the gravity model specification differs across the two sectors. Currency union cannot explain intra-industry trade in the SITC 7 sector. This calls into question the conclusions by Rose (2000) and Frankel and Rose (2002) that common currency robustly promotes bilateral trade.

Table 18: Fixed Effects Models with One-Year Lagged Structural Equivalence, Overall Effect

Dependent Variable: log of sector trade (1962-2000)

	SITC 2	**SITC 7**
Log product real GDP	0.340***	0.797***
	(0.026)	(0.031)
Log product population	0.291***	-0.015
	(0.025)	(0.029)
Economic inequality	-0.193***	-0.555***
	(0.049)	(0.056)
Regional trade agreement	0.301**	0.119
	(0.127)	(0.143)
Currency union	0.741***	0.093
	(0.249)	(0.284)
One-year lagged structural equivalence	0.231	0.462**
	(0.130)	(0.151)
Year dummies	Controlled	Controlled
Constant	1.502***	1.192***
	(0.064)	(0.089)
No. Obs.	47925	47925
R^2	0.244	0.188
ρ in AR(1)	0.430	0.369
Wooldridge F-statistics	12.738***	13.462***

Notes:

1. Numbers in parentheses are standard errors.
2. For two-tailed tests, *, **, and *** denote statistical significance at 10%, 5%, and 1% significance level.
3. R^2 reflects the within group goodness of fit.
4. To test for AR(1) process, Wooldridge F-test statistics are reported (Wooldridge, 2002; Drukker, 2003). The null hypothesis of the test is no first-order autocorrelation. ρ is the autoregressive parameter for the error terms in the AR(1) model.
5. The year fixed effects (38 year dummies) are controlled.

Table 19: Fixed Effect Models with One-Year Lagged Structural Equivalence, Change over Time

Dependent Variable: log of sector trade (1962-2000)

	SITC 2	**SITC 7**
Log product real GDP	0.379***	0.810***
	(0.027)	(0.032)
Log product population	0.296***	0.107***
	(0.024)	(0.029)
Economic inequality	-0.190***	-0.482***
	(0.049)	(0.056)
Regional trade agreement	0.265**	0.239*
	(0.128)	(0.145)
Currency union	0.691***	0.073
	(0.249)	(0.285)
One-year lagged structural equivalence	-0.028	-0.226
	(0.209)	(0.237)
One-year lagged structural equivalence*Trend	0.012*	0.019**
	(0.007)	(0.008)
Trend	-0.018***	-0.021***
	(0.004)	(0.005)
Constant	1.433***	1.437***
	(0.063)	(0.087)
No. Obs.	47925	47925
R^2	0. 242	0.186
ρ in AR(1)	0.432	0.375
Wooldridge F-statistics	14.199***	14.888***

Notes:

1. Numbers in parentheses are standard errors.
2. For two-tailed tests, *, **, and *** denote statistical significance at 10%, 5%, and 1% significance level.
3. R^2 reflects the within group goodness of fit.
4. To test for AR(1) process, Wooldridge F-test statistics are reported (Wooldridge, 2002; Drukker, 2003). The null hypothesis of the test is no first-order autocorrelation. ρ is the autoregressive parameter for the error terms in the AR(1) model.

In order to examine the effect of structural equivalence on intra-industry trade, I derive a structural equivalence elasticity of real intra-industry trade based on Eq. (2):[34]

$$\text{Elasticity} = \frac{\partial \ln(X_{ijt})}{\partial \ln(SE_{ij,t-1})} = \frac{\partial \ln(X_{ijt})}{\partial SE_{ij,t-1}} * \overline{SE}_{ij,t-1} = (\beta_6 + \beta_7 * t) * \overline{SE}_{ij,t-1}$$

The elasticity varies with both the trend variable and the median of structural equivalence. For the SITC 2 sector, elasticity= (- 0.028+0.012*1)* 0.644 = - 0.010 in 1962, while elasticity = (- 0.028+0.012*39)* 0.464 = 0.204 in 2000. If a country pair, A and B, were to increase its degree of structural equivalence by one percent in 2000, intra-industry trade volume would increase by 20.4%.

