KIEP Working Paper 16-09

# Comparative Advantage of Value Added in Exports: The Role of Offshoring and Transaction Costs

CHOI Nakgyoon and PARK Soonchan

Korea Institute for International Economic Policy

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# Executive Summary

This study tests whether Ricardian comparative advantage is valid for value added in exports that does not include intermediate inputs imported from various industries in a number of countries. Using a panel data on valued added contents of bilateral exports, we find that changes in the labor productivity lead to growth of value added in exports. This implies that Ricardian comparative advantage is an important determinant of exports in longitudinal changes. The estimated coefficients of the observed productivity turn out to be larger than those of CDK (2012), implying that Ricardian comparative advantage has greater influence on determining the patterns of trade in a world with global value chains.

This study also investigates the role of offshoring and transaction costs in comparative advantage. We use data on value added in exports, offshoring in materials and services, and transaction costs at the country and industry-level for the period 1995-2009 calculated from World Input-Output Table which covers 40 countries and 14 manufacturing industries. Employing a system GMM estimator to alleviate the potential endogeneity problem, we find that services offshoring has positive effects on comparative advantage while material offshoring affects it negatively. We also find that transaction costs have a negative effect on comparative advantage. Moreover, it turned out that there is a magnification effect of transaction costs on the induced value added in exports.

**Keywords**: Value Added in Exports, Offshoring, Transaction Costs

**JEL Classification**: F12, F14

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# Comparative Advantage of Value Added in Exports: The Role of Offshoring and Transaction Costs

CHOI Nakgyoon* and PARK Soonchan†

## 1. Introduction

Recent studies reveal that assembly and production in global value chains does not contribute to the value added in exports to a substantial degree, but design, R&D, and post-production services occupy more shares of the value added in exports. The composition of value added in exports becomes more important, as companies have located their factories at any place in the world to maximize their profits. The flow of gross export itself does not provide sufficient information on comparative advantage of an industry. It is because the share of domestic value added in gross exports tends to shrink when foreign intermediate inputs contributes more to value added in gross exports. The export performances have been determined by which tasks along global value chains a firm can participate in.

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Thus we need to investigate whether the standard theories of comparative advantage are still valid for value added in exports. Previous literature obtains the gross value added by deducting the intermediate inputs from the total output. It includes the transaction costs such as net taxes on products in the gross value added, which represent about 3 percent of world total input from 1995 to 2011 on average. The inclusion of the transaction costs in the value added in exports, however, overvalues the economic benefit for the business sectors which motivates the international production fragmentation.

In addition, transactions costs are closely related to the production efficiency at the industry level, which can be an institutional source of comparative advantage (Chor 2010). Recent studies pay more attention to the effects of domestic institutions on comparative advantage. They include contracting institution (Nunn 2007), property-rights institutions (Levchenko 2007), financial development (Manova 2013), labor-market-related institutions (Costinot 2009; Cunat and Melitz 2012; Helpman and Itskhoki 2010). Aside from these institutions, transaction costs also are an important institutional aspect which may affect comparative advantage. An industry of a country with high tax rates relative to other industry in other country, for example, has to bear disadvantage in production costs. Thus differences in transaction costs across country and industry have profound effects on the patterns of trade. This issue is closely related with indirect channel of comparative advantage through trade policy.[1]

To address the above-mentioned lacuna of the previous studies, this paper tests whether transaction costs are a determinant of comparative advantage in global value chains. To this end, it obtains the net value added accruing to the factor owners by deducting the transaction costs including product tax, subsidies, and international transport margins as well as the intermediate inputs from the total output.

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[1] Nunn and Trefler (2010) show that countries with poor domestic institutions also tend to have tariff structures that are biased toward less skill-intensive industries, which in turn through a dynamic process reduces a country's comparative advantage in skill-intensive industries.

On the other hand, offshoring, sourcing of intermediate inputs from abroad, is a prominent feature of the global value chains. Although offshoring is not a new phenomenon, the rise of public attention is due to the structural change in offshoring and the fear of job losses. What is new about offshoring nowadays is that it is increasingly in services, while offshoring has for a long time meant only the sourcing of material inputs from abroad. Moreover, when the intermediate inputs are produced in foreign countries rather than at home, the concerns are that jobs at home will be lost.

An examination of offshoring as a source of comparative advantage is closely related to its productivity effects. Previous literature on offshoring including Amiti and Wei (2009), Görg *et al.* (2008), Egger and Egger (2006), and Schwörer (2013) examined its productivity effects, but does not study offshoring as source of comparative advantage. Most existing studies on impacts of offshoring are primarily concerned with addressing labor market issues, maybe due to the fear of job losses and wage reduction in the public media.

Little attention has been paid to the effects of offshoring on domestic value added and production in the previous literature. In present paper, we do not attempt to provide a theoretical model for the relation of offshoring and domestic value added or value added in exports. Instead, we employ an empirical analysis to see if offshored inputs and domestic value added are substitute or complementary.

Specifically, this study investigates the relationship between comparative advantage and value added in exports focusing on the following two issues. First, we examine the validity of Ricardian comparative advantage for value added in exports rather than gross exports. As deepening global value chains allows goods and services to cross border many times, gross value of exports includes foreign intermediates and consequently does not reflect the pure domestic production. Second, we investigate the role of offshoring and transaction costs in productivity differences. Put differently, we assess whether offshoring and transaction costs are important sources of comparative advantage, controlling for various channels of comparative advantage such as factor endowments and contracting institution.

