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**Production Network Related Trade, Supply Chain Connectivity and FDI:
An Analysis of Asian Developing Countries**

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ABSTRACT

The paper examines production network related trade in manufacturing parts and components of Asian developing countries. There is significant heterogeneity among these countries with respect to the nature and intensity of involvement in production network related trade. The determinants of intensity of involvement in production network related trade have been examined using panel data tobit model during 2006-2012. The results suggest that supply chain connectivity and tariff significantly impact the intensity of participation in production network related trade. From the policy perspective, this indicates that improving supply chain connectivity, behind the border trade facilitation and reduction of tariff barrier could enhance the intensity of participation of Asian developing countries in production network in manufacturing parts and components. Nevertheless, the impact of FDI on intensity of participation in production network is not found to be significant, which could be due to ineffectiveness of investment promotion policy in the presence of infrastructure and tariff barriers.

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I. Introduction

Over the past decades, the external liberalization policies undertaken by developing countries have led to the growth in trade (exports and imports) as well as inflow and outflow of Foreign Direct Investment (FDI). More importantly, the nature of trade and FDI has undergone a change. The importance of network related trade and FDI has grown in importance than the one-way trade and FDI. To a considerable extent, participating in global value chains has become inevitable (Gereffi and Luo, 2014). However, there is significant heterogeneity among countries, in general, with respect to the involvement in production network related trade (see Athukorala, 2011; Athukorala and Nasir, 2012), which is led by East Asia and followed by a few other countries (in specific products) from the rest of the continents. Given the heterogeneity in the involvement in production network related trade, especially among developing countries, this paper tries to examine the factors that impact the intensity of participation of Asian countries in international production network.

Network related trade typically refers to the trade in parts and components. It also involves processing of imported parts and components, assembling, re-exporting, re-importing etc. Such trade is more commonly observed in certain industries such as machinery (e.g. electronics and automobile) than others.² However, the exact nature of nature of network related trade could vary across industries and depend on the factor endowment and specialization of the countries, among others.

There are several studies that examine the network related trade with focus on East Asia including China, especially in the automobile and electronics sector (Kimura and Ando, 2005; Athukorala and Yamashita, 2006; Athukorala, 2010; Athukorala and Menon, 2010; Kimura and Obashi, 2011; Amighini, 2012). However, the intensity of network related trade has been examined in fewer studies. Such studies on other Asian developing countries encompassing entire spectrum of manufacturing industries are sparse. In addition, although the conditions for production networks have been discussed previously, barring a few exceptions, there is lack of

² see Athukorala, 2005; Ando and Kimura, 2005; Ando, 2006; Kimura et al. 2007; Athukorala and Menon, 2010; Amighini, 2012; Okubo et al., 2014 for network trade of East Asian countries in specific products.

empirical econometric testing of these propositions. This paper is an attempt to address these gaps by analyzing intensity of network related trade (defined broadly, to include several sectors/industries in the manufacturing sector) of Asian developing countries. The intensity of network related trade is examined for the manufacturing sector that includes several products. These include products belonging to machinery and transport equipment including electrical machinery and road vehicles (SITC 7), miscellaneous manufactured articles (SITC 8), chemicals and related products (SITC 5), manufactured goods classified by material (SITC 6).

The intensity of network related trade has been defined in terms of outward processing trade (OPT) and inward processing trade (IPT). There is heterogeneity in the intensity of involvement in network related trade as captured by OPT and IPT. Since these measures are bounded, the empirical estimation of intensity of involvement in production network related trade has been carried out using censored tobit regression in a panel data econometric framework. The analysis of intensity of involvement in production network related trade shows that countries with better supply chain connectivity is more likely to involve in network related trade. Further, traditional trade barriers in the form of tariff also play a significant role in determining the intensity of participation of Asian developing countries in production network trade. Therefore, countries desirous of improving intensity of involvement in production network could take measures to reduce infrastructure and tariff barriers.

The rest of the paper is organized as follows. Section 2 discusses the methodology for estimating the determinants of intensity of participation in production network related trade. Section three presents the results of the empirical analysis. Section four concludes.

II. Methodology and Data

The nature and intensity of production network related trade has been represented by outward processing trade (OPT) and inward processing trade (IPT) in parts and components of the manufactured segment, which enable us to capture specific nature of participation in international production network by Asian countries.^{3 4} Outward processing trade (OPT) measures the extent to which a country outsource abroad, whereas inward processing trade (IPT) measures the extent to which a country carries out manufacturing activities on intermediate goods for other countries.

In particular,

$$OPT = \frac{\text{Re-import}}{\text{Total import}},$$

$$IPT = \frac{\text{Re-Export}}{\text{Total Export}}$$

Several determinants of network related trade are considered in the analysis. These determinants include index of international supply chain connectivity, trade liberalization captured by tariff rate, and inward and outward FDI stock relative to Gross Domestic Product (GDP).^{5 6}

Research on trade flows has extensively used some variant of the gravity model. The model is suitable for analyzing bilateral trade flows but has limited applicability when it comes to aggregate data. As this paper explores the intensity of involvement of Asian countries in network

³ Production networks trade has been represented in several forms e.g. export or/and import values in parts and components, intermediate goods imports and exports, outward or/and inward processing trade, among others (see Hummels et al. 2001; Athukorala, 2005; Kimura and Ando, 2005; Athukorala, 2010; Orefice and Rocha, 2014; Egger and Egger, 2005; Amighini, 2012). However, some of the measures may not capture the nature and intensity of production network related trade.

