RIETI Discussion Paper Series 14-E-066

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FUJITA Masahisa
RIETI

HAMAGUCHI Nobuaki
RIETI

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Research Institute of Economy, Trade & Industry, IAA

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RIETI Discussion Paper Series 14-E-066
November 2014

Supply Chain Internationalization in East Asia: Inclusiveness and risks

FUJITA Masahisa
(Research Institute of Economy, Trade and Industry & Konan University)
HAMAGUCHI Nobuaki
(Research Institute for Economics and Business Administration, Kobe University &
Research Institute of Economy, Trade and Industry)

Abstract

Supply chain internationalization is promoting a new cascade of agglomeration and dispersion. Headquarter tasks agglomerate in major cities in developed countries, while labor intensive tasks are shed to developing countries where offshored tasks form into a geographical concentration. As a whole, international supply chains are productivity and welfare enhancing through their more efficient use of human resources. This magnifies the cost of volatility. A case study on East Asia illustrates these points.

Keywords: Supply chain, Agglomeration, Globalization, Volatility
JEL Classification: F61, R11

This study is conducted as a part of the Project "Restoration from Earthquake Damage and Growth Strategies of the Japanese Regional Economy". It is also partly supported by MEXT/JSPS KAKENHI Grant #25380299.

1. Introduction

Supply chain internationalization is underway. Production process that used to be completed in a single factory has been fragmented and allocated in different countries. This process is backed by major reduction in transport costs captured in broad sense including technological progress in transportation and communication, together with the multilateral trade facilitation promoted by the World Trade Organization and bilateral and regional free trade agreements.

Supply chain has been studied in many field. It is originally a management issue and there is a rich body of literature on supply chain management (Christopher 1998). With internationalization, supply chain became a subject of study in economics because it would change specialization pattern and have welfare implication through impacts in productivity, growth, and job creation (Grossman and Ross-Hansberg 2008; IDE/JETRO and WTO 2011; Levin 2012). Macro-economist also investigate implication of supply chain internationalization for business cycle (Acemoglu et al. 2012). Interested readers are referred to Park et al. (2012) and Timmer et al. (2014) for more complete survey.

This paper makes a contribution from the perspective of spatial economics. Spatial economics investigate uneven organization of economic activities across the space and its dynamic transformation under technological changed in the means of interactions that have friction of distance. We take into consideration the possibility of supply chain internationalization as an organizational change in the framework of spatial economics. Namely, while generic theoretical models of spatial economics found that transport cost reduction would lead to agglomeration (Fujita and Thisse 2013), the supply chain literature point outs that transportation cost reduction triggers the fragmentation of production driving away certain types of tasks. In our view, these opposing forces interplay with each other and shape today's complex networked global production and trade system.. Although supply chain internationalization is a contemporary and natural subject of interest for this field, very few study have attempted to understand the spatial implication of this issue, with a few exceptions such asf Fujita and Thisse (2006).

The remaining part is organized as follows. In Section 2, we develop a general discussion of a spatial features of internationalized supply chains with an anecdotal evidence using the case of Apple's supply chain. In Section 3, we analyze the data of East Asia to see an evolution. Section 4 investigate empirically the volatility of supply chain trade. The last section concludes the discussion.

2. Formation of international supply chains from spatial economics perspective

2.1 Agglomeration and dispersion

Our argument can be sketched in the following way. Consider two countries which are divided in two regions. Workers are freely mobile within a country but not allowed to cross country borders while capital is perfectly mobile. Let us consider two types of workers, the skilled and the unskilled, and assume that skilled workers are relatively more abundant in country A and unskilled are more abundant in country B. According to the neoclassical international trade theory, country A will be specialized in skill intensive industry, say manufacturing, and country B in unskilled labor intensive industry, say agriculture.

Suppose that with transportation and communication costs reduction, a manufacturing firm is able to split its internal structure into a head quarter (which performs planning, management, research and development) and a final assembly, whereas the former is skill intensive and the latter is unskilled labor intensive. Skilled workers who are afford to pay higher living cost seek to live near the greater consumption variety and better socio-cultural amenity. They may also attach importance to face-to-face communication with professional colleagues that allows them to realize higher productivity from knowledge spillovers (Fujita and Thisse 2013). Hence, headquarters agglomerate in large metropolitan areas (a core) while cost-sensitive final assemblies will be located in the country-side (a periphery) if transportation and communication costs reduction are sufficiently low to justify such separation.

With supply chain internationalization, labor intensive tasks will migrate from country A's country-side to country B. The off-shored tasks will locate in a region with transportation advantage (i.e. coastal area or shorter distance from country A's core) in country B. While this creates international dispersion, agglomeration economies will be strengthened in both countries. In country A, more and more skilled workers will be released from unskilled labor intensive tasks which are transferred to country B and become employed in skill intensive tasks located in country A 's core (Grossman and Rossi-Hansberg 2008). The off-shore hub in country B attracts greater number of unskilled workers from its country-side Country B's country-side also gains because it wage level increases by releasing excess labor to the off-shoring hub.

2.2 Agglomeration of off-shored tasks in developing country

Prager and Thisse (2012: 27-31) point out several reasons for the spatial agglomeration of off-shored tasks. First, because some off-shored tasks are input for other off-shored tasks, it is convenient that they locate close with each other. For example, according to Japan Automobile Manufacturers Association[1], Japanese domestic automobile production decreased from 10.1 million units in 2000 to

[1] http://www.jama-english.jp/statistics/index.html

9.6 million units in 2013 while overseas production increased from 6.3 million to 16.8 million. Japan Auto Parts Industry Association's annual survey on overseas operation[2] reveals that auto parts production affiliates increased from 1,182 in 2002 to 1,852 in 2013. It is remarkable that Asia is responsible for 7.4 million units of 10.5 million unit net increase in overseas automobile production and 555 of 676 net increase in overseas auto parts manufactures' affiliates, both with very high rate of concentration in China.

Second, although off-shoring firms seek cheaper labor in a developing country, they would not locate in isolated country-side. On the contrary, they tend to choose an industrial agglomeration where the wage could be one of the highest in that country. This is probably because matching workers and firms is easier in such places, especially when firms seek workers with certain level of educational attainment and working experience at manufacturing production lines. In developing countries, large urban areas hold sizable informal sector where rural migrant workers usually must spend some time searching formal jobs because of spatial mismatch.[3] While informal sector results from labor market failure, firms can take advantage of it to find workers more easily. In this sense urban informal sector offers a cushion for both off-shoring firm having difficulty in hiring and workers who could had been otherwise discouraged to migrate by spatial mismatch.

Third, large cities can offer a wide range of infrastructure, public services, and private business services. Obviously, transport infrastructure is essential for off-shoring firms. It is difficult for them to locate in a country-side only because of cheaper labor when there is a wide gap in the availability of external services compared to large cities.