This paper is organized as follows. In Section 2, we construct data sets including net value added in exports, offshoring, and transaction, decomposing the gross exports into its value added components. In section 3, we test if the Ricardian comparative advantage is valid for value added in exports, employing the first-difference approach as well as IV techniques to deal with an endogeneity bias. Section 4 analyzes the determinants of value added in exports focusing on the role of offshoring and transaction costs, controlling for Heckscher-Ohlin variables and an institution factor on which the bulk of the data are directly obtained from our created database. Section 5 concludes.

# 2. Construction of Data Sets

This paper uses the World Input Output Tables which contains the information on 40 countries and 35 industries (See Appendix 1). The data set covers the time span during 1995-2011. It uses the data on gross export and gross output by industry at current basic prices, gross value added at current basic prices, proportion of material and services offshoring. We extract the data on number of persons engaged, gross fixed capital formation, total hours worked by persons engaged, hours worked by high-skilled persons engaged, hours worked by medium-skilled persons engaged, and hours worked by low-skilled persons engaged from the WIOD Database.

## 2-1. Deriving Net Value Added in Exports

The GTAP database provides the international input-output data based on agents' price as well as market price. The OECD TiVA database provides the output data based on the basic price while it provides the data on total intermediate inputs based on the purchasers' price. On the contrary, the World Input-output database is consistently constructed on the basis of basic price instead of purchasers' price. It contains the data on net product tax, which is obtained by deducting subsidy from product taxes, and international transport margins separately from the gross value added and total intermediate input.

Thus, this study decomposes the value added in gross exports into its components including domestic value added and foreign value added, using World Input-Output Database (WIOD) and Socio Economic Accounts (SEA) which covers 40 countries and 35 industries. It applies the methodology suggested by Koopman, Wang, and Wei (2010, 2014), Johnson and Noguera (2012a, 2012b), Noguera (2012), Kowalski (2014), Stehrer (2013), Choi and Park (2015) thereby decomposing gross exports into value added components by source.

This paper applies the methodology of input output analysis to derive the net value added in exports. If there is assumed to be *m* countries, then total output ($X^k$) is composed of intermediate input ($X^{kl}$) and final demand ($Y^k$) as follows:

$$x=\begin{bmatrix}X^1\\X^2\\ \vdots\\X^m\end{bmatrix}=\begin{bmatrix}X^{11} & X^{12} & \cdots & X^{1m}\\X^{21} & X^{22} & \cdots & X^{2m}\\ \vdots & \vdots & \ddots & \vdots\\X^{m1} & X^{m2} & \cdots & X^{mm}\end{bmatrix}+\begin{bmatrix}Y^1\\Y^2\\ \vdots\\Y^m\end{bmatrix}$$

$$=\begin{bmatrix}\sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{11} & \sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{12} & \cdots & \sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{1m}\\ \sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{21} & \sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{22} & \cdots & \sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{2m}\\ \vdots & \vdots & \ddots & \vdots\\ \sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{m1} & \sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{m2} & \cdots & \sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{mm}\end{bmatrix}+\begin{bmatrix}\sum_{i=1}^{n}Y_{i}^{11} & \sum_{i=1}^{n}Y_{i}^{12} & \cdots & \sum_{i=1}^{n}Y_{i}^{1m}\\ \sum_{i=1}^{n}Y_{i}^{21} & \sum_{i=1}^{n}Y_{i}^{22} & \cdots & \sum_{i=1}^{n}Y_{i}^{2m}\\ \vdots & \vdots & \ddots & \vdots\\ \sum_{i=1}^{n}Y_{i}^{m1} & \sum_{i=1}^{n}Y_{i}^{m2} & \cdots & \sum_{i=1}^{n}Y_{i}^{mm}\end{bmatrix}$$

$$=\begin{bmatrix}\left\{\sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{11}+\sum_{i=1}^{n}Y_{i}^{11}\right\} & \left\{\sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{12}+\sum_{i=1}^{n}Y_{i}^{12}\right\} & \cdots & \left\{\sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{1m}+\sum_{i=1}^{n}Y_{i}^{1m}\right\}\\ \left\{\sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{21}+\sum_{i=1}^{n}Y_{i}^{21}\right\} & \left\{\sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{22}+\sum_{i=1}^{n}Y_{i}^{22}\right\} & \cdots & \left\{\sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{2m}+\sum_{i=1}^{n}Y_{i}^{2m}\right\}\\ \vdots & \vdots & \ddots & \vdots\\ \left\{\sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{m1}+\sum_{i=1}^{n}Y_{i}^{m1}\right\} & \left\{\sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{m2}+\sum_{i=1}^{n}Y_{i}^{m2}\right\} & \cdots & \left\{\sum_{i=1}^{n}\sum_{j=1}^{n}X_{ij}^{mm}+\sum_{i=1}^{n}Y_{i}^{mm}\right\}\end{bmatrix} \quad (1)$$

The input coefficient matrix (A), which shows the input-output relations of output in *k*th country to *l*th country, is obtained by dividing the intermediate inputs by total output of *k*th country. It can be represented by inverse matrix of input coefficient matrix, B, namely, $(I\text{-}A)^{-1}$.