⁴ See Athukorala (2005), Ando and Kimura (2005), Ando (2006), Athukorala and Menon (2010), Orefice and Rocha (2014), Yamashita (2011, for Japan and the US) for analysis of parts and components trade.

⁵ Investment promotion policies are found to contribute to the emergence of international production networks (Cheewatrakoolpong et al., 2013).

⁶ Real effective exchange rate, technology level and a few other control variables could not be included due to fewer data points.

related (aggregate) trade in manufacturing parts and components, and mainly due to specific nature of the dependent variable (which has a lower bound of zero due to non-reporting or no involvement in network related trade, and a theoretical upper bound of one), censored tobit model in panel data setting has been used. The intensity of involvement in network related trade is estimated using the following two equations

$$OPT_{it} = \begin{cases} OPT_{it}^*, & \text{if } OPT_{it}^* > 0 \\ 0 & \text{if } OPT_{it}^* \leq 0 \end{cases} \dots\dots\dots(1)$$

$$OPT_{it}^* = \beta \times ISCC_{it} + \delta \times TARIFF_{it} + \gamma \times FDISTOCK_{it} + \alpha_i + \varepsilon_{it}$$

$$IPT_{it} = \begin{cases} IPT_{it}^*, & \text{if } IPT_{it}^* > 0 \\ 0, & \text{if } IPT_{it}^* \leq 0 \end{cases} \dots\dots\dots (2)$$

$$IPT_{it}^* = \beta \times ISCC_{it} + \delta \times TARIFF_{it} + \gamma \times FDISTOCK_{it} + \alpha_i + \eta_{it}$$

Where OPT^* and IPT^* are latent variables. OPT and IPT are observed when it is greater than a threshold. OPT and IPT are defined previously, $ISCC$ is international supply chain connectivity index, $TARIFF$ is average tariff rate imposed on manufactured goods, $FDISTOCK$ is the stock of inward and outward FDI relative to GDP of country i at time period t . These equations are estimated for the time period 2006-2012. The selection of time period has been constrained by data availability (see Appendix for the sample Asian countries used in the regression).

Trade values of parts and components (for the sample countries from the Asian region) are obtained from UN Comtrade using 5-digit Standard International Trade Classification (SITC) classification (see Appendix for details). The list of parts and components encompasses entire spectrum of manufacturing trade (Athukorala, 2010). The list contains 362 five-digit products. To measure the intensity of participation in production network, OPT and IPT are computed using the trade values of re-import, total import, re-export and total exports of parts and components obtained from UN Comtrade. The independent variables are obtained from UN ESCAP, UNCTAD, and World Development Indicators (the World Bank).

III. Results and Discussion

The measures of intensity of involvement in production network related trade (in manufacturing parts and components) are computed and plotted in Figure 1. It is observed that there is heterogeneity in the intensity of involvement in production network related trade. Some of the countries are found to have involved in production network related trade (in manufacturing parts and components) by both the measures (e.g. Macao, Thailand), whereas most of the other countries come to picture only in specific measure. OPT is observed for countries such as China, Indonesia, Malaysia, Thailand. In fact, China's intensity of OPT improved quite substantially over the last decade. On the other hand, IPT is commonly observed for most of the sample countries from the Asian region.

