Original Paper

Advancing the Production Networks in East Asia

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Abstract

A remarkable expansion in production networks has been in solid progress in the global economy. The process of expansion has been accelerated through advance in information and transportation technology in addition to the ongoing trend in globalization. In addition, speedily improving production technology of industries enable the capacity to further breakdown their value chains into smaller proportions. Said production sharing helps enhance efficiency and reduce costs. As East Asian economies are in diverse phases of economic development, the relevant production networks would be joined by both developed and emerging economies in the region. However, certain economies might possess the most critical or irreplaceable phase of the production networks. It means that some unexpected and significant disruptions could stop the networks from functioning regularly. It is noteworthy that the production networks and supply chains have been driven by international trade and associated economic activities. For the purpose of risk sharing and cost efficiency, it is necessary to explore means at both regional level and economy level to strengthen or improve production networks at the regional level, whereas major players that formulate the regional networks include China, Japan, Korea, and Taiwan.

Keywords

production network, risk sharing, cost efficiency

1. Introduction

The production network or production sharing has been evolving and playing a key role in the global economy. Multinational production networks through international trade have been evolving, and international trade is all about the competition and cooperation with respect to diverse industrial comparative advantages. Athukorala (2011) identified 3 major developments that have been transforming multinational production networks: a) speedily improving production technology of industries has enabled the capacity to further breakdown the value chains into smaller proportions, b) advancing technology in communication and transportation has shortened the geographical distances among cross-borders production networks and helped promote relevant services links, and c)

liberalization trend via the World Trade Organization (WTO) or free trade agreement (FTA) processes has eliminated substantial obstacles hindering the proper function of trade and production networks.

In a nutshell, production networks are necessary for meeting the needs of economic development and growth at both the international level and domestic level. Second, production networks are involving and benefiting more economies with technological advancement. Third, economies consisting of developed and emerging ones specialize in a specific phase of the vertically integrated supply chain. Fourth, said networks or chains have become increasingly essential for trade and growth in East Asia (Wang, Powers & Wei, 2009).

2. Major Players in Production Networks

In terms of value chains in East Asian production networks, many economies including China, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand are playing the major roles to supply the end market, mainly the United States (Wang, Powers & Wei, 2009). However, Indonesia, Malaysia, Philippines, Singapore and Thailand are all members of Association of Southeast Asian Nations (ASEAN), whereas their local manufacturing and physical connectivity have been supported by the ASEAN Free Trade Area (AFTA). In order to improve regional production networks in a paradigm-shift fashion, it is therefore critical to look at the roles and potential cooperation opportunities for the other four East Asian economies, China, Japan, Korea and Taiwan.

China has become the major assembly economy that imports intermediate goods from other East Asian economies and exports finished goods to the United States or Europe. Gaulier, Lemoine, and Unal-Kesenci (2007) offered that China's critical position in the production networks has significantly helped promote its trade in high tech products. Furthermore, as the world largest exporting economy, China has attracted many regional economies to extend their manufacturing and supply chains to China. Jhangiani and Stocking (2006) stated that China should be considered as the top global supply chain partner in order to succeed in the global markets.

Japan has been one of the foremost economies that initiated regional production networks and supply chains in East Asia. As the first developed economy in East Asia, Japan has been expanding its production to other regional economies such as China and Southeast Asia to advance intra-regional division of labor to pursue multi-objectives: a) promote business in target markets, b) reduce costs, and c) enhance production efficiency. Makishima (2011) examined intermediate goods trade in East Asia and revealed the essential role of Japan. The increase in the parts and components traded in the region indicating the progress of regional production sharing, whereas Makishima (2011) viewed China and Southeast Asia as partners but considered Korea and Taiwan as potential competitors.

Both Korea and Taiwan have also played a very actively role in forming the East Asian production networks with their multinational enterprises (MNEs) that follow the model of Japan. Korea is strong in its efforts committed in research and development (R&D) and its scale of economy. Taiwan's specific

strength lies in its small and medium enterprises (SMEs) (Eriksson, 2005).

Kimura and Obashi (2011) argued that the region of East Asia has been outperforming the world economy in terms of economic growth for the past 30 years owing to the development of international production networks. Said crossed nations production networks mainly started in the 80s have enabled East Asian economies to cope with major economic crises and made the region "world factory". Generally speaking, crises cause impacts on the demand side, and the production networks help strengthen the supply side. Experience in the past three decades proved that an improving supply side can help address the shrinking demand side (Kimura & Obashi, 2011). Figure 1 shows that the growth in East Asia has been more robust compared with the world growth except during two major crises that occurred in the 90s.

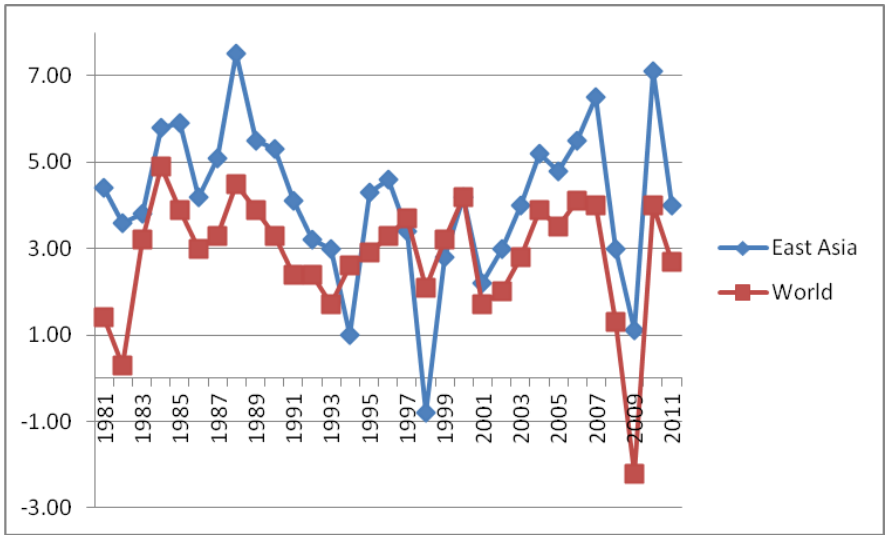

Figure 1. Real GDP growth rates of East Asia and the world (%)[i]

In addition, the East Asian world factory produced end products through its production networks and sold such products to economies outside the region; however, the extra-regional demand has been decreasing due to crises. The intra-regional demand is on the other hand increasing because of the fast expansion of middle income population in East Asia (Kimura & Obashi, 2011). This is a very crucial fact that key players of the regional production networks should pay attention to.