$$\begin{bmatrix} X^1 \\ X^2 \\ \cdot \\ \cdot \\ X^m \end{bmatrix} = \begin{bmatrix} A^{11} & A^{12} & \cdots & A^{1m} \\ A^{21} & A^{22} & \cdots & A^{2m} \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ A^{m1} & A^{m2} & \cdots & A^{mm} \end{bmatrix} \begin{bmatrix} X^1 \\ X^2 \\ \cdot \\ \cdot \\ X^m \end{bmatrix} + \begin{bmatrix} Y^1 \\ Y^2 \\ \cdot \\ \cdot \\ Y^m \end{bmatrix}$$

$$= \begin{bmatrix} B^{11} & B^{12} & \cdots & B^{1m} \\ B^{21} & B^{22} & \cdots & B^{2m} \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ B^{m1} & B^{m2} & \cdots & B^{mm} \end{bmatrix} \bullet \begin{bmatrix} Y^1 \\ Y^2 \\ \cdot \\ \cdot \\ Y^m \end{bmatrix} \qquad (2)$$

The net value added in exports (VAX) can be explained by the diagonal matrix of value added coefficients, the inverse matrix, B, and the off-diagonal matrix of X as follow:

$$\mathrm{VAX} = \begin{bmatrix} V^1 & 0 & \cdots & 0 \\ 0 & V^2 & \cdots & 0 \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ 0 & 0 & \cdots & V^m \end{bmatrix} \bullet \begin{bmatrix} B^{11} & B^{12} & \cdots & B^{1m} \\ B^{21} & B^{22} & \cdots & B^{2m} \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ B^{m1} & B^{m2} & \cdots & B^{mm} \end{bmatrix} \bullet$$

$$\begin{bmatrix} 0 & \left\{\sum_{i=1}^{n}\sum_{j=1}^{n} X_{ij}^{12} + \sum_{i=1}^{n} Y_i^{12}\right\} & \cdots & \left\{\sum_{i=1}^{n}\sum_{j=1}^{n} X_{ij}^{1m} + \sum_{i=1}^{n} Y_i^{1m}\right\} \\ \left\{\sum_{i=1}^{n}\sum_{j=1}^{n} X_{ij}^{21} + \sum_{i=1}^{n} Y_i^{21}\right\} & 0 & \cdots & \left\{\sum_{i=1}^{n}\sum_{j=1}^{n} X_{ij}^{2m} + \sum_{i=1}^{n} Y_i^{2m}\right\} \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ \left\{\sum_{i=1}^{n}\sum_{j=1}^{n} X_{ij}^{m1} + \sum_{i=1}^{n} Y_i^{m1}\right\} & \left\{\sum_{i=1}^{n}\sum_{j=1}^{n} X_{ij}^{m2} + \sum_{i=1}^{n} Y_i^{m2}\right\} & \cdots & 0 \end{bmatrix} \qquad (3)$$

Koopman *et al.* (2014) indicated that the exports of intermediated goods by country *k* to country *l* induce the value added of country *k* directly as well as indirectly as follows. When country *l* processes the exports of intermediate goods of country *k* to country *l*, the exports of the processed products by country $l$ can be decomposed into (1) the exports of country $l$ to country $k$ (2) the exports of country $l$ to the third country.

As the exports of the processed products by country $l$ are basically the exports of country $k$ to country $l$, the decomposition decomposes the domestic value added in intermediates re-exported to third countries, domestic value added in intermediates that returns via final and intermediate imports, and the double counted exports as follows.

