Intermediate goods trade and CO_2 emission: A trade gravity study of East Asia

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Abstract

International production fragmentation has contributed to a rapid increase in trade in intermediate goods. Using panel data from East Asia from 1998 to 2010, this paper investigates the impact of CO_2 emission on international production fragmentation-induced trade in intermediate goods. I find that impact of CO_2 emission on the volume of trade in intermediate goods is positive and statistically significant. This conclusion also holds across different measures of trade in intermediate goods. Further evaluation, shows that the impact of CO_2 emission on intermediate goods trade varies significantly across developed and developing countries. This result confirms that level of economic development plays a crucial role in trade and CO_2 emission nexus.

Keywords: Intermediates trade; CO_2 emission; Trade and environment; East Asia

JEL: F18; Q56

1 Introduction

Increase in the pace of globalization in recent decades has resulted in international production fragmentation, which has contributed to a sharp increase in trade in goods and services (Antweiler and Trefler, 2002; Johnson and Noguera, 2012). A rapid increase in trade in intermediate goods is regarded as one of the most important reasons for the growth of world merchandise trade. According to a World Trade Organization (WTO) report, the share of manufactured intermediate goods, in non-fuel world trade, reached 55 percent in 2011 (WTO, 2013). The region of East Asia[1] accounts for a large proportion of trade in intermediate goods,

[1] East Asia is a geographical area that consists of Northeast Asia, Southeast Asia and nearby areas. The sample country of East Asia concerning in this study will be fully discussed in the next section.

which has played a leading role in its economic growth (Athukorala and Yamashita, 2006; Obashi, 2010; Okubo, Kimura and Teshima, 2014).

The relationship between trade and environment has received a fair share of attention in the existing studies (Grossman and Kruger, 1991; Copeland and Taylor, 2003; Kanemoto, et al., 2014). Despite sizable literature regarding to trade and environment, the link between environment and international production fragmentation-induced trade in intermediate goods stayed largely unsettled. Dean and Lovely (2010) suggested that increase in international production fragmentation-induced FDI has made a positive contribution to a decline in pollution intensity of China's trade. Benarroch and Weder (2006) investigated the connection between intra-industry trade in intermediate products and pollution in the context of international increasing return to scale in production. In a recent study, Swart (2013) considered the heterogeneity in production of intermediate producers. Swart argued that the impact of trade in intermediate inputs depends on the country's level of economic development. As far as the empirical studies are concerned, some country-level studies have focused on the link between trade in final goods and the environment, e.g., Shen (2006) and He and Wang (2012), et al.

The main objective of this paper is to extend the existing literature concerning trade and environment by focusing on international production fragmentation-induced growing trade in intermediate goods. The existing literature suggests that lax environmental policies which lead to high pollution can become a relative advantage in international trade, which is called 'pollution haven hypothesis' (Cole, 2004; Grether et al., 2012; Al-mulali and Foon Tang, 2013). This paper attempts to empirically test for the hypothesis 'high pollution as a result of lax environmental policy will lead to more trade' in the context of international production-induced trade in intermediate goods. I focus on East Asia which is one of the fastest growing but also highly polluted region because (i) this region has registered a sharp increase in trade in intermediate goods and (ii) only a few studies have focused on the link between trade and environment in this region.

In the existing studies concerning economic and pollution, the level of economic development has recognized as an important factor in determining environmental policy (Shen, 2006; Jiang, Lin and Zhuang, 2008; Carson, 2010). As suggested by environmental Kuznets curve (EKC) theory, as income grows the priority of government could transfer from economic development to environmental quality. In order to further explore the implication of economic development in the link between trade and pollution, the sample of East Asia countries will be

expanded and grouped into developed countries and developing countries. It will allow one to take the development level into account and get a better understanding about the determinants of trade in intermediate goods

The rest of the paper is structured as follows. The empirical estimation strategies and data are discussed in section 2. Section 3 presents the estimation results of East Asia as well as different country groups. Conclusions and further discussion are presented in Section 4.