2.3 Is the country-side of developed country be a loser?

Although country A's periphery will lose labor-intensive jobs with supply chain internationalization, it will not necessarily be a sole loser. It is generally possible that firms maintain tasks in the country-side which require cheaper labor but very costly to operate internationally linked operation. For some consumer goods industries, inventory cost turns out very high if a firm fails to react promptly to erratic change in demand. This concern leads to recent broad trend of so-called *re-shoring* of US manufacturing, aided by shrinking wage gap as a consequence of general equilibrium effects of far-reaching off-shoring (lower/higher demand for unskilled labor in country A/ B) and other factors (appreciation of the Chinese currency, decreased energy costs in the US, and

[2] http://www.japia.or.jp/research/seaover.html (in Japanese)

[3] Spatial mismatch is commonly discussed in the literature in the context of the problems of developed countries' inner city ghetto residents earning low wages without having access to suburban better-paid jobs (Gobillon et al. 2007). For developing countries, spatial mismatch is relevant for rural workers seeking urban jobs as implicitly assumed by Harris and Todaro (1970).

increased shipping costs because of high fuel prices). Upstream production that requires intensive interaction with the research laboratories might be another example.

Such task are, in general, not substitute of foreign outsourcing, but complementary. Consumer goods productions in country-side can utilize cheaper intermediate goods produced in country B, and by doing so they can realizing higher productivity (hence higher wage) than to remain producing only in country A. Upstream production in the country-side having un-offshorable technological linkage with headquarters tasks in the core will supply sophisticated intermediate goods to off-shore factories. Therefore, contrary to a common perception of an accelerator of the hollowing out, we consider that supply chain internationalization could support to maintain a part of jobs in advanced countries that otherwise will be gone all together.

It should be also noticed that agglomeration of unskilled tasks in country B will not perpetuate. As the supply of unskilled labor from country B's country-side will get scarce, the wage will increase. This makes the outsourcing hub less attractive for firms in country A and induces them to seek cheaper workers in other countries. At this stage, country B should seek a change to an industrial structure with higher proportion of skilled workers, upgrading its specialization in higher-level tasks, while outsourcing unskilled labor intensive tasks to a third country. A failure of such transition can drive a country to stuck in the "middle-income trap".

2.4 Apple's supply chain: an example

In order to illustrate our argument, we take a close look at the Apple's *Supplier List 2014* [4] published in Apple's website. The list contains 792 factories with identified address of 192 firms. They represent at least 97 percent of procurement expenditures of the company in 2013, according to Apple's comment on the website.

Table 1 summarize the geographical distribution of headquarters and factories of these suppliers. It shows that USA, Taiwan, and Japan are top three countries of origin of suppliers. Japan tops in the number of factories. There are twice as many Japanese suppliers' factories as Taiwanese ones. This implies greater variety of parts are supplied by Japanese firms. However, nationalities of ownership do not coincide with their production locations because global companies establish multiple off-shore hubs. In electric machinery industry, productions of semiconductor and hard-disk drive represent such examples. We can observe that US and Japanese suppliers allocate their factories in almost same proportion in between China and other Asia.[5] Yet, Japanese firms show higher

[4] https://www.apple.com/supplier-responsibility/pdf/Apple_Supplier_List_2014.pdf
[5] Here, US firms' production in "other East Asia" includes those conducted in Japan, Taiwan, and

propensity to produce in country-side in Japan. This is partly because Japanese suppliers attach importance to the technological linkage between headquarters and factories. It also reflects a location advantage of Japan being closer to final assembly plants of Apple products in Guangdong and Shanghai in China, operated by Taiwanese EMS contractors Foxconn and Pegatron. However, the home country stickiness of Japanese suppliers makes a contrast with Taiwanese suppliers who mostly produce in China (112 of 138) although Taiwan is much closer to the assembly plants. Korean suppliers show similar location pattern as the Japanese, maintaining more than a half of factories in home country. Korean suppliers' off-shoring locations strongly concentrate in China, while those of Japanese and American suppliers are divided equally between China and ASEAN. Supplies from Singapore and Hong Kong are strongly attracted to produce in China, probably because of higher sensitivity to transportation cost because of lower degree of product differentiation and cultural proximity for them to work in China. All 12 suppliers of Chinese-origin produces only in China.

Table 1

Headquarters' location of US suppliers show some concentration in California (11 of 45) either in Santa Clara County (Silicon Valley) or in Orange County. Others are only loosely concentrated in the Northeastern manufacturing belt from New England to the surrounding of Chicago, as well as in the South, notably in Texas. Headquarters of Japanese suppliers are strongly concentrated in Tokyo metropolitan region and Kyoto-Osaka region (23 and 13 of 43, respectively). These observations confirms our theoretical prediction: agglomeration of high skill intensive headquarters and dispersion of factories that employ unskilled labor.

Figure 1

We can see in Table 1 that 670 of all 792 Apple suppliers' factories are in East Asia. Figure 1 shows factories location of Apple suppliers in East Asia where each dot represents factor locations. These factories are internationally dispersed in East Asia as a whole, expanded to Southeast Asia (Singapore, Indonesia, Malaysia, Philippines, Thailand, and Vietnam). They are also localized in each country. For example, factories in China show strong concentration in Shanghai and its vicinity and Guangdong Province where final assembly plants are located. Factories are sparsely distributed within Japan despite of the strong geographical concentration of headquarters location as commented above.

3. Implications for Regional Integration and Development in East Asia

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Korea.

Supply chain internationalization has brought structural changes in the world trade. Firstly, the total trade value is growing more rapidly, increasing on annual average by 8.4% between 2000 and 2012 compared to 6.7% growth in 1990s (Calculated with *UN Comtrade* database, the same hereafter). noted that the recent trade growth has been accompanied by decrease in value added contents, particularly more relevant in manufacturing sector trade among geographically proximate countries. The total amount of recorded trade within supply chains is a multiple of the value of final goods because goods in process could cross several national borders before getting assembled as final products (Athukorala and Yamashita 2006). Because of this multiple accounting nature, value added contents in each country could be small despite of expanded trade volume (Johnson and Nogueira 2012a).

Secondly, because international supply chain trade is sensitive to distance, expansion of such trade drives regionalization (Johnson and Nogueira 2012b) In fact, supply chain trade is geographically concentrated to regional hubs (USA, China, Japan, and Germany) as evidenced by the trade map by Ferrarini (2013). As supply chain internationalization enhances intermediate goods trade, Figure 2 captures a remarkable growth of intra-regional intermediate goods trade in East Asia, whose share in the world total intermediate goods trade expanded from 20% in 2000 to 28% in 2012. European Union maintains its share of around 20% in the same period with the eastern enlargement promoted inclusion of Poland, Czech Republic, Slovakia, Romania, and Lithuania in the regional supply chain network (Curran and Zignago 2012), while NAFTA experienced a loss from 13% to 7% because of Mexico's growing substitution of sourcing from East Asia for that from the United States.

Figure 2

Thirdly, supply chain internationalization has changed export commodity composition. In the old flying geese paradigm, countries climbed gradually the ladder of industrial specialization from cotton shirts to high tech electronics and automobile acquiring higher labor productivity. Today some developing countries can make leapfrog change from exporters of primary goods or labor-intensive manufactured goods to those of high valued manufactured goods such as automobiles and mobile ICT equipments. However, as Baldwin (2011) explains, high valued exports from these countries contain advanced-nation technology and value added in developing countries is thin where productivities of workers in high-technology products assembly is the same as in cotton shirts, or anything else. Hence, traditional product-country resource endowment based traditional comparative advantage concept of product-country link has become tenuous. Countries are specialized in tasks which use its abundant factor of production relatively intensively but not in industries[6] (Park et al.