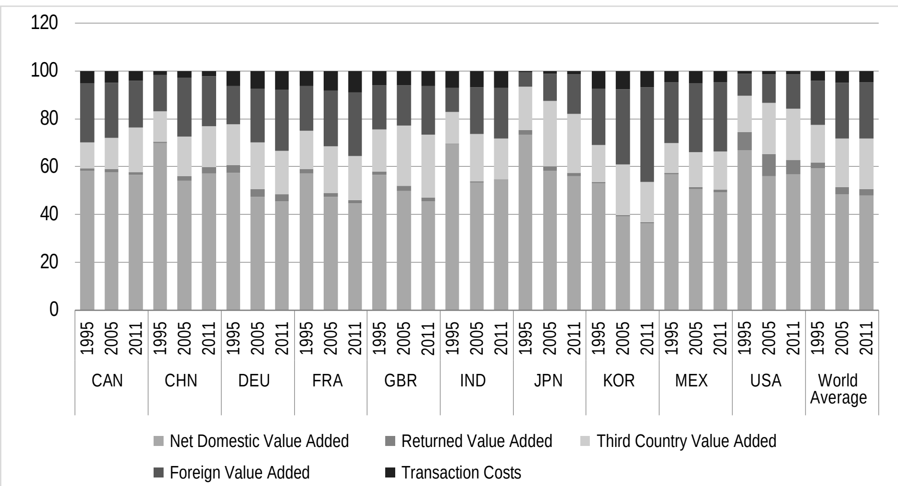
$$
\begin{aligned}
\mathrm{VAX}^{kl} = {} & \mathrm{V}^{k} \bullet \mathrm{B}^{kk} \bullet \left\{ \sum_{i=1}^{n} \sum_{j=1}^{n} \mathrm{X}_{ij}^{kl} + \sum_{i=1}^{n} \mathrm{Y}_{i}^{kl} \right\} \\
& + \mathrm{V}^{k} \bullet \mathrm{B}^{kl} \bullet \left\{ \sum_{i=1}^{n} \sum_{j=1}^{n} \mathrm{X}_{ij}^{lk} + \sum_{i=1}^{n} \mathrm{Y}_{i}^{lk} \right\} \\
& - \mathrm{V}^{k} \bullet \mathrm{B}^{kl} \bullet \left\{ \sum_{i=1}^{n} \sum_{j=1}^{n} \mathrm{X}_{ij}^{lk} + \sum_{i=1}^{n} \mathrm{Y}_{i}^{lk} \right\} \\
& + \sum_{p \neq k,l}^{n} V^{k} \bullet \mathrm{B}^{kl} \bullet \left\{ \sum_{i=1}^{n} \sum_{j=1}^{n} \mathrm{X}_{ij}^{lp} + \sum_{i=1}^{n} \mathrm{Y}_{i}^{lp} \right\} \\
& - \sum_{p \neq k,l}^{n} V^{k} \bullet \mathrm{B}^{kl} \bullet \left\{ \sum_{i=1}^{n} \sum_{j=1}^{n} \mathrm{X}_{ij}^{lp} + \sum_{i=1}^{n} \mathrm{Y}_{i}^{lp} \right\} \\
& + \mathrm{V}^{l} \bullet \mathrm{B}^{lk} \bullet \left\{ \sum_{i=1}^{n} \sum_{j=1}^{n} \mathrm{X}_{ij}^{kl} + \sum_{i=1}^{n} \mathrm{Y}_{i}^{kl} \right\} + \cdots \\
& + \mathrm{V}^{m} \bullet \mathrm{B}^{mk} \bullet \left\{ \sum_{i=1}^{n} \sum_{j=1}^{n} \mathrm{X}_{ij}^{kl} + \sum_{i=1}^{n} \mathrm{Y}_{i}^{kl} \right\}
\end{aligned}
\tag{4}
$$

Where $\mathrm{V}^{k} \bullet \mathrm{B}^{kl} \bullet \{\sum_{i=1}^{n} \sum_{j=1}^{n} \mathrm{X}_{ij}^{lk} + \sum_{i=1}^{n} \mathrm{Y}_{i}^{lk}\}$ represents the domestic value added in intermediates that returns via intermediate and final imports. $\sum_{p \neq k,l}^{n} V^{k} \bullet \mathrm{B}^{kl} \bullet \{\sum_{i=1}^{n} \sum_{j=1}^{n} \mathrm{X}_{ij}^{lp} + \sum_{i=1}^{n} \mathrm{Y}_{i}^{lp}\}$ represents the domestic value added in intermediates re-exported to third countries.

When we decompose gross exports into its components including domestic value added and foreign value added, the share of domestic value added tends to be smaller during the period from 1995 to 2011 (See Figure 1). When we sum up the net domestic value added, domestic valued added re-exported to third countries, and domestic value returned through imports, the world average of the percentage of domestic value added in gross exports decreased from 77.5% in 1995 to 71.7% in 2011. Specifically, most of the countries including Korea (-15.5%), Japan (-11.2%), India (-11.2%), Germany (-11.0%), China (-6.0%), and USA (-5.5%) turned out as having experienced substantial drops in the share of domestic value added.[2]

**Figure 1. Decompostion of Gross Exports**

(Unit : %)




Source: Author's calculation using World Input Output Tables.

[2] Results in previous studies including Stehrer (2013) indicate the similar trends of gross domestic and foreign value added in exports. See also Choi and Park (2015).

## 2-2. Offshoring

Amiti and Wei (2009) suggest that there are at least five possible channels through which offshoring can affect productivity: (i) a static efficiency gain; (ii) restructuring; (iii) learning externalities; (iv) variety effects; and (v) R&D investment.[3] First, a static efficiency gain is generated when firms relocate their relatively inefficient production processes to overseas locations and focuses on their core activities that are still competitiveness, so the specialization of firms and their average productivity increases. Second, offshoring may induce firms to restructure in a way that drives the technology frontier outward and reorganize the way in which tasks are combined or to improve the communication and reporting system between departments. Amiti and Wei (2009) argue that this is more likely to arise from offshoring of service inputs rather than offshoring of material inputs. Third, learning externalities may be generated due to the interaction with foreign suppliers. For instance, mutual interaction may enable workers in offshoring firms to learn about new software packages. Fourth, productivity arises due to the use of new material or service input varieties or their high quality. Fifth, Glass and Saggi (2001) argue that offshoring to low wage countries lowers the marginal production costs and raises profits, which creates incentives for additional R&D investments.

Assuming perfect complementarity between tasks, Grossman and Rossi-Hansberg (2008) show that wages of unskilled workers may increase if the productivity effect induced by offshoring is large enough to offset the other negative effects. Mitra and Ranyan (2010) also show that the positive productivity effect of offshoring may decrease unemployment. The key to the unemployment reducing effect of offshoring is the positive productivity effect of offshoring due to a complementarity between the offshored input and the domestically procured input. In contrast, Ranjan (2013) presents a model where

[3] See also Schwörer (2013).

offshored input and domestic labor are perfect substitutes and shows that offshoring is going to increase unemployment. He also identifies increasing effects of offshoring on unemployment go through when the elasticity of substitution is high. However, for lower elasticity of substitution increased offshoring is associated with reduced unemployment.