China, Japan, Korea and Taiwan have been enjoying the benefits of multinational production networks, because said networks can reduce costs as trade conducted among these economies and with other East Asian markets would be mostly trade in parts and components. Outsourcing middle- or down-stream supply chain would be a feasible means to fulfill the objective of economic efficiency as those phases of the networks could be relatively more labor intensive. Therefore, trade in intermediate goods in the region of East Asia via the fragmentation of production would make the most of diverse economies'

comparative advantages (Jones, Kierzkowski, & Lurong, 2005).

In addition to trade in intermediate goods, trade in finished goods presumably would also help promote economic growths of major players engaging in the East Asia's production networks. Figure 2 shows the comparisons of GDP growth rates versus exports growth rates of China, Japan, Korea, and Taiwan. For certain economies, the series of GDP growth rate and exports growth rate seem not as correlated as we assume they are. In addition, it seems those two series are more correlated at certain periods of time for specific economies. It is sensible that some economies are relatively more investment reliant than others such as China, and some economies are comparatively more exports dependent than the rest such as Taiwan. It is also noticeable that the exports growth turned slow at bad times such as a major scale financial crisis.

Figure 2. Real GDP and exports growth rates (%)[ii]

Table 1. Correlation coefficients of GDP and exports growth rates

	1990-2000	2001-2011
China	0.387145	0.472104
Japan	0.643443	0.943048
Korea	0.060086	0.544713
Taiwan	0.156742	0.967384

Correlation coefficients displayed in table 1 show certain patterns: a) Japan's economic growth and exports growth were more correlated compared with China, Korea and Taiwan from 1990 to 2000, b) both China's and Taiwan's economic growth and exports growth were significantly correlated from 2001 to 2011, and c) all economies' economic growth and exports growth became more correlated in the period of 2001-2011 than that of 1990-2000.

The percentages of a specific economy's trade volume to the other three economies over its total trade to the world spanned from around 20% to nearly 35%. Figure 3 shows that China, Japan, Korea, and Taiwan are close trade partners as their trades in a hypothetical region, region A,[iii] have been significant. Dynamic trade in intermediate and finished goods among major players that formulate production networks is a sufficient and necessary condition (Kimura & Obashi, 2011).

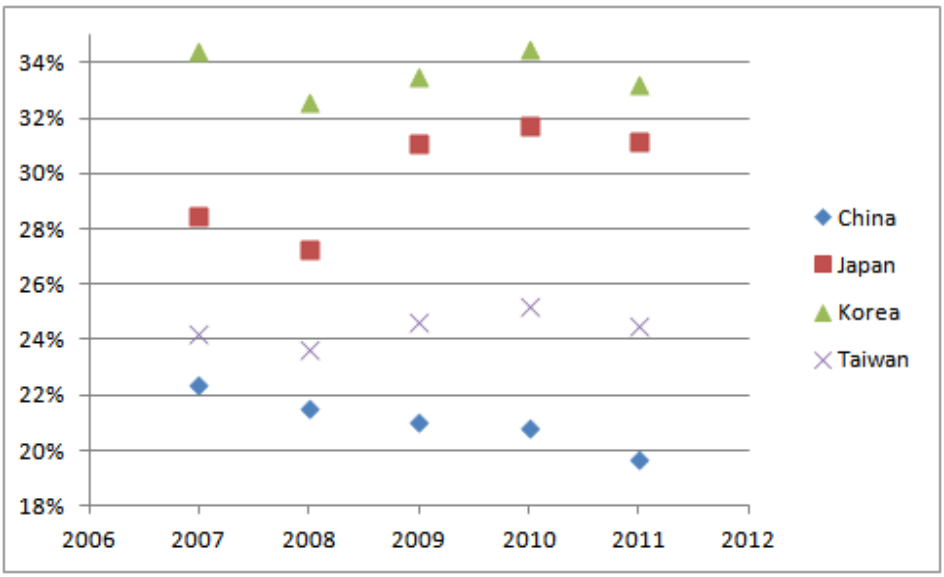

Figure 3. Percentage of trade to region A over trade to the world[iv]

Such findings would be consistent with the arguments that a) expansion in production networks and exports patterns would shift in the same positive direction, b) production networks driving down relevant costs could ensure sustained economic growth, and c) active players in East Asia are exports oriented to a certain extent (Athukorala, 2011; Makishima, 2011; PECC, 2012).

3. Impacts from Disruptions

Many have agreed with the concept that fragmentation theory and the game of comparative advantage jointly create production networks, whereas technological advance and freer trade make the theory and game practicable. The objectives of forming production networks in this first place were to fulfill better efficiency and pursue lower costs (Kimura & Obashi, 2011; PECC, 2012). Significant trade conducted among China, Japan, Korea, and Taiwan also signifies that these major players are constructing well

functioning production networks. However, it is noteworthy that major disruptions are capable of holding back all efforts and hindering the networks from functioning properly.

The estimated global economic loss in 2011 caused by natural disasters stood at around US$ 363.79 billion,[v] and the estimated loss in the region of East Asia was around US$ 224.62 billion in the same year.[vi] Accordingly, the economic loss of East Asia in 2011 accounted more than 60% of the world's entire loss due to natural disasters. As shown in figure 4, natural disasters had stricken East Asia and caused huge economic costs from the 1990s to 2011. That means East Asia is a region specifically vulnerable to impacts of natural disasters.

Among East Asia countries, Japan's economic loss caused by natural disasters was calculated as around US$ 212.52 billion or 95% of the region's total loss in the year of 2011. The significance of Japan's economic costs because of inevitable natural disasters in 2011 came from the Great East Japan Earthquake. Such catastrophic event containing severe seismic and tsunami devastated Japan on March 11, 2011.