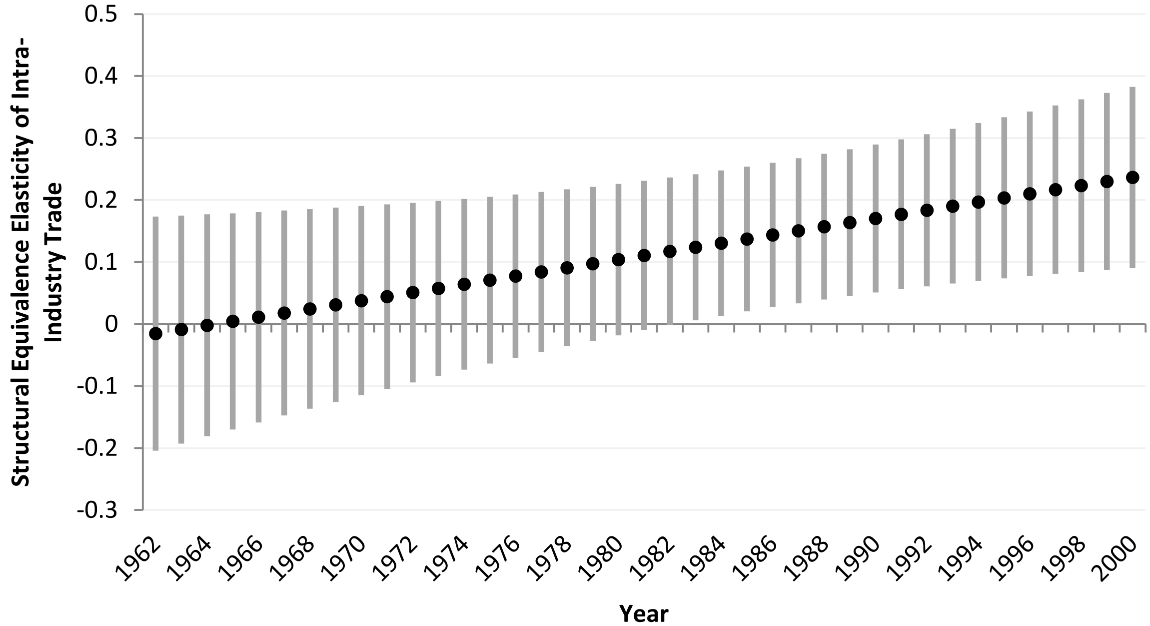
Figure 14 shows the statistical significance of elasticity at each point in time. The scatter plots demonstrate the structural equivalence elasticity of intra-industry trade over the years, and the grey lines represent the 90% confidence interval at each point in time. The dynamics of the elasticity are quite similar in the two sectors. Both scatter plots have an evidently upward trend, suggesting that the effect of structural equivalence on intra-industry trade is increasingly important over time. In the early years of the sample, structural equivalence actually had a statistically insignificant and negative effect on intra-industry trade. The effect gradually increases over the years and does not turn statistically significant and positive until the 1980s. The results are supportive of my second hypothesis that structural equivalence has an increasingly important role in promoting intra-industry trade. The results are also consistent with Zhou and Park (2012), which finds growing importance of structural equivalence in boosting aggregate trade.

[34] Discussions on the marginal effect of trend on intra-industry trade flows are less of focus and are provided upon request.