Since offshoring makes it possible for offshoring firms to source the intermediate inputs at lower costs and to relocate its relatively inefficient activities to foreign countries, offshoring increases productivity of these firms. Offshoring also induces tougher competition within industry that forces competing firms to save costs and some firms with least productivity to exit the markets. Thus offshoring contributes to an average productivity increase at the industry levels.

However, increase in the sectoral productivity does not mean increase in output and domestic value added at the industry level. These productivity effects could lead to a decrease in domestic value added since production of the intermediate inputs offshored move to foreign countries. Also, lower prices of imported intermediates could result in substitution away from domestic inputs. Alternatively, offshoring could lead to an increase in domestic value added because of scale effects. As offering firms become more competitive, demand for their goods could rise and hence increase in output and domestic value added. Therefore, the net effect is ambiguous.

Though these theoretical models do not present the direct impacts of offshoring on domestic value added and value added in exports, they can be extended to the relationship between offshored input and domestic value added. If labor demand is proportional to domestic value added,[4] then the relationship between offshored inputs and domestic labor can be translated into that be-

[4] The stability of the labor share of income has been a fundamental feature of macroeconomic models. Karabarbounis and Neiman (2013) show, however, that the global labor share has significantly declined since the early 1980s. In this paper, we do not attempt to provide a theoretical model for the relation between offshoring and domestic value added or value added in exports. This remains for future research.

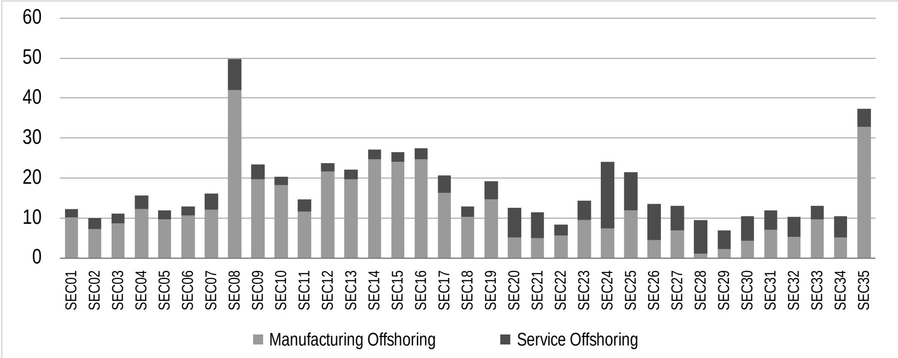
tween offshored inputs and domestic value added: if offshored inputs and domestic labor are substitute (complementary), offshored inputs and domestic value added are also substitute (complementary). Therefore, the impacts of offshoring on domestic value added could depend on whether offshored input and domestic value added are substitutable or complementary. The substitution (complementarity) relation between offshored intermediate inputs and domestic value added is more likely to lead to a (an) decrease (increase) in value added in exports.

In order to estimate the impacts of offshoring on value added in exports, we obtain the data on the proportion of offshoring by dividing foreign intermediate inputs by total intermediate inputs. As we can see in Appendix 1, the 35 sectors in the WIOD are classified into manufacturing sectors (SEC01 – SEC16) and service sectors (SEC17 – SEC35).

Figure 2 indicates that shares of offshoring in manufacturing sectors are higher than agriculture and services sectors. The share of offshoring in SEC08 (Coke, refined petroleum and nuclear fuel) turns out to be the highest followed by SEC35 (Private households with employed persons), SEC16 (Manufacturing, not elsewhere classified; recycling), SEC14 (Electrical and optical equipment), and SEC15 (Transport equipment).

**Figure 2. Share of Offshoring in Total Inputs, 2011**

(Unit : World Average, %)




Source: Author's calculation using World Input Output Tables.

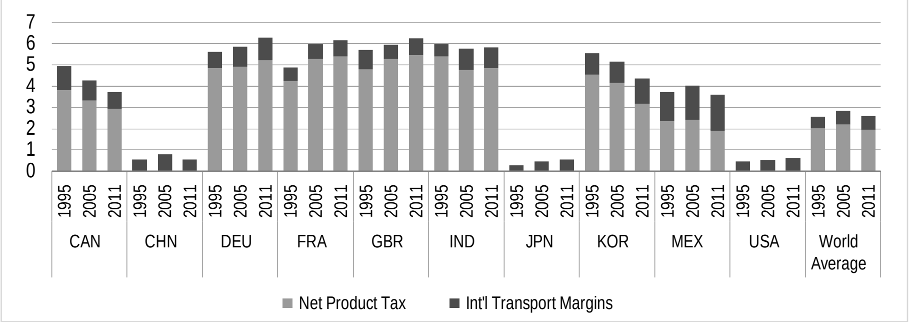
## 2-3. Transaction Costs

Previous literature does not deal with the transaction costs including product tax, government subsidies, and international transport margins among others, because there is not a relevant database available except the WIOD. When we look into the World Input-Output Tables, however, it turns out that we need to exclude the transaction costs out of the gross value added in order to obtain the information on net value added for producers. It is because the transaction costs represent a substantial portion of the total input which is shown in Figure 3.