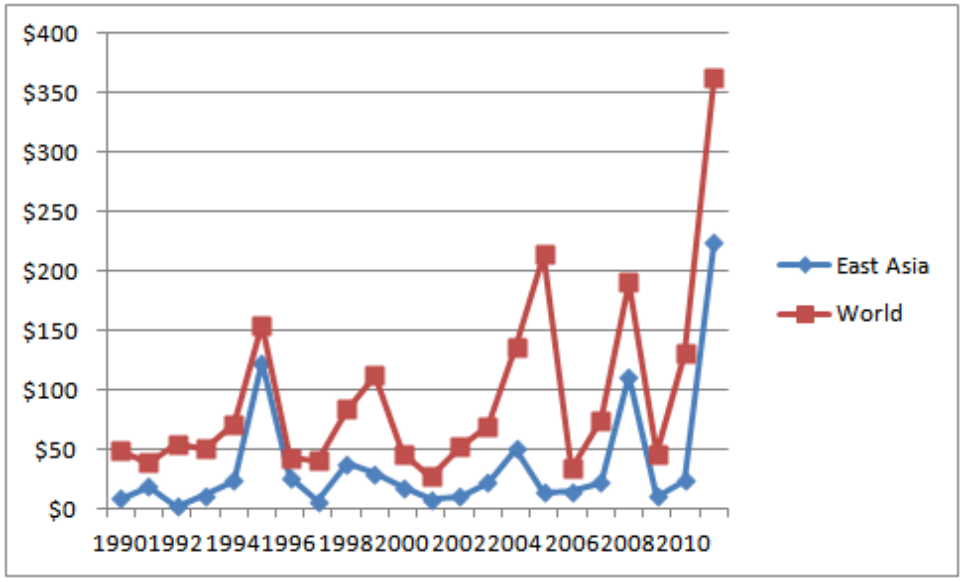

Figure 4. Estimated economic loss of East Asia vs. the world due to natural disasters (Unit: billion US$)[vii]

The major damaged areas of Japan, Tohoku and Kanto, are recognized as one of the most important production centers or the critical upstream of global production networks for electronics, steel, machinery, and automobiles industries. As a result, pertinent and extended loss could actually be much worse than the estimated figures; potential damages would also be on other phases meaning middle- and down-streams of industry production networks. Accordingly, East Asian economies that rely more on Japan's supply for specific parts and components would suffer from more consequent costs (Choi, No, Lee, Lee & Park, 2011; PECC, 2012).

Table 2. Rate of reliance on Japan's supply for parts and components[viii]

2011	Import	Export
China	15%	8%
Korea	25%	6%
Taiwan	29%	7%

Table 2 shows that Taiwan depended more on Japan's supply for parts and components than others, followed by Korea, and then China. The serious disruptions in parts and components would be the cause for Japan's electric production to contract by 8.3% and automobile production to reduce by 47.7% (PECC, 2012). Nevertheless, contraction in production also spread to other economies through the networks.

Figure 5 shows that Japan's monthly industrial production change ratio turned negative since the incident of Great East Japan Earthquake. The percentage change of Japan's industrial production slightly moved up to gain positive reading only twice after the disaster in 2011: one in August and the other in October. After October 2011, the percentage change of Japan's industrial production continued to decline until an obvious recovery in March 2012. The disaster reconstructions helped boost Japan's economic recovery in the first half of 2012.

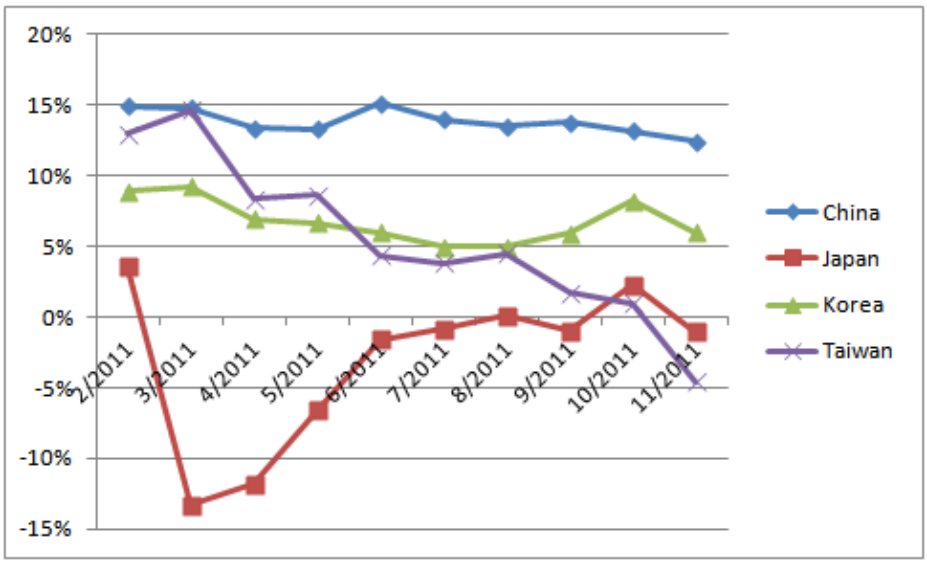

Figure 5. Percentage change of industrial production[ix]

As it is noted that contraction due to the Great East Japan Earthquake in production also spread to other economies through the networks, the other three East Asian economies' percentage change of industrial production also went down after March 2011.

By comparison, China's percentage change of industrial production (IP) after the incident was

relatively steady with an average as of 14% for the rest of 2011. In spite of the contagious impacts, Korea's performance in IP after the devastating event remained moderate with an average of percentage change as of 6% from April till December 2011. As the most dependent economy for parts and components from Japan as identified in table 2, Taiwan's percentage change of IP plunged more sharply compared with others. Figure 5 presents a very obvious downward sloping curve of Taiwan's IP change ratio indicating a drop from nearly 13-15% in the first quarter to minus 5-8% in the fourth quarter in 2011. The IP change ratio of Taiwan on average from April to December 2011 stood at a tepid 2%, barely remained positive.

Again, assume region A comprising only four economies, China, Japan, Korea, and Taiwan; it was found that the region A's overall IP change ratio and real GDP growth rate from 2001 to 2011 were highly correlated with an estimated correlation coefficient as of 0.9238. This simply implies that a decline in IP would almost certainly cause harmful impacts on economic growth of region A.