[6] Baldwin and Robert-Nicoud (2014) proposes an integrating theoretical framework

2013).

The rise of intra-regional intermediate goods trade in East Asia was initially triggered by overseas investment of Japanese firms after the exchange rate realignment in mid 1980s with sharp appreciation of Japanese yen against dollar and dollar-pegged Asian currencies. Imports of finished products from Japanese firms' overseas factories which used parts and components imported from Japan gave first impetus to intra-regional trade. Such investment fostered subsequent catching-up industrialization in recipient countries following the path characterized as the flying-geese pattern (Fujita and Hamaguchi 2008).

More recently, some major institutional changes in East Asia during 1990s and 2000s contributed to reduce regional trade costs. China's economic reform and its accession to WTO in 2001 were major factors. Moreover, the original six ASEAN countries adapted the common effective preferential tariffs (0-5%) in 2002 five years ahead of original schedule and established the ASEAN Free Trade Area in 2010 with full elimination of tariffs. ASEAN's free trade agreements with Japan (2008), China (2010), and Korea (2010) successively entered in force. Major infrastructure investment was made in seaport facilities to support intensifying container traffic among industrial agglomerations in the region. Road infrastructure development in the Indochina Peninsula opens opportunities for less developed ASEAN countries (Cambodia, Laos, Myanmar, and Vietnam) to be integrated in the East Asian supply chain network as studied by Kuroiwa (2012).

Figure 3 depict an evolution of the intensity of intermediate goods trade among East Asian countries between 2000 and 2012. Our definition of intermediate goods is based on the classification of Broad Economic Categories (BEC) that includes 42 (parts and accessories of capital goods, except transport equipment), 53 (parts and accessories of transport equipment), and 22 (other processed industrial supplies) in the UN Comtrade. Each circle represents the size of intermediate goods import of each country in each year. Solid line arrows represent transaction flow greater than $10 billion where volume is differentiated by thickness. Broken line arrows represent transactions less than 10 billion but those less than $1 billion are not drawn.

Most remarkably, China's intermediate goods imports grew by 5.6 times (from $44.4 billion to $249.8 billion) between 2000 and 2012. The growth was also outstanding in Thailand, Indonesia, and Vietnam also expanded.

Over all, the network had simpler structure in 2000. We can observe two most intensive trilateral sub-groups, China-Japan-Korea and Japan-Singapore-Malaysia, for which Japan was positioned as an intermediate goods supply hub. Cambodia, Lao PDR, and Myanmar were not involved yet in the

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that encompasses both trade in goods trade in tasks n the same model.

network.

The figure shows a substantial growth of the China-Japan-Korea trilateral intermediate goods trade flows by 2012. The new structure is apparently more dense and complex. China caught up Japan's total intermediate goods export value (see Appendix Table), and became a major supplier as shown by the bold line outflows to various countries. Specific connections such as those from Japan to Thailand and from Singapore to Malaysia and Indonesia were strengthened. Vietnam was drawn as a recipient of a couple of minor intermediate goods inflow in the 2000 figure but the total inflow growth by 2012 exceeded that of the Philippines and Vietnamese transaction became intense in both inflow and outflow in the 2012 figure. Cambodia, Lao PDR, and Myanmar entered as new comers to the network. It is worth noting that these countries receive intermediate goods mainly from China, Thailand, and Vietnam which used to assume most labor intensive tasks in international supply chains, implying that some trickle-down is occurring.

Figure 3

With these background, supply chain internationalization developed into Factory Asia (Baldwin 2011). In this new pattern of international specialization, developing countries integrated in international supply chains gain more manufacturing employment with massive migration from rural to urban areas. Because productivity of these workers is still higher than traditional sectors, these countries are catching-up in terms of per capita income in last decades. This feature is shown by Figure 4 that depicts an evolution of per capita incomes of countries in the region in comparison to that of Japan which is taken to be unity. For the calculation, we used a data expressed in 2005 price US dollars but not a purchasing power parity data because our concern here is not consumption level.

In 1950s and 1960s Japan took a decisive lead in economic growth widening the gap of per capita income against all other countries, Then, in 1970s and 1980s Singapore, Hong Kong, Korea, and Taiwan started grow no less faster than Japan, so the gap ceased to increase. Since the beginning of 1990s these countries achieved continuous catch-up. More recently, because of the supply chain effect, average income level of less developed countries in ASEAN and China are also rising clearly.

Figure 4

This impartial and inclusive nature of the experience of supply chain internationalization in East Asia invites discussions favoring such trend. For example, UNCTAD (2013: 175) argues that how to gain access to GVC (global value chain – another popular expression for international supply chain) is a key challenge for policy makers, especially for the majority of smaller developing economies with limited resource endowments.

However, it should be clear from the theoretical accounts in Section 2 that this proposition should be announced with caution. First, poorly conducted supply chain internationalization can only cause loss of unskilled jobs in an advanced country, mainly in country-side. As discussed above, industrial structural adjustment will be needed to make tasks performed by unskilled workers in advanced countries complementary to but not directly competing with the off-shored tasks. Second, although labor market matching is facilitated by the existence of the large informal sector in developing countries, such labor market inefficiencies should be addressed with appropriate policies in order to avoid to aggravate social problems in the informal sector. Third, because low wage unskilled labor is exhaustible resource even in developing countries, transition to middle and high skill tasks must occur to avoid the "middle income trap". Fourth, there is a growing concern that supply chain linked international trade could be volatile. This issue is analyzed in next section.

4. Volatility

4.1 The downside

International supply chains are efficient and growth-enhancing under normal conditions. However, previous studies point out a problem of higher volatility when supply chains become longer and complex (Acemoglu, et al. 2012; Levine 2012). Here we are interested in two different sources of shock transmissions. One is an idiosyncratic supply shock on any firm that leads to a reduced production or even a temporary disruption of entire supply chain. The other is a macroeconomic demand shock by which impact on production tend to be magnified toward the upper end of a supply chain. In either way, internationalization of supply chain implies that the volatility will propagate internationally.

4.2 Risk of disruption

In last couple of decades, serious disruption of supply chains have been caused by hurricane, earthquake, tsunami, flood, fire, and infectious disease epidemics. Man-made factors such as workers' strike, terrorist attack, and organized protest and boycott also can be serious threats. Once happened, the damage of local disruption propagate through supply chains and have repercussion far and wide at international scale. For example, Fujita and Hamaguchi (2012) showed that when the Great East Japan Earthquake occurred in March 2011, the disruption of automobile parts supply in

the affected area made automobile production fall sharply not only in Japan but also in China, Southeast Asia, and to lesser extent in the United States.