When we look into the world average, the share of transaction costs turns out to occupy 2.59% out of the total input in 2011 (See Figure 3). It was 2.56 percent and 2.85 percent in 1995 and 2005, respectively. Previous literature, which includes the transaction costs in gross value added, does not capture the net value added. This paper decomposes the transaction costs out of the domestic as well as foreign value added because global companies have more interest in the net value added after excluding various costs accruing from the global business activities.

**Figure 3. Share of Transaction Costs in Total Inputs, 1995-2011**

(Unit : %)




Source: Author's calculation using World Input Output Tables.

We will show the difference between the net and gross value added using an example of the international input-output table and elucidate the importance of transaction costs in dealing with global value chains. Table 1 shows the example of 2 countries and 2 industries. The rows of the table represent the distribution after production while the columns represent the input structure for production. The Table 1 reveals that total input (output) amounts to 1,468.7 while total intermediate input, transaction costs, and net value added amount to 682.4, 21.0, 765.2, respectively. Previous literature adds the product taxes and other costs (21.0) to net value added (765.2), thereby overvaluing the value added by the amount of transaction costs.

**Table 1. Example of World Input-Output Tables (2 countries and 2 industries)**

| | | Intermediate Demand | | | | Final Demand | | Total Output |
|---|---|---|---|---|---|---|---|---|
| | | Country 1 | | Country 2 | | Country 1 | Country 2 | |
| | | Industry 1 | Industry 2 | Industry 1 | Industry 2 | | | |
| Country 1 | Industry 1 | 170.3 | 884.6 | 7.3 | 44.3 | 354.4 | 7.7 | 1,468.7 |
| | Industry 2 | 488.3 | 18,085.6 | 54.6 | 739.1 | 22,366.9 | 445.6 | 42,180.1 |
| Country 2 | Industry 1 | 12.7 | 180.3 | 179.8 | 678.6 | 21.0 | 545.2 | 1,617.6 |
| | Industry 2 | 11.1 | 427.6 | 340.2 | 3,719.3 | 334.8 | 5,082.9 | 9,916.0 |
| Total Intermediate Input | | 682.4 | 19,578.2 | 581.9 | 5,181.2 | | | |
| Transaction Costs | | 21.0 | 542.7 | 5.4 | 96.5 | | | |
| Value Added | | 765.2 | 22,059.2 | 1,030.3 | 4,638.3 | | | |
| Total Input | | 1,468.7 | 42,180.1 | 1,617.6 | 9,916.0 | | | |

Source: Author's calculation.

If we add the transaction costs to the value added, then the induced effects by industry sum up to 1.00, which is shown in Scenario 1 of Table 2. To the contrary, the induced effects by industry sum up to 0.975, 0.976, 0.991, and 0.980, if we exclude the transaction costs out of the value added in Scenario 2.

The total sum of the effects accrued to the production factors turns out to be less than 1.0, meaning economic inefficiency occurs due to the transaction costs. The induced value added accrued to country 1 turns out to be less than country 2 because the transaction costs of country 1 are higher than country 2. As Table 2 indicates, the transaction costs accrued to industry 1 and 2 of country 1 are 0.014 and 0.016, respectively, while those to industry 1 and 2 of country 2 are 0.003 and 0.010, respectively.

We can show a generalized example using input coefficient (A), value added matrix (V), and transaction vector (T) as follows.

**Table 2. Matrix of Induced Value Added (V • B)**

| | | Industry 1 of Country 1 | Industry 2 of Country 1 | Industry 1 of Country 2 | Industry 2 of Country 2 |
|---|---|---|---|---|---|
| <Scenario 1: Inclusion of transaction costs into value added > | | | | | |
| | | Industry 1 of Country 1 | Industry 2 of Country 1 | Industry 1 of Country 2 | Industry 2 of Country 2 |
| Matrix V·B | Industry 1 of Country 1 | 0.614 | 0.023 | 0.006 | 0.008 |
| | Industry 2 of Country 1 | 0.360 | 0.954 | 0.067 | 0.124 |
| | Industry 1 of Country 2 | 0.011 | 0.007 | 0.740 | 0.082 |
| | Industry 2 of Country 2 | 0.015 | 0.016 | 0.187 | 0.787 |
| | Sum | 1.000 | 1.000 | 1.000 | 1.000 |
| <Scenario 2: Exclusion of transaction costs out of value added > | | | | | |
| | | Industry 1 of Country 1 | Industry 2 of Country 1 | Industry 1 of Country 2 | Industry 2 of Country 2 |
| Matrix V·B | Industry 1 of Country 1 | 0.598 | 0.022 | 0.006 | 0.008 |
| | Industry 2 of Country 1 | 0.352 | 0.931 | 0.066 | 0.121 |
| | Industry 1 of Country 2 | 0.011 | 0.007 | 0.736 | 0.082 |
| | Industry 2 of Country 2 | 0.014 | 0.016 | 0.183 | 0.771 |
| | Sum | 0.975 | 0.976 | 0.991 | 0.980 |

Source: Author's calculation using the data of Table 1.