2 Empirical strategies and data

The determinants of international trade have been debated for decades (Krugman, 1991; Deardorff, 1998; Limao and Venables, 2001; Novy, 2013). In recent years, a fair share of studies have focused on the influence of environment factors on international trade (Suri and Chapman, 1998; Cole, 2003, 2004; Lehmijoki and Palokangas, 2010). Based on the basic trade gravity model as well as the research objective of this paper, the baseline empirical model is set as follows:

$$Trade_{ij,t}^{k} = f(GDP_{i,t}, GDP_{j,t}, pollution_{\alpha t}, barriers_{p,} barriers_{p,t}, I_i, I_j year_t) \qquad (1)$$

where $Trade_{ijt}^{k}$ represents trade type k (for example intermediate imports, exports and aggregate) between country i and trading partner j in year t . GDP_{it} and GDP_{jt} measures the economic mass of country i and its trading partner country j, respectively. $pollution_{\alpha t}$ is a measure of pollution: when superscript k refers to exports, $pollution_{\alpha t}$ represents pollution level in country i, i.e., $pollution_{it}$, whereas when superscript k refers to imports, $pollution_{\alpha t}$ indicates pollution level of the trading partner j , i.e., $pollution_{jt}$. Based on literature about trade gravity model, control variables that captures the trade barrier can be grouped into constant trade barrier factors and time-varying trading barrier factors. $barrier_p$ measures the constant trading barriers such as common language, common border, distance between country i and its trading partner country j ; while $barrier_{pt}$ measures the time-varying trade barrier such as telephone penetration, which indicates the convenience of trade between two economies. Country dummy variables I_i, I_j are introduced because country dummy variable capture the features of each country therefore it is a simple solution for the measure of 'multilateral trade resistance (MTS)' proposed by Anderson and van Wincoop (2003). The estimation is based on fixed effect (FE)

model and random effect (RE) model of panel data estimation technique where country-pair represents the panel.

In the empirical study, the dependent variables are intermediate exports and imports as well as aggregate trade in intermediate goods which consist of imports and exports. Trade data are collected from UN ComTrade dataset and organized based on Classification by Broad Economic Categories (BEC). This study pays special attention to trade in intermediate goods, therefore it is important to properly measure the trade in intermediate goods. BEC is used to distinguish between intermediate goods trade from trade in final consumption goods. It is worth mentioning that BEC is not an independent classification system. Instead, it is based on information collected under SITC and data grouped by end-use in the System of National Account (SNA). In SNA, besides goods that cannot be classified, data on intermediate goods trade, consumption goods trade, and capital goods trade is included.[2] GDP is used as the measure of economic mass of each economy. Like most application of trade gravity model, distance, common language, and geographic neighbourhood are used as the trade barrier of two areas. Another proxy of trade barrier is the number of telephone line per 100 people in each country which measures the accessibility of telecommunication. Additionally, total CO_2 emission is used as the proxy of environmental input. The data concerning GDP, CO_2 emissions and number of telephone are collected from the World Data Bank (www.worldbank.org). Data of distance, common language and neighbourhood are collected from Penn World Table and CEPII dataset. All data are deflated to constant 2005 US dollars using the GDP deflator of the relevant country. Additionally, all variables used in empirical estimation, except for dummy variables, are in logarithms.

I use country level panel data from 1998 to 2010. The timeframe is chosen for two reasons: (i) international trade has grown rapidly since late 1990s in East Asia, especially in the less-developed economies of East Asia and (ii) the required data is only available from 1998. The sample countries are presented in Appendix 1. The sample includes countries from North East Asia (i.e., China, Japan, and Korea) as well as major countries ASEAN countries (Indonesia, Malaysia, Philippine, Singapore, Thailand, and Vietnam).[3] As indicated earlier, for

[2] The further information, please refer to the latest version of the BEC. This version was revised by United Nations Department of Economic and Social Affairs Statistics Division in 2011(https://unstats.un.org/unsd/class/intercop/expertgroup/2011/AC234-25.PDF).

[3] Due to unavailability of data, other countries in ASEAN area (such as Laos, Cambodia, Burma) have not been included in our sample. Additionally, the trade volume of the above economies is small and hence it is reasonable to ignore the effect of trade of these countries.

the comparison purposes, besides the data of major East Asian economies, the data from other economies are collected and grouped into developed and developing. The classification criteria is borrowed from the World Bank in that countries with GNP per capita higher than US$12,616 in 2012 are grouped as developed countries.