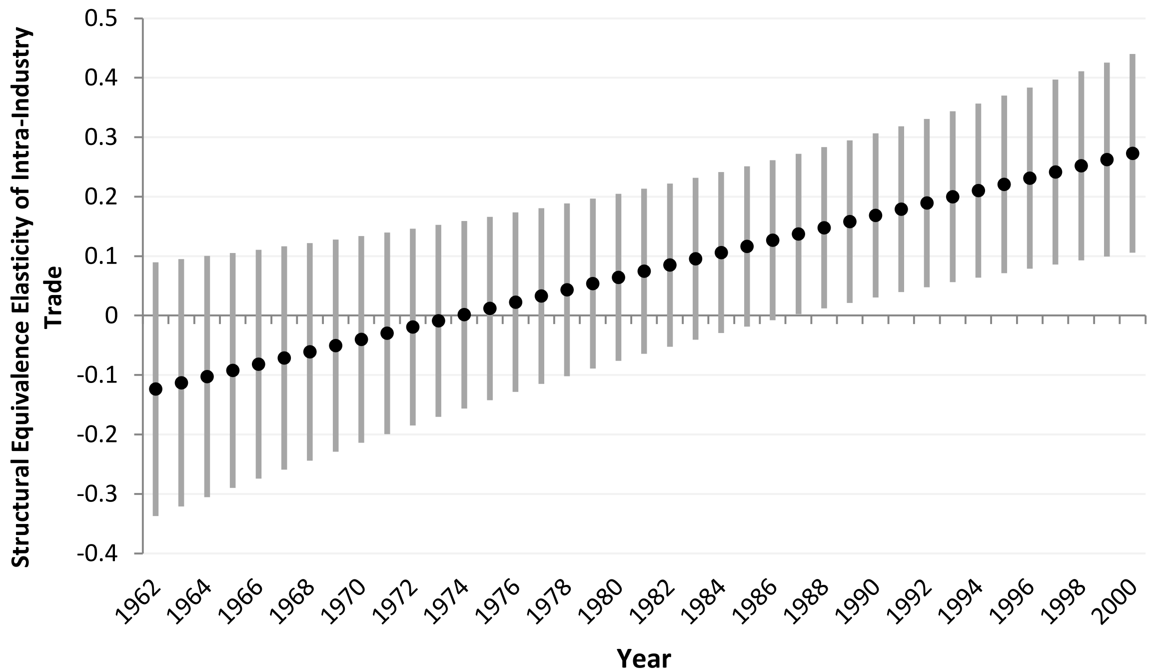
Taken together, Table 18 and Table 19 demonstrate that the effect of structural equivalence on intra-industry trade actually experienced structural shift over the years. In the earlier years, network information is not so useful for establishing trade ties and the trade-promoting effect of structural equivalence is not salient. As the global trade network gets more complex and information search becomes more costly, economies are more dependent on network information to establish trade relations. As a result, structural equivalence is getting more and more important in promoting intra-industry trade in both sectors. The overall effect of structural equivalence in the final product sector is statistically significant, which likely reflects a generally stronger growth of the effect during the sampling period. Even though the overall effect of structural equivalence in the raw material sector is statistically insignificant during the 1962-2000 period, it is reasonable to anticipate that a statistically significant and positive overall effect would emerge in the raw material sector if I look at more recent years.

To test the robustness of the results above, I also examine models with two-year lagged structural equivalence. Table 20 and Table 21 report estimation results using two-year lagged structural equivalence based on Eq.(1) and Eq.(2), respectively. The results are substantively the same as those obtained using one-year lagged structural equivalence, suggesting that my estimation results are robust to variable specifications.

Figure 14: Structural Equivalence Elasticity of Intra-Industry Trade over Time
Panel A. Structural Equivalence Elasticity of Intra-Industry Trade (SITC 2)



Panel B. Structural Equivalence Elasticity of Intra-Industry Trade (SITC 7)



Notes: The scatter plot represents the predicted structural equivalence elasticity of intra-industry trade at each point in time, and the grey line shows the 90% confidence interval at each prediction.

5. Conclusion

Intra-industry trade has been growing steadily in the recent few decades. Intra-industry trade is shaped not only by country pair-specific characteristics stressed in the conventional gravity model of trade, but also by the country pair's trade relations with others in the global trade network. Country pairs with common trade ties are likely to have more information about each other through their common trade partners. Availability of network information reduces the cost of searching for business opportunities, and hence facilitates the establishment of closer trade ties between countries. Structural equivalence is the conventional measure used to capture this network effect.

Bridging social network analysis with the gravity model of trade, this chapter extends Zhou and Park (2012) and analyzes the effect of structural equivalence, the similarity of two countries' trade relationships with other countries in the global trade network, on intra-industry trade volume. Using panel data of bilateral intra-industry trade among 182 countries from 1962 through 2000, I develop two fixed effects models that incorporate structural equivalence and standard gravity variables. The first model controls for common year effects and examines the overall effect of structural equivalence on intra-industry trade. The second model includes a trend variable and captures the change in the effect of structural equivalence over time. Lagged structural equivalence is used in both models to mitigate the risk of reverse causality.

The estimation results show that the overall effect of structural equivalence varies across sectors, which is fundamentally different from the conclusion in Zhou and Park (2012) that structural equivalence promotes aggregate bilateral trade. Structural equivalence is statistically significant in promoting intra-industry trade in the sector of SITC 7, suggesting that intra-industry trade in the final product sector is more affected by social network information. In contrast, structural equivalence is statistically insignificant in intra-industry trade in the SITC 2 sector. My conclusions are consistent with previous studies (Rauch, 1999; Rauch & Trindade, 2002; Kim & Skvoretz, 2013) which hold that trade network is more important for the trade of heterogeneous products than homogeneous products. The crude material sector has a lower degree of product differentiation and a lower level of demand for information in international trade, possibly making its intra-industry trade less dependent on information transmitted through networks.