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix},\ V = \begin{bmatrix} V_1 & 0 \\ 0 & V_2 \end{bmatrix},\ T = \{t_{1,} \quad t_2\}$$

If t1 = t2 = 0, then a + c + v1 = b + d + v2 = 1.

$$V \bullet \mathrm{B} = \frac{1}{\{(1-d)(1-a)-bc\}} \begin{bmatrix} (1-d)v_1 & bv_1 \\ cv_2 & (1-a)v_2 \end{bmatrix}$$

The first column of the V·B matrix sums up to [1/{(1-d)·(1-a) - bc}]·{(1-d)$v_1$ + c$v_2$} turns out to be 1 because $v_1$ = 1 - a –c, $v_2$ = 1 - b –d. The second column of the V·B matrix also equals 1. If $t_1$ and $t_2$ do not equal 0 and $t_2$ = 0, then a + c + $v_1$ + $t_1$ = b + d + $v_2$ + $t_2$ = 1. And [1/{(1-d)·(1-a) - bc}]·{(1-d)$v_1$ + c$v_2$} < 1. [1/{(1-d)·(1-a) - bc}]·{(1-d)·($v_1$ + $t_1$) + c($v_2$ + $t_2$)} = 1. [1/{(1-d)·(1-a) - bc}]·{(1-d)$t_1$+ c$t_2$} represents the size of extortion due to the transaction costs including product tax and international transport margins among others. This implies that the net value added is more relevant than the gross value added in explaining the business activities along global value chains.

# 3. Value Added in Exports and Ricardian Comparative Advantage

## 3-1. Empirical Model and Data

The Ricardian model predicts that countries produce and export goods in which they have comparative advantage. A large number of empirical studies including MacDougall (1951), Stern (1962), Balassa (1963), and Golub and Hsieh (2000) have examined the Ricardian comparative. There has recently been growth in literature based on multisector extensions of the Eaton and Kortum (2002) model including Burstein and Vogel (2010), Chor (2010), Costinot, Donaldson and Komunjer (2012), Kerr (2013), and Levchenko and Zhang (2016).

Most previous studies use the dependent variable measured by total exports or bilateral net exports while the recent studies built on multi-country and multi-sector model of Eaton and Kortum (2002) use exports at the industry level. In particular, Costinot, Donaldson and Komunjer (2012), henceforth CDK (2012), employs bilateral exports at the industry level, disaggregated by exporting and importing countries and adjusted for differences in levels of "openness."

As Grossman and Rossi-Hansberg (2007) puts it, the measurement of trade as gross values of imports and exports was perhaps appropriate at a time when trade flows comprised mostly of finished goods. However, such measures are inadequate to investigate the importance of Ricardian comparative advantage in a world with global value chains. With deepening global value chains allowing goods to cross border many times, gross value of total exports as well as exports at the industry level do not appropriately reflect the actual domestic production. Though adjusting for differences in levels of openness, as CDK (2012) suggested, helps to correct for the endogenous selection of varieties that are actually produced domestically; it only corrects for imports of the own industry. As a result, previous literature does not consider the intermediates from other industries and imported from foreign countries that are used for the production in an industry. One way to deal with this problem is to calculate the domestic value added in exports by using World Input-Output Tables.

Therefore, our contribution is to empirically test whether Ricardian predictions are valid for value added in exports. To the best of our knowledge, this is the first study to investigate the importance of Ricardian comparative advantage in value added in exports by countries and industries. Our basic equation is to extend the empirical specification of CDK (2012) to use the dependent variable as value added in exports and include time $t$:

$$\ln(VA_{ijt}{}^{k}) = \delta_{ijt} + \delta_{jt}{}^{k} + \theta \ln(z_{it}{}^{k}) + \varepsilon_{ijt}{}^{k}, \tag{5}$$

where $i$, $j$ and $k$ denote exporter, importer and industry, respectively; $VA_{ijt}{}^{k}$ is value added in exports, $\delta_{ijt}$ represents exporter-importer-year fixed effect, $\delta_{jt}{}^{k}$ is importer-industry-year fixed effect, $z_{it}{}^{k}$ is productivity, and $\varepsilon_{ijt}{}^{k}$ is the error term. The exporter-importer-year fixed effects remove the time-varying aggregate effects by bilateral country-pairs common across industries, thus omitted variable bias generated from specific characteristics of exporters and importers. The importer-industry-year fixed effects control for unobserved changes of an industry in the importing country such as changes in tariffs, the industrial growth, relative price and so on.[5]

Although eq. (5) includes exporter-importer-year and importer-industry-year fixed effects, OLS may yield biased and inconsistent coefficient estimates if the productivity is correlated with the error term. As CDK (2012) indicated, potential sources of endogeneity bias are simultaneity bias and measurement error in productivity. The general methods for dealing with this issue include using the

[5] In order to compare the impacts of relative productivity on value added in exports and gross exports, we report the additional results on the relationship between productivity and gross exports.

fixed effects model, the first-difference approach, or IV techniques. As Wooldridge (2002, Ch.10) notes, standard econometric discussions of circumventing endogeneity bias in the context of panel data focus on a choice between estimation using a fixed effects model versus using first-differencing method. Kerr (2013) suggests using the first-differencing method, eq. (6), because the exporter-importer-year fixed effects $\delta_{ijt}$ in eq. (5) only account for the aggregate productivity changes for the exporter, but not long-term differences in productivity across industries for the exporter. We estimate the following equation with a first-differenced form suggested by Kerr (2013)

$$\Delta \ln(VA_{ijt}{}^{k}) = \delta_{ijt} + \delta_{jt}{}^{k} + \theta\Delta \ln(z_{it}{}^{k}) + \varepsilon_{ijt}{}^{k} \tag{6}$$

IV techniques will be applied to the estimation of cross-section for 1997 in robustness check for below. The dataset features a panel structure that covers 40 countries and 14 manufacturing industries for years 1995-2009 (see Appendix 1). The panel data on trade flows come from the World Input-Output Table. The labor productivity is defined as an output measure divided by a labor input measure (Inkaar and Timmer 2008). We use the volume of gross output or the volume of value added as the output measure and the labor input measure is the number of hours worked. These data are taken from World Socio Economic Accounts. These annual data are collapsed into their mean for each five-year period from 1995-1999 to 2005-2009.