Major firms of electronics and high-tech sectors of East Asian production networks were hit hard and went through major decline in production due to shortages of relevant components (Parker, 2011; PECC, 2012). For example, northern Japan generally supplies around 20% of the global semiconductor manufacturing industry's required components, and deficiency in supply for printed circuit boards would affect all products associated with the production networks of electronics (Dempsey, 2011). Manufacturing and exports in electronics has been the key to sustain economic growth for Taiwan and other export-oriented economies. As a result, risks for economic downturn rise inevitably.

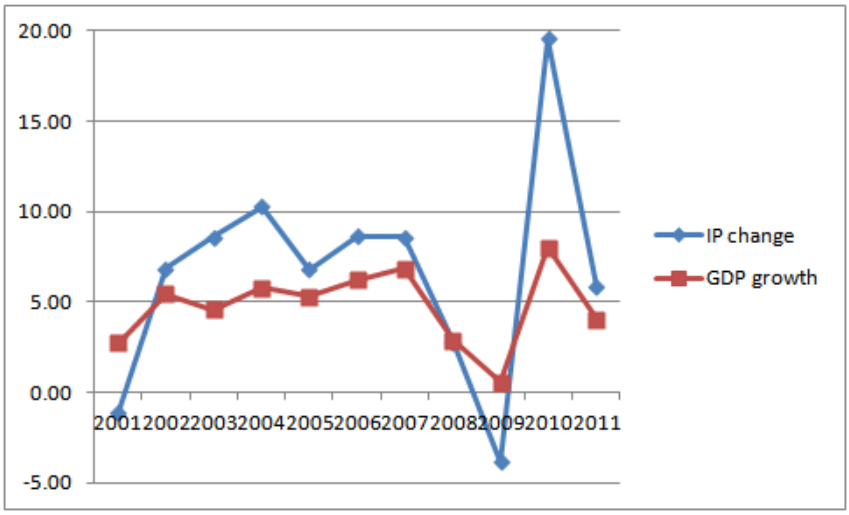

Figure 6. IP Change (%) vs. real GDP growth (%) of region A[x]

Shih (2011) adopted the Miller and Blair's input-output model to examine how the economies of China, Korea and Taiwan were affected by the supply chain disruption caused by the Great East Japan Earthquake. The findings suggested that the GDP growth in terms of percentage points of Taiwan in

2011 dropped more severely due to the disruption compared with China and Korea. Three scenarios assumed by Shih (2011) were: a) the disrupted supply chain would recover in the 3rd quarter of 2011, b) in the 4th quarter of 2011, and c) in the 1st quarter of 2012. From table 3, the findings also suggested that the impacts on GDP growths of China, Korea and Taiwan would be even worse in case the recovery of disrupted supply chain was further delayed.

Table 3. Impacts on GDP growth due to great East Japan earthquake[xi]

Drop in percentage points	Recovered in Q3 2011	Recovered in Q4 2011	Recovered in Q1 2012
China	0.0284	0.0483	0.0622
Korea	0.0236	0.0402	0.0518
Taiwan	0.1492	0.2536	0.3267

To come to the point, East Asia has been the region particularly vulnerable to impacts of natural disasters among all regions in the world. It also means that the East Asian production networks would be more likely to be disrupted by natural disasters. As the economic strength and sustainability of East Asia rely on the well functioning of production networks, exploring feasible means to improve the East Asian production networks and fulfill the pertinent objectives: risk sharing and cost efficiency would be necessary.

4. Cost Efficiency and Risk Sharing

Efficiency in production and distribution would be the reason of forming multinational production networks in the first place. As “efficiency” in economics concept is defined as a) cost minimization with respect to fixed profit or b) profit maximization with regard to constant cost. Regarding cost minimization, technology leading economies expanding their production lines to emerging economies are looking less expensive labor costs, mitigating impacts of exchange rate fluctuation, and avoiding expenses on carrying redundant inventory (Makishima, 2011).

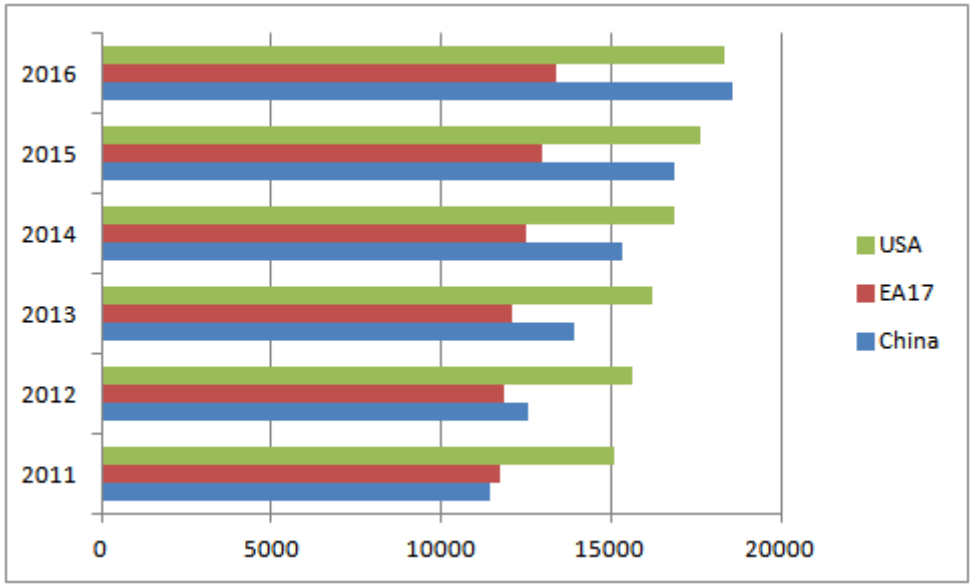

Figure 7. Forecast of nominal GDP (US$ billion, PPP)[xii]

On the subject of profit maximization, nurturing emerging markets and helping them not only take more active part in regional production networks but also gain consumption power in the future would be merit one. Merit two would be the proximity to these potential markets through production networks. Up to this moment, major finished products manufactured and assembled in East Asia have been delivered and shipped to advanced economies outside the region, the US and Europe. However, East Asian economies are steadily acquiring the purchasing power as they have been outgrowing the US and Europe. That means that most final products will be consumed in the region than sold to elsewhere in the future. For example, the economic size of China is forecast to surpass the Euro Area in 2012 and exceed the US in 2016 in terms of purchasing power parity (PPP). Said development of connecting supply chain and end markets would help further the production networks created in the region (Makishima, 2011).