Furthermore, structural equivalence has become increasingly important in encouraging intra-industry trade for the two sectors. Similar to Zhou and Park (2012), the evidence in my paper is supportive of the positive effect of structural equivalence on intra-industry trade, captured by structural equivalence elasticity, increases over time for both sectors. Structural equivalence is not salient in boosting intra-industry trade during the 1960s. Globalization and increasing product differentiation elevate the importance of network information in establishing trade relations, and structural equivalence plays a more and more important role in impacting intra-industry trade. The effect of structural equivalence eventually turns statistically significant and positive during the 1980s.

The empirical models also show that the gravity model specification is sensitive to sectors. The statistical significance and signs of gravity variables are not the same across the two sectors. In particular, common currency is not important for intra-industry trade in the final product sector, but it boosts the intra-industry trade in the raw material sector. The heterogeneous effects of common currency on sector trade volumes are consistent with earlier studies (Flam & Nordstrom, 2006a, 2006b; Baldwin et al., 2005), and cast doubts on the conclusion of Rose

(2000) and Frankel and Rose (2002) that common currency robustly promotes aggregate bilateral trade.

Table 20: Fixed Effects Models with Two-Year Lagged Structural Equivalence, Overall Effect

Dependent Variable: log of sector trade (1962-2000)

	SITC 2	**SITC 7**
Log product real GDP	0.390***	0.802***
	(0.027)	(0.032)
Log product population	0.166***	-0.035
	(0.030)	(0.030)
Economic inequality	-0.041	-0.545***
	(0.054)	(0.057)
Regional trade agreement	0.591***	0.204
	(0.134)	(0.143)
Currency union	0.774***	0.252
	(0.267)	(0.301)
Two-year lagged structural equivalence	-0.041	0.350**
	(0.133)	(0.149)
Year dummies	Controlled	Controlled
Constant	1.935***	1.256***
	(0.074)	(0.092)
No. Obs.	46750	46750
R^2	0.212	0.186
ρ in AR(1)	0.424	0.363
Wooldridge F-statistics	13.618***	13.131***

Notes:

1. Numbers in parentheses are standard errors.
2. For two-tailed tests, *, **, and *** denote statistical significance at 10%, 5%, and 1% significance level.
3. R^2 reflects the within group goodness of fit.
4. To test for AR(1) process, Wooldridge F-test statistics are reported (Wooldridge, 2002; Drukker, 2003). The null hypothesis of the test is no first-order autocorrelation. ρ is the autoregressive parameter for the error terms in the AR(1) model.
5. The year fixed effects (38 year dummies) are controlled.

Table 21: Fixed Effect Models with Two-Year Lagged Structural Equivalence, Change over Time

Dependent Variable: log of sector trade (1962-2000)

	SITC 2	**SITC 7**
Log product real GDP	0.392***	0.817***
	(0.027)	(0.033)
Log product population	0.292***	0.109***
	(0.025)	(0.030)
Economic inequality	-0.185***	-0.497***
	(0.050)	(0.057)
Regional trade agreement	0.256**	0.212
	(0.128)	(0.146)
Currency union	0.666***	0.194
	(0.263)	(0.303)
Two-year lagged structural equivalence	-0.325	-0.345
	(0.220)	(0.249)
Two-year lagged structural equivalence*Trend	0.019***	0.024***
	(0.007)	(0.008)
Trend	-0.022***	0.018***
	(0.005)	(0.005)
Constant	1.463***	1.404***
	(0.066)	(0.090)
No. Obs.	46750	46750
R^2	0.236	0.181
ρ in AR(1)	0.425	0.368
Wooldridge F-statistics	15.261***	14.576***

Notes:

1. Numbers in parentheses are standard errors.
2. For two-tailed tests, *, **, and *** denote statistical significance at 10%, 5%, and 1% significance level.
3. R^2 reflects the within group goodness of fit.
4. To test for AR(1) process, Wooldridge F-test statistics are reported (Wooldridge, 2002; Drukker, 2003). The null hypothesis of the test is no first-order autocorrelation. ρ is the autoregressive parameter for the error terms in the AR(1) model.

Although this study provides some interesting results, it has several limitations upon which future research may improve. First, although I arrive at a general conclusion about the effect of structural equivalence on intra-industry trade, I do not investigate the exact way in which structural equivalence affects intra-industry trade of a given country pair in practice. The specific mechanism through which network information shapes international trade is likely to vary across country pairs. In future studies, I will explore how structural equivalence affects the intra-industry trade of a specific country pair, such as South Korea and Vietnam, using case studies.