As customization of parts and components develops through long-term contractual relationship in supply chains may increase a disruption risk because there will be no substitute, at least in the short-run, once disruption occurs. Certain types of products may be unintendedly produced by very small number of producers because of scale economies, which, in turn, become a focal firm of disruption risks. Although one can easily perceive such risk, expanded network reduces visibility and increases probability of unexpected loss of access to input providers or customers (Park, et.al. 2013).

4.3 Final demand shocks

Some researchers point out that trade in supply chains is sensitive to final demand shocks than normal trade. Ferrantino and Taglioni (2014) points out three possible reasons. First, it might be just a statistical issue due to the multiple accounting nature of supply chain trade as mentioned above. Second, there is a compositional effect such that demand for goods produced in international supply chains such as electronics and automobiles have higher elasticity of income.

Third, reduction in final demand leads to even larger reductions in intermediate demand through greater variation in inventory control toward the upper stream of the supply chain, the so-called *bullwhip effect* (Lee, et al. 1997a 1997b, Bems et al. 2012). Lee, et al. (1997b) and more previously Kahn (1987) showed that when firms' sales projection follows AR(1) process and there exists uncertainties due to a replenishment lead-time (i.e. time required from placing order to receiving them) subject to market condition, firms' inventory management cost minimization behavior results in greater variance of order of replenishment than that of sales. Thus, bullwhip effect emerges as supply chains get longer and more uncertain by crossing national borders more often. Alessandria et al. (2010) showed an evidence from the U.S. data on the role of inventory adjustment in trade collapse. Using French firm-level transaction data, Altomonte et al. (2012) found that intra-group trade in intermediate goods showed a faster drop followed by a faster recovery than arm's length trade during the international trade collapse of 2008-2009.

4.4 Empirical findings

In order to investigate the link between the internationalization of supply chain and the volatility of world trade, we consider the following simple adjustment process:

$$T_t = \alpha_0 + \alpha_1 m_t + \alpha_2 T_{t-1} + \varepsilon_t , \qquad (1)$$

where T_t is a total world trade in a period *t* expressed in current dollar and T_{t-1} is its one period

lag. We use monthly world trade data for 24 years (288 months) period obtained from IMF's *Direction of Trade* statistics. The variable m_t is a discrete index of months which takes 1 in the initial period (January 1990) and 288 in the terminal period (December 2012) and ε_t is an error term. Estimation of time trend α_1 and AR(1) adjustment parameter α_2 by OLS regression yields:

$$T_t = 5052.34 + 358.54 m_t + 0.93 T_{t-1} \qquad R^2=0.98$$
$$(6042.3) \quad (109.30) \quad (0.022) \qquad \text{Standard errors are in parentheses.}$$

We use this result to calculate the residuals from fitted values for the period between February 1990 and December 2012 (the first observation was dropped because of the lag term). These residuals are deviation from the expected value from the baseline adjustment process of equation (1). This is our measure of volatility. Figure 5 depicts an evolution of the volatility compared to the intermediate goods to final goods ratio in the world trade[7] which represents the intensity of supply chain trade. We can see that volatility was very large in the middle of and right after the great trade collapse in 2008 but it already started to grow around 2002[8] in the same way as the intensity of supply chain trade grew. This observations is consistent with the view to link supply chain internationalization and higher volatility of associated intermediate goods trade, although that correlation does not necessarily imply causality.

Figure 5

As mentioned above, the inventory adjustment, which is considered as a casual force of the bullwhip effect, is more variable as uncertainties of supply chains get larger. Uncertainty can be defined as a broad concept to include fluctuations in trade costs such as: transport stability (i.e, fuel price, custom procedure, port cargo handling); exchange rate variation; production disruption risks and resiliency of direct suppliers and customers; invisibility of supply chain structure; and insurance coverage. Our conjecture is that less uncertain supply chain has smaller volatility under more stable inventory control.

It is ideal to investigate this hypothesis with firm level trade data but unfortunately we do not have access to such data. Instead, we chose to use intra-regional intermediate goods trade monthly data aggregated at sector level, for electric machinery (HS85) and transport equipment (HS87) from UN Comtrade database.

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[7] This figure is calculated using RIETI-TID database (http://www.rieti-tid.com/).

[8] As mentioned in Section 2, China's accession to WTO and the adaptation of the common effective preferential tariffs by six ASEAN countries prompted intra-regional intermediate goods trade in East Asia. In Europe, European Union was enlarged from 15 to 25 countries in 2004 Included lower wage Central European countries became more important source of both intermediate and final products (Curran and Zignago 2012).

We turn to equation (1) to estimate the baseline trade, from which we calculate residuals to evaluate the volatility. Assuming that supply chain trade is regionalized, we estimate both East Asia and European Union for a comparison. Note that we included seasonal dummies to control for seasonal drops of production, that is the Lunar New Year celebrated by the Chinese community in East Asia and the summer vacation (August) and a Christmas (December) for European Union. Table 2 shows the results.

Table2

The estimated models give expected values of supply chain trade. Then we calculate residuals from fitted values and, in order to compare the results, normalize them by the fitted values. These are, therefore, ratio of deviation to the expected value depicted in Figure 6. Unfortunately, the data is available for only short period (January 2000 – September 2012), but the result shows impact of two large natural disasters in East Asia: Great East Japan Earthquake (March 2011) and Thailand Flood (October-December 2011).

Figure 6

We can draw following observations. East Asian supply chain experienced a strong downturn after the earthquake in Japan in both sectors. The shock was deeper and longer in transport equipment sector where Japan's intermediate goods exports has the greatest share.

There was a substantial shock on electric machinery sector as well, although China's intermediate goods exports is quite dominant. There was an upturn in subsequent period and then turned downward again during the Thailand flood. Because Thailand produced about a half of the global supply of hard disk drives[9], the disruption caused a collapse of production of equipment with digital storage device (for instance personal computers and DVD recorders) and intermediate goods for such products were also affected.

The impact of Thailand flood on transport equipment sector was not very large because Thailand's share in auto parts supply in East Asia is still small. However, as Fujita and Hamaguchi (2012) pointed out, not only automobile production in Thailand but that in other ASEAN countries was also negatively affected because Japanese manufactures had adapted parts sharing scheme for automobile assembly in ASEAN member countries taking advantage of preferential tariff benefit of ASEAN Industrial Cooperation (AICO) Agreement established in 1996 .

Overall, volatility of electric machinery sector supply chain in East Asia seems not significantly different from that of EU. However, East Asia's transport equipment sector supply chain in

[9] Information from an interview at a hard disk drive manufacture.

apparently more stable than EU's, except the short turbulence after Japan's earthquake. Does it mean that international supply chains of transport equipment sector in East Asia have any superior institutional arrangement? Is there anything to do with location pattern? Our knowledge on this point is still limited to answer these questions. This topic will be e explored in our future research.

5. Concluding remarks

Recent progress in transport cost reduction captured in broad sense has induced to further fragmentation of production processes and internationalization of supply chain. This has become a subject of study of economics and business. This paper set out to provide the body of literature with interpretation of this phenomenon from the perspective of spatial economics.