It is sensible that cost efficiency has provided the incentive for improving regional production networks. As the region's economic powers constantly grow stronger, such incentive will also be stronger. What lacks direct and immediate incentive for improving production networks would be risk sharing. There are cost implications to enhance the resilience of the region's production networks in response to increasing frequency of natural disaster related disruptions and meet the objective of risk sharing in the region. Paying greater emphasis on inputs management and multi-sourcing are costly measures that have been discussed repeatedly; nevertheless, PECC (2012) offered that the costs of pertinent risk-sharing measures were needed in the long run. As meeting the ends of regional production networks risk sharing as well as economic efficiency is not targeting at an immediate cure, the treatment would be on more comprehensive and continuing policy measures.

To improve the East Asian production networks, policy measures can be conducted at the regional level or at the economy level. The difference is that improving production networks at the regional level is an attempt to optimize the overall regional objective by ensuring the properly function of supply chains and relevant networks; whereas improving the networks at economy level is focus on strengthen an economy's capacity associated with the supply chains and networks.

5. Improving the East Asian Production Networks at the Regional Level

5.1 REI

Intra regional trade in intermediate goods and extra regional trade in final goods have been jointly providing East Asia the much needed growth momentum (Athukorala, 2011). Increasing intra regional trade in parts and components has also been the result of expanding regional production networks (Makishima, 2011; PECC, 2012). In addition, the extra regional trade in finished products with developed economies such as the US and Europe is still the main growth engine for East Asia (Athukorala, 2011). However, given the tremendous growth potential of East Asia, there would be a maximum likelihood of drastically rising intra regional trade in final goods in the foreseeable future.

Since trade, intra-regional and extra-regional, plays a key role in linking production networks and economic growths for East Asia, eliminating redundant barriers to promote trade through regional economic integration (REI) would be necessary. REI can take many forms, whereas the free trade agreement (FTA) has been recognized as a practicable means to create trade (Molders & Volz, 2011). Furthermore, it is tested with East Asia's panel data that REI with FTA can promote vertical specialization-based trade meaning that furthering REI will improve the East Asian production networks (Harvie, 2009; Li, 2009).

It is noteworthy that FTA is in general executed by following rules of origins (ROO), which also means that it is good for final goods trade but not necessarily helpful for intermediate goods trade (Athukorala, 2011). The tariff exemption guaranteed by FTA would be more complicated for trade in intermediate goods to enjoy due to ROO. As intra regional final goods trade in East Asia is also anticipated to be a dominant market force, the ROO issue should not be a main concern regarding it could be detrimental to trade in parts and components. Furthermore, modern FTA has been evolving beyond duty free and includes many important issues that can help strengthen production networks, such as technological standards (Das, 2012).

Molders and Volz (2011) offered that bilateral economic integration can achieve a more significant anticipation trade effect compared with the multilateral economic integration. Chia (2010) stressed the need for multilateral economic integration in East Asia to continue the economic momentum, and offered that FTA has a tendency for enlarging, docking and merging. Therefore, it would be sensible for major players in the regional production networks to conduct bilateral cooperation first and make it multilateral later with the enlarging, docking and merging functions.

Table 4. Export similarity index[xiii]

	China	Japan	Korea	Taiwan
China	1	0.60	0.73	0.76
Japan	0.60	1	0.76	0.67
Korea	0.73	0.76	1	0.80
Taiwan	0.76	0.67	0.80	1

The export similarity indices (ESI) between major players in East Asia's production networks were estimated by TIER (2011).[xiv] Table 4 shows that China and Japan have the lowest ESI, 0.60, implying a good kickoff point to launch bilateral economic integration would start with China and Japan. When the ESI ratio closes to 0 or relatively smaller, it means there is more room for the two relevant economies to forge cooperation. Therefore, China-Japan economic cooperation can be a starting point from the perspective of ESI to fulfill the goal of REI, and it could involve Korea and Taiwan afterward. Economic incentive is relatively weak for Korea and Taiwan to strike a deal for potential FTA, since their ESI was estimated to be 0.80 that is the highest above all in the region. However, a comprehensive REI can be fulfilled by adopting functions of enlarging, docking and merging. When it comes to FTA, more participants will generate more overall benefits but it would be more difficult to negotiate (Scollay, 2001). Starting with bilateral cooperation and connecting relevant agreements afterward would be a means to improve regional production networks.

5.2 APEC

A comprehensive REI can help advance and strengthen production networks; however, political obstacles can hinder the progress of good economic cooperation (Cheong, 2003). ESI is a good reference to explore economic incentives to launch bilateral cooperation; political impediments however complicate the process. The Asia-Pacific Economic Cooperation (APEC) has been serving as this region's multilateral mechanism to coordinate diversities economically and politically. The goals of APEC are to promote economic liberalization, facilitation and cooperation (Chiu & Lao, 2008). The recent APEC activities designed to fulfill the goals and pertinent to regional production networks would be the "Supply Chain Connectivity" (SC) framework (APEC, 2009).

The SC framework identified eight chokepoints that deter the smooth flow of goods, services and business travelers throughout the region of Asia-Pacific. The chokepoints are further summarized as: a) lack of transparency, awareness, coordination and single contact point of logistics issues, b) lack of sufficient transport infrastructure, c) lack of capable local or regional logistics providers, d) lack of efficiency in clearance of goods at the border, e) lack of simplicity of customs documentation and procedures, f) lack of multi-modal transport capacity, g) lack of consistency in cross-border standards and regulations, and h) lack of cross-border customs transit arrangements in the region (APEC, 2009).

In addition to identifying chokepoints, APEC further specified what have been done and what can be

done to improve the supply chain connectivity of the Asia-Pacific region.