Second, a further direction to improve my analysis would be to base the empirical analysis on more rigid and explicit theoretical framework. Studies so far provide little guidance on the theoretical background on two aspects: the exact mechanism through which networks influence trade and the exact theoretical gravity model for intra-industry trade.

Third, using a measure of structural equivalence based on intra-industry trade may provide different information. I use the broad measure of structural equivalence based on aggregate trade, so as to be comparable to Zhou and Park (2012). As an alternative, future studies might use structural equivalence based on intra-industry trade to explain real intra-industry trade.

Fourth, a more recent dataset may uncover the latest effects of structural equivalence on intra-industry trade. Global economy has experienced important changes in recent years, and the effect of the global trade network on international trade is likely to manifest new features. In future studies, one can use updated data and the analysis is anticipated to reveal some changes about structural equivalence.

Chapter Five: Conclusion and Future Research

The three chapters in this dissertation contribute to the empirical literature in international economics. Chapter Two examines the symmetry of macroeconomic shocks and ease of response in eleven East Asian countries as a way of identifying economies that could form a currency union. I set up a series of structural VAR models with both long-run restrictions and block exogeneity restrictions to identify various shocks.

The forecast error variance decomposition analysis shows that domestic supply shocks are most important to domestic output growth. Based on the correlation of shocks, two geographic groups are selected as exhibiting symmetry in domestic supply shocks. One group includes Hong Kong, South Korea, Malaysia, and Singapore, while the other is made up of Indonesia, South Korea, Malaysia, and Thailand. Investigations into size and response of shocks show that the two sub-groups generally experience smaller-sized shocks and faster adjustment upon shocks compared with the US and the European Union. The analysis shows that it is economically feasible for the two groups of economies to establish common currencies.

In contrast to earlier literature, my study tests for cointegration among variables. Although cointegration does not exist in this study, it is important to check for cointegration for reasons discussed before. Another contribution to the empirical literature is that I impose block exogeneity restrictions in addition to long-run restrictions, which ensures external shocks are identical for the East Asian economies.

In future studies, I will try other ways to identify shocks. The long-run restrictions imposed in the second chapter are subject to many criticism, such as unreliable structural inferences (Faust & Leeper, 1997) and invalid economic interpretation (Cooley & Dwyer, 1998). I may impose short-run restrictions on larger-dimensional models with multiple shocks.

Chapter Three attempts to differentiate the effect of intra-industry trade and inter-industry trade on business cycle comovement among OECD countries. Economic theory implies that intra-industry trade and inter-industry trade may move business cycles towards convergence and divergence, respectively.

I construct a series of Instrument Variable estimations to investigate the effects of intra- and inter-industry trade on business cycle synchronization, controlling for financial market linkages and monetary policy making. The empirical analysis shows that intra-industry trade increases business cycle synchronization, whereas inter-industry trade lead to divergence of business cycles. The conclusion is robust to de-trending methods. Moreover, financial integration and policy coordination provide no explanation for synchronization when intra- and inter-industry trade are accounted for, although the two transmission channels are statistically significant in increasing synchronization when studied in isolation. In addition, I derive the non-linear relationship between the measure of business cycle correlation and intra-industry trade index. Intra-industry trade index increases synchronization most when the index ranges between 0.2 and 0.4.

According to the theory of Optimum Currency Area, the contrasting effect of intra- and inter-industry trade on synchronization provides economic implication for the eurozone enlargement and establishment of other monetary unions. Earlier studies maintain that aggregate trade intensity may contribute to higher synchronization, although the positive relationship is not robust. My analysis explores further, by decomposing aggregate trade into two components. Because intra- and inter-industry trade have opposite effects on synchronization, I argue country pairs with higher intra-industry trade intensity, instead of the aggregate trade, are more likely to experience synchronized business cycles and to join a monetary union. Compared to previous studies, Chapter Three clarifies the different roles that trade components play in driving synchronization, and helps to understand the relationship between aggregate trade and synchronization.

While this study has provided important conclusions, it needs further improvement. The analysis, or more generally studies on intra- and inter- industry trade, suffers from a multicollinearity issue, because measures of intra- and inter-industry trade intensity are constructed using both intra-industry trade index and aggregate trade. The multicollinearity might explain the low instrument quality for intra- and inter-industry trade, as well as the statistical insignificance of financial integration and policy similarity. In future studies, I will measure inter-industry trade separately, using either the sector specialization in Imbs (2004) or vertical specialization in Hummels et al. (2001).