Supply chain internationalization is promoting new type of a cascade of agglomeration and dispersion. It will strengthen agglomeration of knowledge intensive headquarter tasks performed by high skilled people in major cities in developed countries, while dispersing to developing countries separated unskilled labor intensive tasks more than ever. The country-side of developed countries also may receive unskilled labor intensive tasks which are too costly to off-shore. In developing countries, off-shored tasks agglomerate in particular location and promote industrialization. In fact, it is always the case that low wage seeking off-shoring will locate in major agglomerations where wage is relatively high in selected developing countries because agglomeration economies affect productivity. As a whole international supply chain is productivity and welfare enhancing through more efficient use of human resources.

With progress of fragmentation division of tasks between developing countries may arise by which more underdeveloped countries may also join. In this sense, international supply chain could be a route for inclusive globalization. Our analysis of East Asia can illustrate this point. However, accessing to international supply chains will not be sufficient for long-term development but it remains challenge for developing countries policy makers to avoid remaining locked into low value added activities under poor working conditions and job security (UNCATD 2013).

Such benefit need to be counter-balanced by potential cost of volatility. It comes from both idiosyncratic supply shock triggered by big natural disasters or any other reasons and final demand shocks. The impact will be propagated and magnified through supply chain links. Business continuity plan (BCP) is now widely discussed by firms at any level of a supply chain to protect their business: to mitigate impacts to its own facilities and employees from presumable hazardous events; to strengthen a resiliency from eventual disruption as quickly as possible; to become more flexible in

managing external factors by increasing visibilities in the supply chain and diversifying potential risks. It is also important that ISO22301, the international standard for business continuity management (BCM), has been set by the International Organization for Standardization (ISO) in 2012 to certify firms' preparedness.

However, we should admit that true that there is no such thing as a risk-free supply chain. We then agree the remark by Levin (2012:279) "high volatility is the price we must pay for high welfare." The policy question is how to increase benefit that will be shared across the economic space while decreasing the cost by addressing the volatility.

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Tables and Figures

Table 1. Geographic distribution of Apple suppliers

	By home country of HQs		By factory location					
	Number of HQs	Factories	Home	East Asia		Europe	North America	Others
				China	Other			
USA	45	220	52	71	62	20	7	8
Japan	43	276	130	74	66	4	2	0
Taiwan	44	138	22	112	2	0	1	1
Korea	12	43	23	17	2	0	1	0
China	16	25	-	25	0	0	0	0
Singapore	9	24	2	19	1	0	1	1
Hong Kong	8	20	0	20	0	0	0	0
Others	14	46	10	11	11	9	4	1
Total by production location			239	349	144	33	16	11

(Source) Author's own elaboration based on Apple's Supplier List 2014.

Table 2. Baseline estimate (unit: $ billion)

Electric machinery

	East Asia			EU		
	Coeff.	S.E.		Coeff.	S.E.	
month	0.0133	0.0073	*	-0.0091	0.0051	*
T_{-1}	0.2137	0.1247	*	0.3312	0.1671	*
Season D.	-1.1305	0.2344	***	-0.2896	0.1344	**
Constant	4.7381	0.7446	***	0.7082	0.5957	***
R^2	0.5802			0.3208		

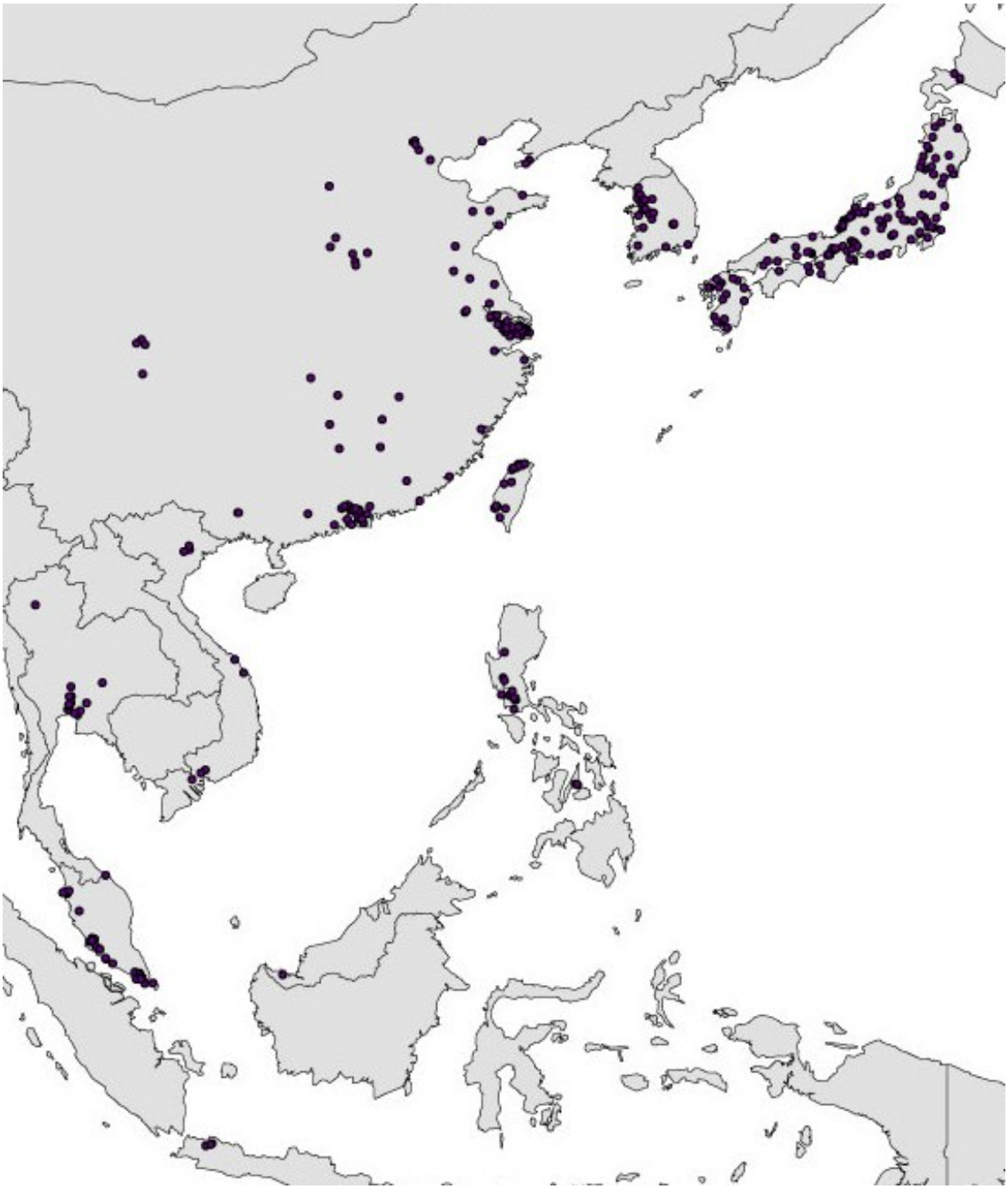
Transport equipment

	East Asia			EU		
	Coeff.	S.E.		Coeff.	S.E.	
month	0.0140	0.0049	**	0.0090	0.0149	
T_{-1}	0.1559	0.1676		0.2515	0.1332	*
Season D.	-0.2311	0.1367	*	-2.2146	0.3910	***
Constant	1.6006	0.3245	***	6.7415	1.1586	***
R^2	0.4590			0.5562		