3 Estimation results

3.1 Estimation results of East Asia

Table 1 presents the estimated results of different model specifications that aim to test the determinants of trade in intermediate goods, considering environmental factor which is measured by *CO2* pollution. Given that variables are in the logarithmic form, the estimated coefficients measure the elasticity of determinants on trade. The results presented in Table 1 suggest that, after controlling for the country-pair effect by panel setting, pollution has a positive and statistically significant impact on the intermediate goods exports from East Asia. The estimated results presented in column 1 (i.e., Model 1) indicate that a 1 per cent increase in pollution leads to around 0.096 per cent increase in East Asia's intermediate goods exports. Model 2 in Table 1 shows that the trading partner's pollution has a positive and statistically significant impact on East Asian imports of intermediate goods. Specifically, 1 per cent increase in trading partner's pollution leads to 0.253 per cent increase in East Asia's import of intermediate goods. These results confirm that pollution of East Asia's trading partners makes a positive contribution to trade as measured by imports

In terms of the aggregate trade, as shown in the estimated Models 3, both country's CO2 emission and trading partner's CO2 emission have a significant and positive impact on aggregate trade in intermediate goods. This result is reasonable – aggregate trade in intermediate goods consists of exports and imports. Since pollution has positive and statistically positive impact on both exports and imports of intermediate goods, its impact on the sum of the two components must also be positive and statistically significant.

Table 1 Panel estimation of trade gravity model for East Asia

	Model 1		Model 2		Model 3	
	Intermediate exports		Intermediate imports		Intermediate trade	
	FE	RE	FE	RE	FE	RE
GDP	0.422***	0.421***	0.300***	0.300***	0.308***	0.308***
	-0.0656	-0.0656	-0.0555	-0.0554	-0.0498	-0.0497
Partner GDP	0.614***	0.614***	0.376***	0.375***	0.422***	0.422***
	-0.0654	-0.0654	-0.0594	-0.0593	-0.0519	-0.0518

CO2	0.0958**	0.0960**			0.193***	0.193***
	-0.0463	-0.0463			-0.0353	-0.0353
Partner CO2			0.253***	0.253***	0.372***	0.372***
			-0.0468	-0.0468	-0.0411	-0.0411
telephone	0.333***	0.333***	0.455***	0.454***	0.327***	0.327***
	-0.0368	-0.0368	-0.0291	-0.0291	-0.028	-0.0279
Partner telephone	0.226***	0.226***	0.163***	0.163***	0.111***	0.111***
	-0.0362	-0.0362	-0.0341	-0.034	-0.0298	-0.0298
Common language		-0.0548		-0.00392		-0.0284
		-0.21		-0.201		-0.157
Neighbourhood		0.348		0.212		0.274
		-0.239		-0.229		-0.178
Distance		-0.36***		-0.379***		-0.373***
		-0.114		-0.109		-0.0845
Country individual dummy	Yes	Yes	Yes	Yes	Yes	Yes
Trading partner individual dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-8.941***	-6.952**	-1.612	1.531	-5.761***	0
	-2.444	-2.741	-2.119	-2.423	-1.857	0
Observations	1,364	1,364	1,364	1,364	1,364	1,364
R-squared	0.774		0.815		0.853	
Number of country-pair	108	108	108	108	108	108
Hausman test	Prob > chi2 =1.0000		Prob > chi2 = 0.9998		Prob > chi2 = 0.9997	

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
All variable except for dummy variables are estimated in logarithm.

The estimated results presented in Table 1 also suggest that, a country as well as its trading partner's GDP have a positive and statistically significant impact on trade in East Asia. This conclusion is robust across alternative measures of trade. This implies that the size of the economies, as suggested by the traditional trade gravity theory, is an important determinant of trade. Telephone penetration of a country and its trading partner also makes a positive and statistically significant contribution to trade in East Asia. This result confirms the importance of modern telecommunication in prompting international trade. It seems that the impact of time-invariant factors such as a common language and shared border on trade in East Asia is insignificant. While the distance between two countries is an important determinant of trade, as the estimated coefficients of the distance in Table 1 are all negative and significant.