Chapter Four extends Zhou and Park (2012) and examines the effect of structural equivalence on intra-industry trade flows in the crude material and final product sectors. The study is the first attempt that bridges social network theory with the gravity model of intra-industry trade. I develop two fixed effects models that incorporate structural equivalence and gravity variables of intra-industry trade. The first model controls for fixed year effects and examines the overall effect of structural equivalence, while the second includes a trend variable and captures the change of the effect over the years. Different from Zhou and Park, I use lagged structural equivalence throughout the analysis to mitigate the risk of reverse causality.

The first model shows that structural equivalence is statistically significant in promoting intra-industry trade in the final product sector, whereas the effect is statistically insignificant in the crude material sector. The variation of effect across the two sectors are consistent with previous studies (Rauch, 1999; Rauch & Trindade, 2002; Kim & Skvoretz, 2013) which hold that trade network is more important for the trade of heterogeneous products than homogeneous products. The second model shows that the effect of structural equivalence on intra-industry trade, measured by structural equivalence elasticity of intra-industry trade, increases over the years for both sectors. Consistent with Zhou and Park (2012), I argue that the growing importance of structural equivalence is largely due to the increasingly complex global trade and differentiated products.

The empirical models also show that the specification of gravity model of intra-industry trade varies with sectors. For instance, common currency is not important for intra-industry trade in the final product sector, but it increases intra-industry trade in the raw material sector. The heterogeneous effects of common currency on sector trade volumes are consistent with earlier studies (Flam & Nordstrom, 2006a, 2006b; Baldwin et al., 2005).

Although this study provides some preliminary results, it needs further improvement. It is interesting to explore the exact way in which structural equivalence affects intra-industry trade for a specific country pair, and I would like to discuss the importance of structural equivalence using case studies. In addition, I need to provide more rigorous theoretical justifications to the exact mechanism through which networks influence trade and to the gravity model of intra-industry trade. Moreover, building up a measure of structural equivalence based on intra-industry trade may provide different information.

In addition to the specific improvement to each chapter (as discussed above), I am interested in the factors that explain symmetry of macroeconomic shocks and would like to explore it in future research. Some scholars argue that business cycle synchronization is closely related to symmetry of domestic supply shocks (Babetskii, 2005; Frenkel & Nickel, 2005). Business cycle synchronization measures the correlation of domestic output change across countries, which is reflected by symmetry of domestic supply shocks to certain extent. It is natural to question whether and how the business cycle transmission channels, namely international trade, financial integration, and macroeconomic policy coordination, help to explain symmetry of domestic supply shocks.

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Appendix A

Table: Data Source of Chapter Three

Variable	**Notation**	**Database**	**Variable Definition**	**Unit**
Real GDP	y_{it}, y_{jt}	OECD	GDP, expenditure approach, volume estimates, fixed PPPs, OECD reference year, annual, seasonally adjusted	Million USD
Aggregate bilateral trade	X_{ijt}, M_{ijt}	UNCTAD	Merchandise trade matrix, product groups, annual	Thousand USD
Aggregate trade	X_{it}, M_{it}	UNCTAD	Exports and imports of goods and services, annual	Million USD
Industry-level bilateral trade	X_{ijkt}, M_{ijkt}	UNCTAD	Merchandise trade matrix, product groups, annual	Thousand USD
Bilateral FDI flows	FI_{ijt}, FO_{ijt}	OECD	FDI flows by partner country, annual	Million USD
Aggregate FDI flows	FI_{it}, FO_{it}	UNCTAD	Inward and outward foreign direct investment flows, annual	Million USD
Currency exchange rate	e_{ijt}	OECD	Main aggregate: annual exchange rates	National currency per USD
Nominal long-term interest rates	i_{it}^{LR}	OECD	Monthly monetary and financial statistics: long-term interest rates	Per cent per annum
Nominal short-term interest rates	i_{it}^{SR}	OECD	Monthly monetary and financial statistics: short-term interest rates	Per cent per annum
Consumer price index	CPI_{it}	World bank	Consumer price indices (2005=100)	Index
Equity index	S_{it}	World bank	S&P global equity indices (2005=100)	Index

Notes:

1. UNCTAD is the statistical database of United Nations Conference on Trade and Development, OECD refers to the statistical database for Organization for Economic Co-operation and Development, and World Bank denotes the databank of the World Bank.
2. Bilateral dummies, including geographic distance, common border, and common language, common legal origin, and accounting standards, are taken from Otto et al. (2005).