*** 1% significant. ** 5%. *10%. S.E.: Standard error

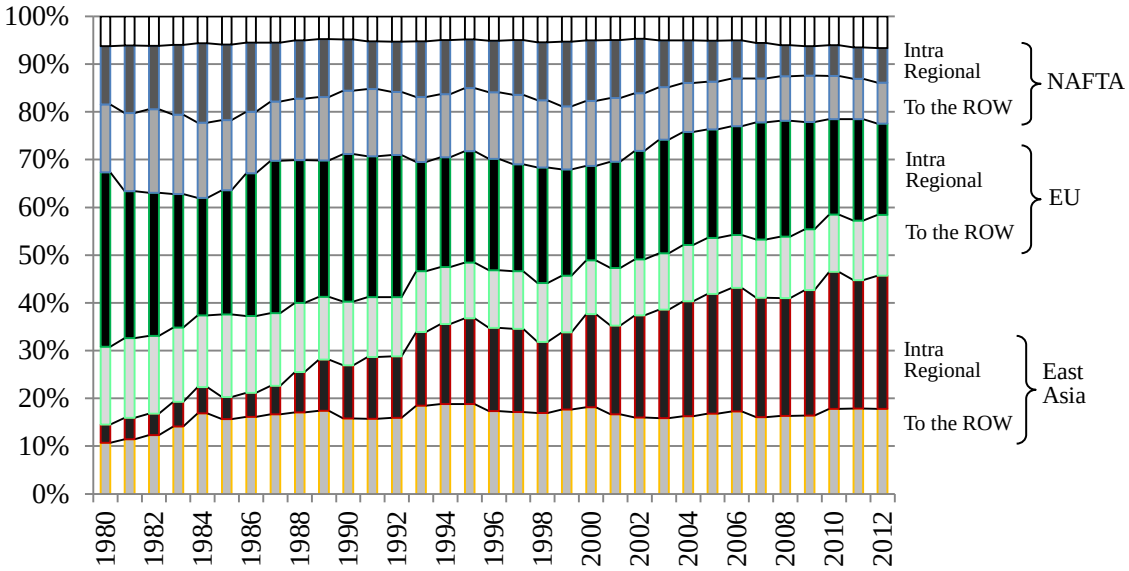
East Asia includes China, Indonesia, Japan, Malaysia, Philippines, Singapore, Thailand for which monthly data are available. EU is current 27 member countries.