3.2 Estimation results of different country groups

The empirical results concerning panel data estimation of the case of the developed and developing countries, respectively, are presented in Table 2. This allows one to examine whether or not the impact of CO_2 pollution on trade in intermediate goods is affected by the level of economic development. By doing so, I am able to test for the role of economic development in environment-trade nexus, which is one of the main concerns of this paper.

The empirical results presented in Table 2 reveal that higher pollution leads to significant decline in intermediate goods exported from developed countries. The estimated coefficient of CO_2 in Model 1 of developed countries suggests that a 1 per cent increase in pollution leads to 0.115 per cent decrease in intermediate goods exported from developed countries. The result is somewhat surprising because pollution, in theory, is viewed as a type of input used in the production process, which is associated with an increase in production and hence exports. However, developed countries tend to adopt a relatively stricter environmental policy to control pollution. Ceteris paribus, strict environmental policy arising from rising pollution will decrease production and hence the exports of intermediate goods. This explanation is consistent with the results of developing counties reported in Table 2. The coefficient of CO_2 of Model 1 for developing countries suggests that a 1 per cent increase in pollution in developing countries leads to 1.168 per cent increase in the exports of intermediate goods from developing countries. As compared to the developed countries, the government environmental policy is relatively lax in developing countries. As economic growth is the main priority of developing countries, higher pollution does not change the way environmental policy is implemented and hence the industrial output remains largely unaffected.

The empirical results presented in Table 2 suggest that pollution of the trading partners can have a positive and statistically significant impact on the intermediate goods imports. This conclusion holds for both country groups. This result is not surprising. As the production process becomes more pollution intensive, it makes sense for both developed and developing countries to import such goods.

The empirical results presented in Tables 2 also highlight the role of GDP on intermediate goods trade. The impact of GDP on intermediate goods exports is positive and significant in the case of developed countries. However, in the case of developing countries, this relationship is statistically insignificant. This result could be explained by the fact that, in the early stages of economic development, developing countries tend to adopt export-oriented

industrialization (EOI) policy. This leads to high growth in export-oriented sector, which is not proportional to the country's economic mass. Another interesting point is, while accessibility of telephone is an important determinant of developing country's exports, its impact on developed country exports is insignificant, which could be attributed to the increased reliance on the internet in developed countries. Like the estimated results for East Asia, the impact of common language and neighbourhood on trade in the case of both developed and developing countries is statistically insignificant. However, distance between trading partners is an important determinant of trade.