Table 5. Summary of APEC supply chain connectivity framework[xv]

Chokepoints	Contents	What have been done	What can be done
Chokepoint 1	Lack of transparency, awareness, coordination and single contact point of logistics issues.	Publication of guidebook and organizing meetings to disclose relevant information.	Enhance transparency and coordination through public-private information and best practices sharing.
Chokepoint 2	Lack of sufficient transport infrastructure.	Conduct studies on the relevant impact and launch a pertinent working group.	Study international best practices and explore funding options.
Chokepoint 3	Lack of capable local or regional logistics providers.	Conduct customs and business dialogue and conduct relevant study project.	Review relevant constraints and come up with feasible models.
Chokepoint 4	Lack of efficiency in clearance of goods at the border.	Conduct surveys to measure the potential benefits of enhancing efficiency.	Encourage economies to lower thresholds and provide single windows as coordinating point.
Chokepoint 5	Lack of simplicity of customs documentation and procedures.	Call for simplification and harmonization of relevant procedures.	Explore means to simplify customs documentation and procedures.
Chokepoint 6	Lack of multi-modal transport capacity.	Launch working groups to pin down the issue.	Conduct impact analysis and provide incentives to enhance multi-modal transport capacity.
Chokepoint 7	Lack of consistency in cross-border standards and regulations.	Launch working groups to pin down the issue.	Develop common standards and explore ways to facilitate service providers.
Chokepoint 8	Lack of cross-border customs transit arrangements in the region.	Nothing specific has been done.	Identify difficulties of such transit arrangement and address the difficulties.

In the 2012 APEC Leaders' meeting, they stressed that it's confirmed by all to achieve a 10% improvement in supply chain performance by 2015, whereas the performance will be evaluated in terms of efficiency in moving goods and services in the region of Asia-Pacific with respect to diverse conditions facing regional economies (APEC, 2012b). APEC process is bottom up; APEC decision making is top down (Chiu & Lao, 2008). Since decision makers at the very top have openly announced an objective to be met, the working levels will take specific actions to improve the region's supply

chain performance.

Both REI and APEC are mechanisms that can be utilized to improve production networks at the regional levels. The differences are a) REI is binding and APEC is non-binding, b) REI is rule based, and APEC is voluntary, and c) REI is flexible on the number of members, and APEC is set with 21 members for the time being. Regional level solutions are ideal for resolving regional issues; however, the most challenging issue is that this region lacks of effective leadership to start concrete actions (Chiu & Lao, 2008).

6. Improving the East Asian Production Networks at the Economy Level

6.1 R&D

To maximize or optimize the region's overall objective is not easy, because there are diverse interests of players. Decision makers, say APEC leaders, have their own domestic agendas that could be very different from the region's overall priorities (Chiu & Lao, 2008). For that reason, to improve the East Asian production networks at the economy level would be supported by a relatively stronger incentive, as a means to sustain the supply side of an individual economy's economic growth. Decision variables derived from the regional level objective function requires leadership; decision variables obtained from the economy level objective needs incentives (Chiu & Lao, 2008).

New supply chain strategy emerged after the Great East Japan Earthquake, and the strategy consists of suggestions like a) reviewing sufficient buffer stocks for key parts and components and b) looking for other key parts and components suppliers from other regions (BCI, 2012). The major damaged areas of Japan were recognized as one of the most important production centers or the critical upstream of global production networks for electronics, steel, machinery, and automobiles industries. Therefore, it is necessary to have enough buffer stocks, and it is costly to find alternative suppliers from other regions. Makishima (2011) considered economies in the East Asian region that have the potential to advance their high technology and compete with Japan are Korea and Taiwan. Therefore, if Korea and Taiwan can move closer to the network stream of Japan, the regional networks would be more resilient by meeting the ends of risk sharing and cost efficiency. In spite of everything, East Asian economies especially Korea and Taiwan that rely more on Japan's supply for specific parts and components would suffer from more consequent costs resulted from the Great East Japan Earthquake (Choi, No, Lee, Lee & Park, 2011; PECC, 2012). It is sensible that Korea and Taiwan would wish to relieve the reliance.

Expenditures on research and development (R&D) would be the key to advance high technology. Japan's total expenditure on R&D stood at US$ 140,833 million in terms of purchasing power parity (PPP) in 2010. In the same year, Korea and Taiwan spent US$ 53,185 million (PPP) and US$ 23,918 million (PPP) respectively. As Japan's spending on R&D was almost twice as much as Korea's and Taiwan's spending put together, and R&D expenditure is the cost necessary to ensure Japan's superlative position at the regional supply chain.

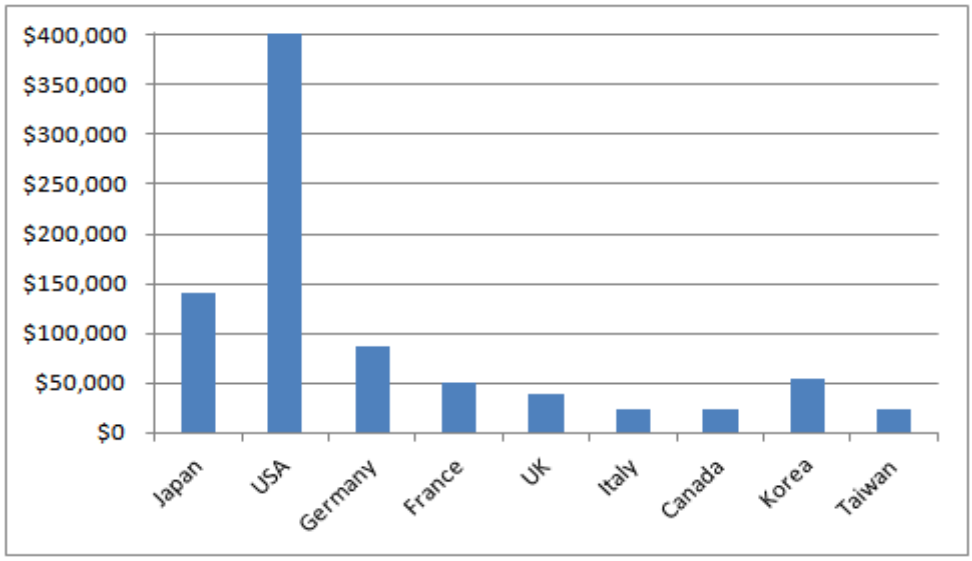

Figure 8. Expenditure on R&D in 2010[xvi]

Unit: US$ million (PPP)

Compared with the group of advanced economies, Japan's annual expenditure on R&D would be the second largest among them only next to the United States of America. That also explains why Japan has had the capacity to dominate the critical spot of the global production networks. It further explains why the negative impacts caused by the Great East Japan Earthquake would be so significant, as the networks are connected in a way that Japan plays the most critical role. The significant amount of capital invested in R&D has helped Japan secure that vital role.