Figure 1. Apple's suppliers' location in East Asia



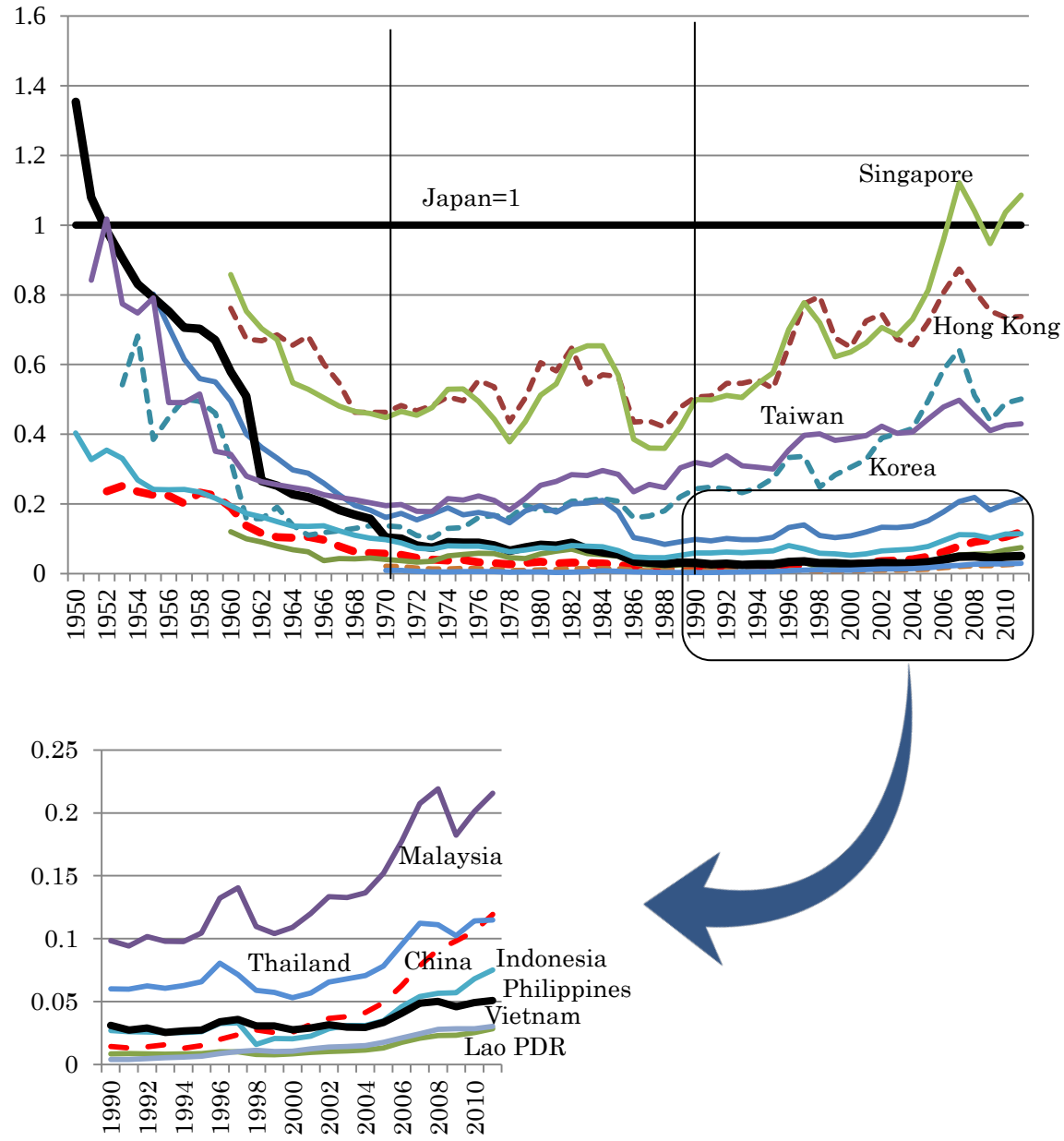
(Source) Table 1

Figure 2. World intermediate goods trade regional shares



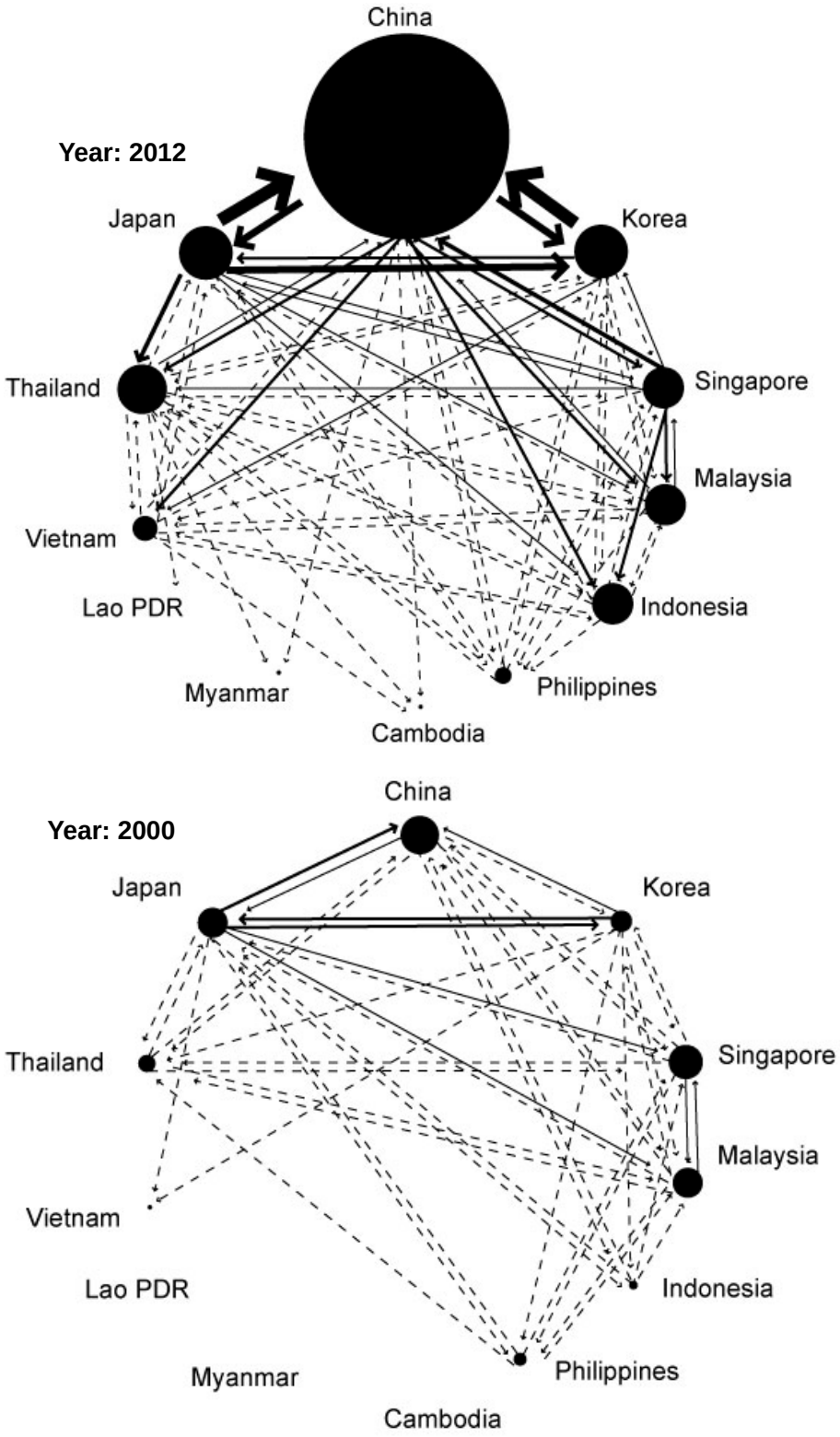
(Source) Author's elaboration based on RIETI-TID.