Table 2 Panel estimation of trade gravity model for different country groups

	Developed countries						Developing countries					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
Independent variables	Dependent variables						Dependent variables					
	Intermediate exports		Intermediate imports		Intermediate trade		Intermediate exports		Intermediate imports		Intermediate trade	
	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE
GDP	0.529***	0.529***	0.314***	0.314***	0.451***	0.451***	0.0852	0.0850	0.879***	0.880***	0.219**	0.220**
	(0.0644)	(0.0642)	(0.0571)	(0.0570)	(0.0529)	(0.0528)	(0.124)	(0.124)	(0.111)	(0.111)	(0.0974)	(0.0972)
Partner GDP	0.692***	0.692***	0.377***	0.377***	0.472***	0.472***	0.622***	0.622***	0.382***	0.382***	0.419***	0.419***
	(0.0647)	(0.0645)	(0.0614)	(0.0613)	(0.0560)	(0.0559)	(0.0744)	(0.0743)	(0.0784)	(0.0782)	(0.0606)	(0.0605)
CO2	-0.115**	-0.115**			0.377***	0.377***	1.168***	1.168***			1.217***	1.216***
	(0.0496)	(0.0494)			(0.0444)	(0.0443)	(0.112)	(0.112)			(0.0883)	(0.0881)
Partner CO2			0.234***	0.233***	0.0211	0.0212			0.322***	0.322***	0.398***	0.398***
			(0.0485)	(0.0484)	(0.0409)	(0.0408)			(0.0611)	(0.0609)	(0.0473)	(0.0472)
telephone	0.0268	0.0265	0.860***	0.860***	0.392***	0.391***	0.166***	0.166***	0.254***	0.254***	0.117***	0.117***
	(0.155)	(0.155)	(0.130)	(0.130)	(0.128)	(0.127)	(0.0381)	(0.0380)	(0.0372)	(0.0371)	(0.0300)	(0.0299)
Partner telephone	0.260***	0.260***	0.201***	0.200***	0.117***	0.117***	0.242***	0.242***	0.196***	0.196***	0.133***	0.133***
	(0.0344)	(0.0343)	(0.0334)	(0.0333)	(0.0305)	(0.0304)	(0.0422)	(0.0421)	(0.0468)	(0.0467)	(0.0362)	(0.0362)
Common_language		-0.0534		-0.398		-0.205		-0.397		-0.0922		-0.230
		(0.245)		(0.262)		(0.202)		(0.261)		(0.276)		(0.214)
Neighbour		0.237		0.106		0.167		0.311		0.0476		0.168
		(0.519)		(0.554)		(0.426)		(0.294)		(0.311)		(0.241)
distance		-0.589***		-0.466***		-0.521***		-0.372**		-0.503***		-0.444***
		(0.150)		(0.161)		(0.124)		(0.173)		(0.183)		(0.142)
Country individual dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Trading partner individual dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-10.33***	-6.225**	-3.764	-0.351	-9.354***	-5.190**	-13.91***	-13.43***	-17.30***	0	-16.41***	0
	(2.654)	(2.976)	(2.286)	(2.735)	(2.182)	(2.447)	(3.471)	(3.975)	(3.534)	(0)	(2.735)	(0)
Observations	896	896	896	896	896	896	1,058	1,058	1,058	1,058	1,058	1,058
R-squared	0.760		0.781		0.822		0.812		0.805		0.873	
Number of country-pair	72	72	72	72	72	72	84	84	84	84	84	84
Hausman test	Prob>chi2 = 1.0000		Prob>chi2 = 1.0000		Prob>chi2 = 1.0000		Prob>chi2 = 1.0000		Prob>chi2 = 1.0000		Prob>chi2 = 1.0000	

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
All variable except for dummy variables are estimated in logarithm.

4. Conclusions

Recent decades have witnessed a sharp increase in trade in intermediate goods, which can be attributed to increased international production fragmentation. This paper focuses on the impact of CO_2 emission on trade in intermediate goods. The empirical analysis presented in this paper is based on panel data from East Asia. East Asia is selected for a case study because this region accounts for a very large proportion of the worldwide trade intermediate goods. In order to estimate the influences of CO_2 emission on trade in intermediate goods, alternative measures of trade (i.e., import, export and aggregate trade) are used. In order to examine the role of the level of economic development, the initial sample was extended to include some important non-East Asian economies. The empirical analysis presented in this paper is based on an extended trade gravity model.

The estimation results suggest that CO_2 emission does have a significant impact on the volume of trade in intermediate goods. This result holds across alternative measures of trade in intermediate goods. For East Asia countries, country's CO_2 emission has positive and significant impact on its exports of intermediate goods, while trading partner's CO_2 emission has positive and significant impact on the imports of intermediate goods. . This result supports the view that CO_2 emission can be regarded as an input in the production process in East Asia.

The estimation based on different country groups shows that the impact of CO_2 emission on intermediate goods trade varies significantly across the developed and developing countries. An increase in CO_2 emission decreases intermediate good exports from developed countries. In contrast, in the case of the developing country group, higher CO_2 emission leads to an increase in intermediate good exports. This result highlights the differences in environmental policies across developed and developing countries, where the priority of the developing countries is economic growth but the priority of developed countries is less pollution.

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Appendix 1: Country classification

Group 1: East Asia	Group 2: Developed	Group 3: Developing
China	Japan	China
Japan	Korea	India
Korea	Singapore	Indonesia
Indonesia	USA	Malaysia
Malaysia	Australia	Thailand
Thailand	Euro area	Vietnam
Singapore		Philippines
Vietnam		
Philippines		

Classification: GNP per capita USD 12,616 in 2012