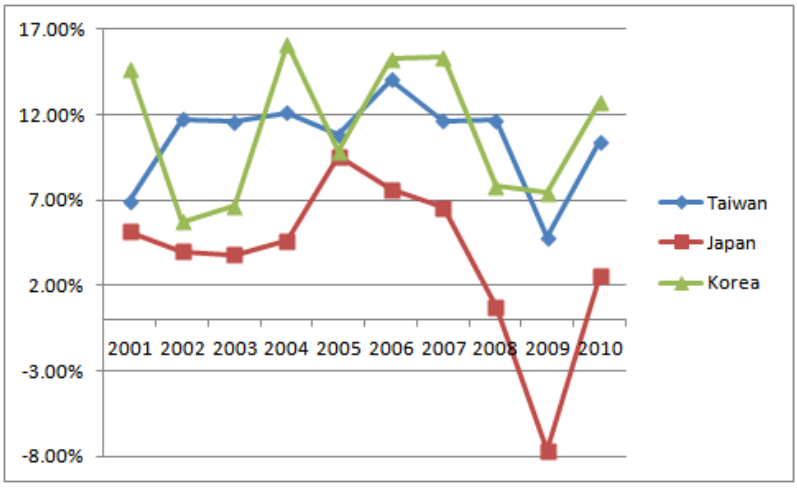

Figure 9. Increasing rate of expenditure on R&D[xvii]

However, economies that have a relative large size of GDP tend to spend more on R&D. As Japan is an economy larger than Korea and Taiwan put together, increasing rate of expenditure on R&D can mirror

economies' endeavors to upgrade their advantages in production networks. Figure 9 shows that the increasing rates of expenditures on R&D of Korea and Taiwan have been in general higher than Japan's since 2001. It also shows that the increasing rates declined significantly during the most recent global financial crisis. It also verifies the situation that both Korea and Taiwan have also strived to play a more actively role in attending the East Asian production networks by following the model of Japan. Korea is strong in its efforts committed in R&D and its scale of economy; whereas Taiwan's specific strength lies in its small and medium enterprises (SMEs) (Eriksson, 2005).

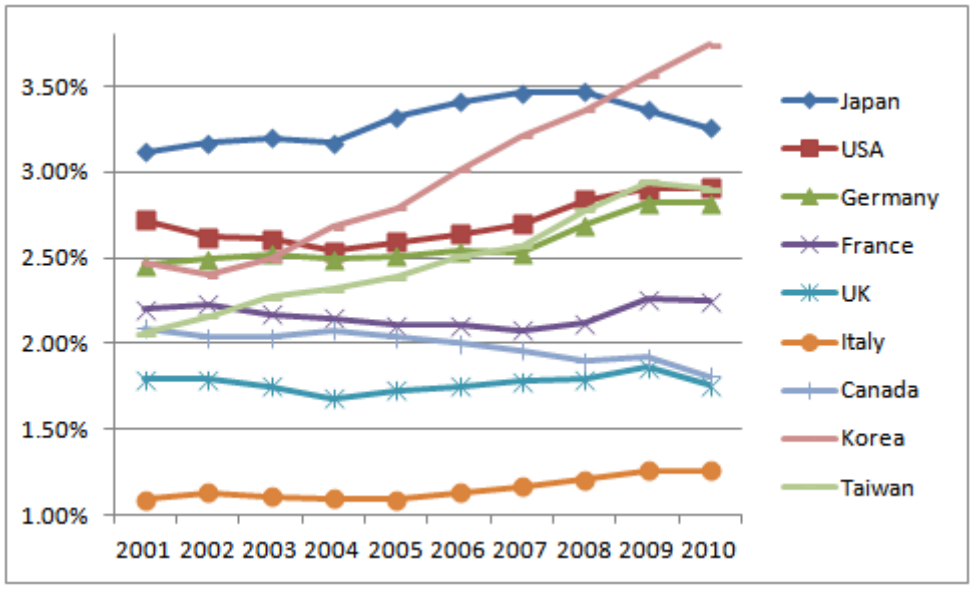

Figure 10. Ratio of R&D expenditure over GDP[xviii]

In terms of R&D expenditure over GDP ratio, Korea had had the second highest ratio only next to Japan from 2004 to 2007 and has had the highest ratio among all OECD countries since 2008. Before 2008, Japan's R&D expenditure over GDP ratio had been the highest compared with all other advanced economies and has been second to Korea since 2008. As for Taiwan, its R&D expenditure over GDP ratio has never surpassed the ratio of Japan and Korea. From the perspective of R&D endeavor, Korea is more likely to catch up with Japan when it comes to playing a critical role in the regional production networks.

Enhancing R&D is the means to improve the East Asian production networks at the economy level, and the idea is to upgrade technology of certain economies, so they can step in and supply key parts and components when the critical supplier cannot supply normally due to unexpected disruptions.

6.2 SMEs

In general, large firms dominate production networks; however, it is important to include SMEs in the regional networks as SMEs serve as the major driving force for East Asia's economic performance and

sustainability (Harvie, 2009; Clark, 2012; Wignaraja, 2012).

To improve the regional production networks at the economy level, regional economies' specific economic structures and characteristics need to be taken into account in addition to incentives. As SMEs play a very significant role for most economies in the region, engaging SEMs in the production networks meets the ends of cost efficiency and risk sharing. Wignaraja (2012) offered that involving more SMEs in production networks through supply chain links could help sustain the economic growth of East Asian region. In the 2012 APEC Ministerial Meeting Joint Statement, ministers pledged to help and enhance participation of SMEs in global production chains as well as capacity building and best practices sharing on global supply chains (APEC, 2012a).