Figure 3. East Asian countries income convergence



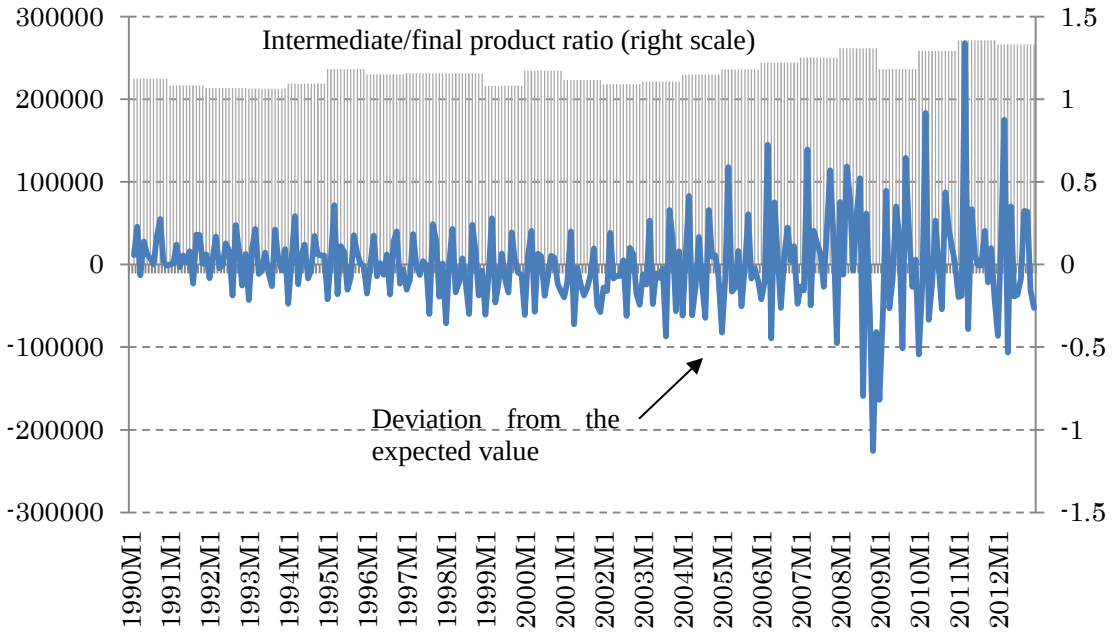
(Source) PENN World Tables

Figure 4. Intermediate goods trade in East Asia: 2000, 2012



(Source) Appendix Table

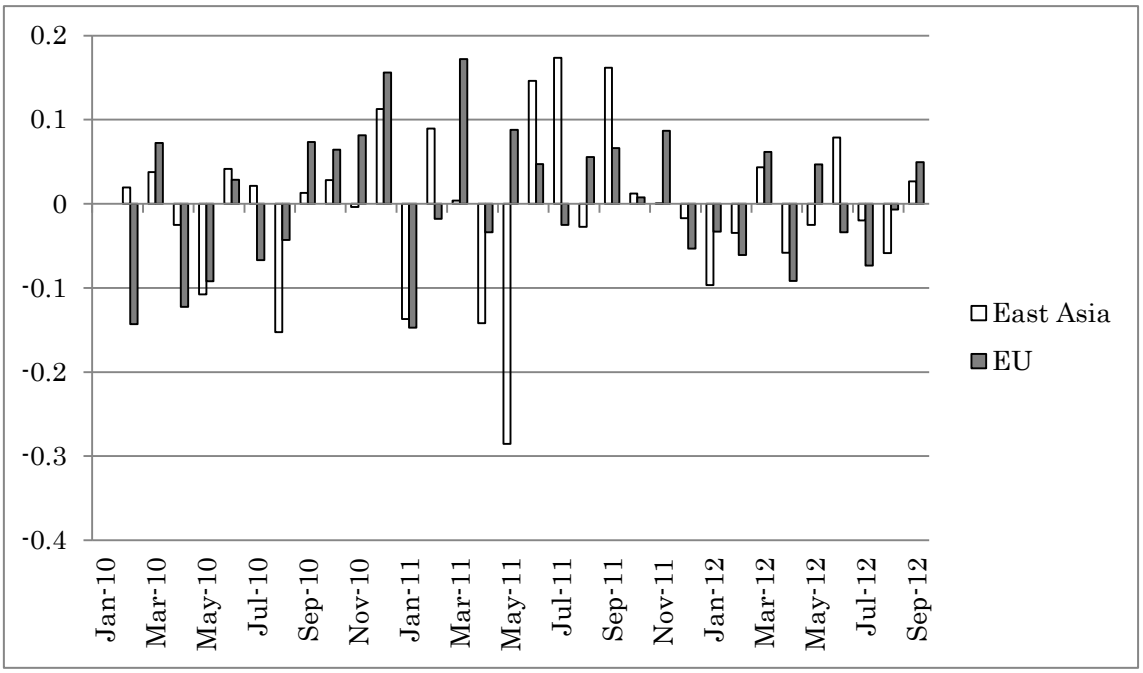
Figure 5. Supply chain and volatility in the global trade: 1990-2012



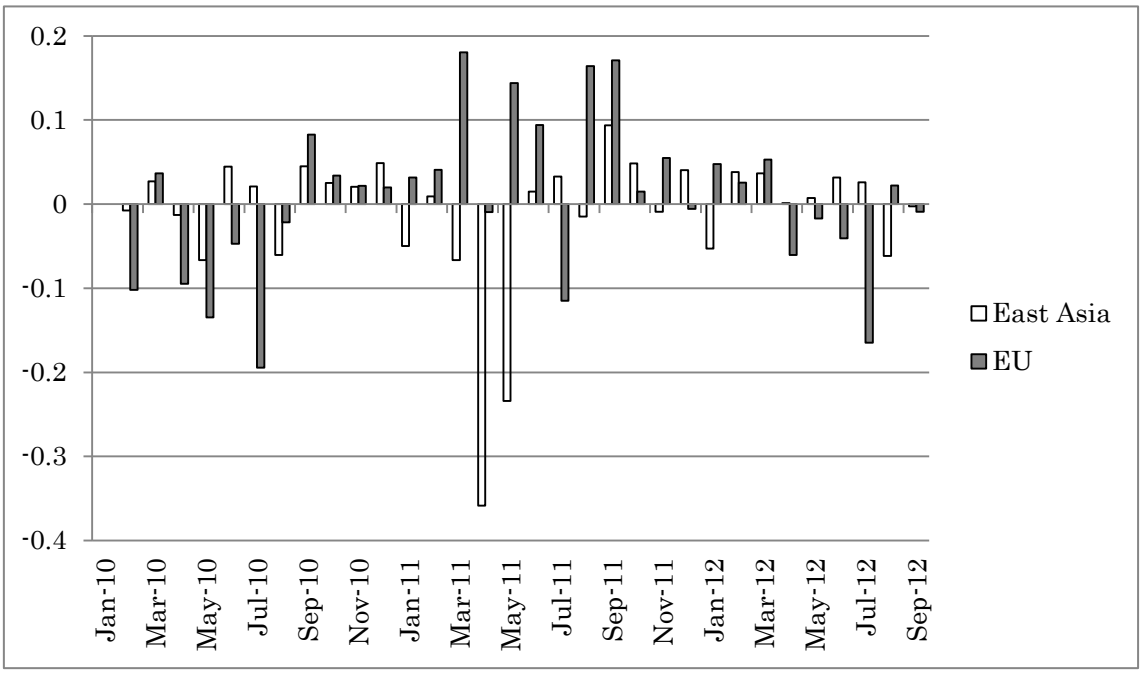
(Source) Authors own elaboration.

Figure 6. Volatility of supply chain trade: East Asia and EU

Electric machinery



Transport equipment



Appeidix Table

East Asian intermediate goods trade in 2000 and 2012 ($ million)

2000	China	Japan	Rep. of Ko	Singapore	Malaysia	Thailand	Philippines	Indonesia	Viet Nam	Myanmar	Cambodia	Lao Peopl	Export tota
China		11,046	5,240	2,721	1,137	1,390	826	1,266	640	264	107	13	24,649
Japan	21,740		20,124	12,106	9,939	9,717	7,397	5,848	1,149	92	11	3	88,126
Rep. of Ko	13,873	9,436		4,173	2,960	1,561	2,511	2,507	1,131	157	48	2	38,360
Singapore	3,489	5,839	2,998		17,140	4,214	1,928	0	624	168	63	2	36,466
Malaysia	1,720	5,371	1,530	12,343		2,195	1,228	797	288	30	34	0	25,538
Thailand	1,624	4,326	795	3,426	1,802		732	783	520	259	118	161	14,546
Philippines	467	3,249	879	2,572	1,252	1,130		103	51	5	1	0	9,710
Indonesia	1,428	3,952	917	3,106	1,217	628	414		268	43	28	1	12,003
Viet Nam	39	357	63	42	87	192	350	0		4	27	22	1,184
Cambodia	23	1	0	12	5	14	1	1	5	0		2	65
Import tota	44,402	32,533	27,309	37,781	34,403	19,653	14,563	10,038	4,037	759	330	193	

2012	China	Japan	Rep. of Ko	Singapore	Malaysia	Thailand	Philippines	Indonesia	Viet Nam	Myanmar	Cambodia	Lao Peopl	Export tota
China		54,687	48,805	16,513	16,658	16,925	8,370	16,415	19,237	2,835	1,893	377	202,715
Japan	90,485		42,091	11,324	11,667	30,685	7,480	13,273	7,277	117	77	14	214,489
Rep. of Ko	88,060	19,437		8,295	4,310	6,340	4,858	6,443	11,522	1,103	300	18	150,687
Singapore	29,556	10,689	11,358		22,541	11,091	3,558	17,622	4,006	445	173	4	111,043
Malaysia	16,697	6,542	3,179	14,302		6,509	1,737	4,173	2,061	140	146	8	55,493
Thailand	13,580	9,628	2,155	3,683	5,300		2,249	5,751	3,565	1,026	1,255	981	49,174
Philippines	2,820	6,060	1,602	3,688	564	1,841		567	411	2	5	0	17,562
Indonesia	4,647	7,614	2,155	5,448	4,368	2,616	1,142		1,239	241	50	20	29,539
Viet Nam	3,925	4,492	1,451	775	1,745	1,133	810	1,098		80	1,328	252	17,088
Cambodia	17	10	11	649	2	45	0	1	14	0		0	749
Import tota	249,786	64,472	64,000	48,164	50,498	60,260	21,835	48,927	30,096	3,154	3,335	1,296	

(Source) Compiled with UN Comtrade data BEC Classification 22, 42, 53.