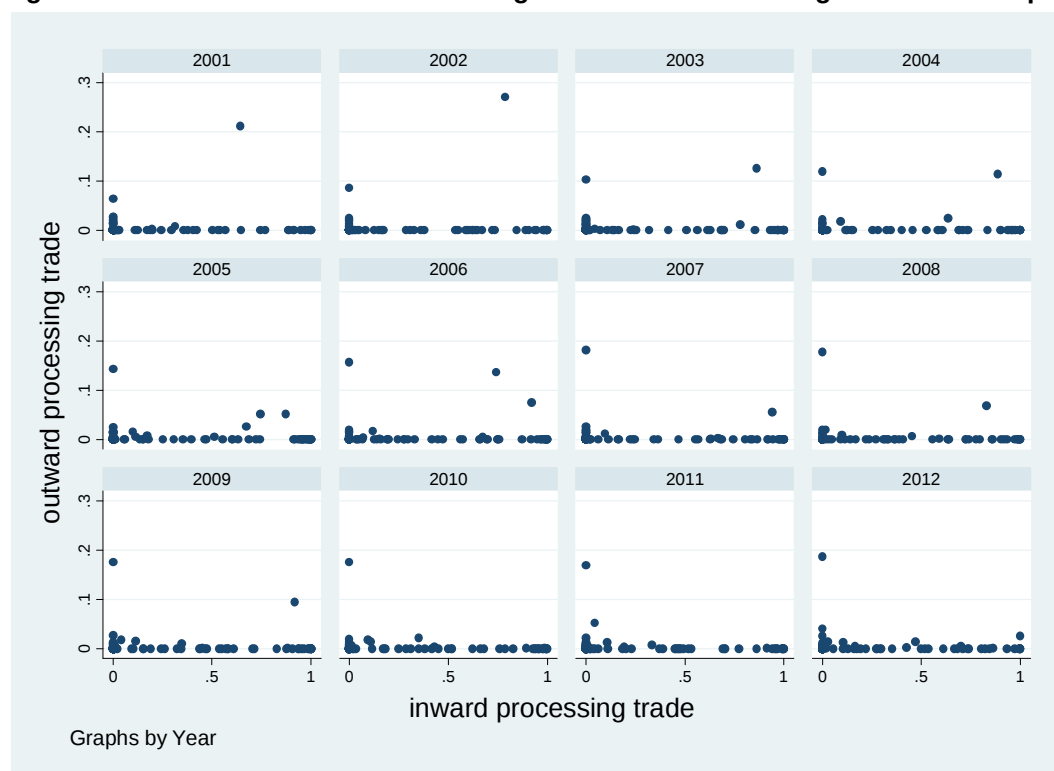
The cross-sectional relationship between intensity of involvement in production network related trade and supply chain connectivity index is presented in Figure 2 and Figure 3. A positive relationship can be observed between OPT and ISCC index (Figure 2), which indicates that better supply chain connectivity could facilitate participation in network related trade intensively. The relationship between IPT and ISCC is positive albeit for a segment of the sample (Figure 3). A positive relationship is suggestive especially after a country attains certain level of supply chain connectivity. Nevertheless, there could be other factors that determine a country's involvement in production network. The econometric approach designed in the previous section is expected to provide better insights as regards the impact of supply chain connectivity and other factors on the intensity of involvement in network related trade in manufacturing parts and components. The results of the econometric exercise are presented below (see Table 1 for descriptive statistics of the variables).

The results of the econometric analysis pertaining to equation (1) and (2) are presented in Table 2, which identify the significant determinants of network related trade in manufacturing parts and components. It can be observed that the determinants of network related trade vary by nature of participation (i.e. OPT and IPT). Nevertheless, the significant determinants of network related trade include supply chain connectivity and tariff. In particular, ISCC has positive and significant impact on OPT. On the other hand, higher tariff on manufactured goods significantly reduces the

network related trade as measured by IPT. The results hold with the use of alternative measures of tariff rate on manufactured products, namely the applied simple mean (Tariff_asm) and most favored nation simple mean (Tariff_mfnsm). The finding is in line with Brooks and Ferrarini (2014).⁷ However, FDISTOCK (inward and outward) did not turn out to be significant.

The results have pertinent implications for trade policy. In particular, improving supply chain connectivity, behind the border trade facilitation, and further reduction of tariff could enhance participation of Asian developing countries in international production network and global value chain. However, the investment promotion (inward and outward) policies could be ineffective in the presence of infrastructure (hard and soft) bottlenecks and trade barriers. Nevertheless, to enhance economic prosperity through trade, specific policy (or combination of policies) may be undertaken by the individual developing countries depending on the preferred nature and intensity of involvement in network related trade within the global value chain.

Figure 1: Outward and Inward Processing Trade in Manufacturing Parts and Components



Source: Author's compilation from UN Comtrade

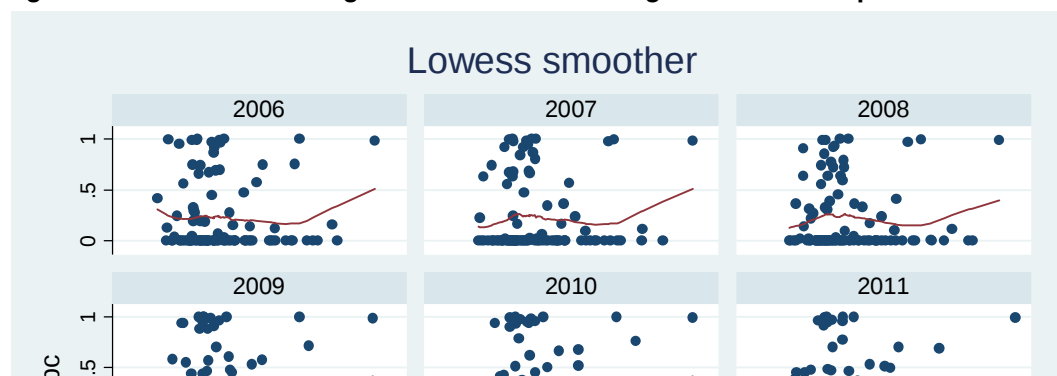
⁷ Processing trade among country pairs is promised on a lower tariff environment. In addition, network trade can be highly sensitive to even small tariffs due to thin margins (Athukorala, 2005).

Figure 2: Outward Processing Trade in Manufacturing Parts and Components and ISCC



Source: Author's compilation from UN Comtrade and UN ESCAP

Figure 3: Inward Processing Trade in Manufacturing Parts and Components and ISCC



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