In general, SMEs have to address more constraints such as a) lack of access to finance, b) lack of advanced technology, c) lack of skilled working force, d) lack of networking and market information, and e) lack of scale of economy, and so on compared with large firms (Clark, 2012; Harvie, 2009). Said constraints facing SMEs also mean that SMEs are dealing with more difficulties in engaging regional production networks. In the production networks, SMEs normally play the role as a downstream supplier or assembler, but such position also means that other suppliers and assemblers can replace them easily (Harvie, 2009). Therefore, it is important for SMEs to move up their position in the networks by improving relevant added value. With numerous constraints facing SMEs, the government's role is essential to help upgrade the capacity of SMEs.

The role of SMEs is crucial for certain East Asian economies especially Taiwan, as 97.63% of all enterprises in Taiwan are SMEs. The Taiwanese government has identified 5 key operational areas to help advance SMEs: a) creating a healthy environment for nurturing SMEs, b) strengthening the SME's management guidance function, c) building a platform for enterprise start up and incubation, d) enhancing information technology capabilities of SMEs, and e) integrating the SME financing mechanism. These operational areas aim at addressing the constraints facing SMEs, therefore the policies also help SMEs to engage in the production networks. Strong economic incentives support the Taiwanese government to allocate its budget on enhancing SMEs. Nevertheless, the incentives for other major East Asian players say Korea might not be as strong to promote SMEs, as Korea's economic strengths lie in big firms with scale of economy (Eriksson, 2005).

When it comes to regional production networks, large firms play the leadership role, and SMEs serve as followers. Since SMEs are mainstay of the East Asian economy and production networks provide growth momentum for the region, engage SMEs in the regional production networks is needed. As the operation of SMEs is more challenging than large firms due to the gaps in financial and technological capacity, the government must provide in due course policy incentives.

7. Conclusion

The ongoing expansion in production networks has been accelerated through advance in information

and transportation technology with respect to globalization and regionalization. Fragmentation of production helps enhance efficiency and reduce costs, whereas the production networks would be joined by both developed and emerging economies in the region of East Asia. As certain economies possess the most critical or irreplaceable phase of the production networks, unexpected and significant disruptions may stop the networks from functioning regularly.

For the purpose of risk sharing and cost efficiency, it is therefore necessary to explore means to strengthen or improve production networks. Focus of this article was on China, Japan, Korea and Taiwan due to the facts that they have been major players of the regional production networks, they have been close partners of trade in both intermediate and final goods, and they represent different phases and positions in the networks. Furthermore, unlike ASEAN economies, the hypothetical sub region of East Asia has not yet been supported by in depth REI.

Formula suggested in this article has two folds: a) improve the East Asian production networks at the regional level and b) improve the networks at the economy level. The former approach can be conducted by forming REI or utilizing an existing intergovernmental platform, APEC. For REI, starting with bilateral economic cooperation is suggested, and REI as a means to improve the networks can be fulfilled by adopting functions of enlarging, docking and merging. APEC process include natures of voluntary, non-binding, peer pressure and top down decision making; leadership is required to make use of APEC as a platform to enhance the regional production networks.

By comparison, incentives for improving the regional production networks at the economy level are stronger, since relevant incentives are related to the economic sustainability of specific economies. Enhancing R&D and promoting SMEs are means necessary to improve the networks. R&D capability is the key to continue the proper functioning of production networks especially when disruptions deter the critical player from operation. As for SMEs, they are essential for this region's economic growth but they are also relatively more vulnerable, the government needs to take an active role and provide policy incentives.

Future studies can take a more comprehensive view to examine the development of East Asian production networks by also reviewing the roles of ASEAN economies in addition to four players. Second, though a comprehensive REI can be fulfilled by adopting functions of enlarging, docking and merging bilateral cooperation agreements, incentives and leadership roles to fulfill such goal need to be further explored and identified. Third, how the production networks have been connected by pertinent players might also make a difference. If the networks are connected in a way that a major player plays a pivotal role and external shock centered at said player, the shock can be amplified. It is therefore worthy of looking how the networks can absorb or balance out shock impacts with respect to different styles of network connections. For example: examining how network players are interconnected in a relatively balanced format can result in different outcomes. Fourth, foreign direct investment (FDI) and regional production networks have been recognized as highly correlated. Besides trade, patterns of FDI

could be further reviewed in future studies and see how and what formats of FDI can contribute to the resilience of production networks.

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[i] Source: EIU Country Data, Retrieved on September 10, 2012.

[ii] Source: IMF data and statistics, Retrieved on September 10, 2012.

[iii] Assume region A consists of only 4 economies, China, Japan, Korea, and Taiwan.

[iv] Source: StatsAPEC, Retrieved on September 11, 2012.

[v] Natural disasters defined by the International Disaster Database includes Drought, earthquake (seismic activity), epidemic, extreme temperature, flood, insect infestation, mass movement dry, mass movement wet, storm, volcano, and wildfire.

[vi] East Asia area defined by the International Disaster Database includes China, Japan, Korea, Mongolia, and Taiwan.

[vii] Source: EM-DAT International Disaster Database, Retrieved on September 11, 2012.

[viii] Source: Choi et al (2011).

[ix] Indicated by the EIU Country Data as "percentage change in value added of industrial production over previous year".

[x] Source: EIU Country Data, Retrieved on September 12, 2012.

[xi] Source: Shih (2011).

[xii] Source: EIU Country Data, Retrieved on September 17, 2012.

[xiii] Source: TIER (2011).

[xiv] The ESI was calculated by examining global market shares of specific economies with Global Trade Analysis Project (GTAP) database. ESI lies between 0 and 1. When ESI closes to 0 means that the specific two economies have relatively more dissimilar exports structure implying more room for bilateral cooperation. When ESI closes to 1 means that the associated two economies have relatively more similar exports structure implying they are more likely to compete in global markets.

[xv] Source: APEC, 2009.

[xvi] Source: OECD Main Science and Technology Indicator & National Science Council, Taiwan.

[xvii] Source: OECD Main Science and Technology Indicator & National Science Council, Taiwan.

[xviii] Source: OECD Main Science and Technology Indicator & National Science Council, Taiwan.