Table 3 shows the summary statistics for the 14 industries, aggregating over countries. Electrical and Optical Equipment has the highest average exports and value added in exports. In all industries the standard deviations are larger than the means, implying that bilateral trade flows are spread out over a wider range of values.

Table 3. Summary Statistics

| | Exports (Mil. US$) | | Value added in export (Mil. US$) | | Labor productivity based on sectoral output | | Labor productivity based on sectoral value added | |
|---|---|---|---|---|---|---|---|---|
| | mean | St. D. | mean | St. D. | mean | St. D. | mean | St. D. |
| Food, Beverages and Tobacco | 271.1 | 1,018.2 | 99.0 | 367.0 | 0.55 | 0.49 | 0.63 | 0.57 |
| Textiles and Textile Products | 233.6 | 1,387.1 | 95.8 | 547.2 | 0.78 | 1.01 | 0.73 | 0.93 |
| Leather, Leather and Footwear | 48.1 | 321.0 | 17.0 | 103.5 | 0.72 | 0.71 | 0.72 | 0.77 |
| Wood and Products of Wood and Cork | 47.9 | 287.2 | 28.3 | 143.8 | 0.65 | 0.66 | 0.76 | 0.72 |
| Pulp, Paper, Printing and Publishing | 130.2 | 574.5 | 93.6 | 380.8 | 0.75 | 0.74 | 0.72 | 0.67 |
| Coke, Refined Petroleum and Nuclear Fuel | 181.2 | 1,005.1 | 53.3 | 305.4 | 0.91 | 1.19 | 0.36 | 0.81 |
| Chemicals and Chemical Products | 487.1 | 1,750.8 | 205.7 | 753.6 | 0.69 | 0.70 | 0.68 | 0.71 |
| Rubber and Plastics | 125.8 | 510.1 | 77.1 | 309.9 | 0.62 | 0.52 | 0.61 | 0.53 |
| Other Non-Metallic Mineral | 62.5 | 218.3 | 42.5 | 155.8 | 0.75 | 0.62 | 0.63 | 0.53 |
| Basic Metals and Fabricated Metal | 423.2 | 1,608.3 | 257.8 | 1,027.4 | 0.67 | 0.56 | 0.60 | 0.51 |
| Machinery, Nec. | 394.3 | 1,537.4 | 169.0 | 684.9 | 0.63 | 0.53 | 0.56 | 0.48 |
| Electrical and Optical Equipment | 868.0 | 4,300.1 | 320.4 | 1,516.9 | 0.51 | 0.45 | 0.37 | 0.44 |
| Transport Equipment | 623.0 | 3,162.0 | 198.4 | 1,055.1 | 0.59 | 0.54 | 0.53 | 0.44 |
| Manufacturing, Nec; Recycling | 142.3 | 839.6 | 56.6 | 301.0 | 0.67 | 0.61 | 0.50 | 0.46 |

Source: Author's calculation.

## 3-2. Empirical Results

The estimation results according to eq. (6) are shown in Table 4. The first and second column report the impacts of labor productivity based on either sectoral output or value added on the gross value of exports at the industry level. Columns (3) and (4) present the estimates of $\theta$ when the dependent variable is measured by value added in exports and the coefficients are positive and significant at the 1% level implying that Ricardian comparative advantage does matter for value added in exports. The magnitudes of these estimates are somewhat lower than the elasticities reported in the studies with cross-sectional analysis. As Kerr (2013) notes, this might be attributed to the measurement error in productivity of non-OECD countries.

**Table 4. Empirical Results for Ricardian Comparative Advantage from Panel Data**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dep. Variable | △ln(export) | △ln(export) | △ln(value added in export) | △ln(value added in export) |
| △ln(labor productivity based on sectoral output) | 0.508 (0.019)*** | | 0.372 (0.014)*** | |
| △ln(labor productivity based on sectoral value added) | | 0.311 (0.018)*** | | 0.346 (0.013)*** |
| Exporter-importer-year fixed effect | yes | yes | yes | yes |
| Importer-industry-year fixed effect | yes | yes | yes | yes |
| observations | 43,241 | 43,241 | 43,511 | 43,511 |
| $R^2$ | 0.35 | 0.35 | 0.43 | 0.37 |

Note: Heteroskedasticity-robust standard errors are reported in parentheses. *** denotes significance at the 1% level.

Source: Author's calculation.

## 3-3. Robustness Check

We check the robustness of our empirical results using the data on internationally comparable productivity and value added in exports across countries and industries. In order to compare our estimation results with CDK (2012), we use the dataset of CDK covering 21 countries (18 European countries plus Japan, Korea and the U.S.) and 13 industries. CDK (2012) argue that in a Ricardian world, variation in relative productivity level should be fully reflected in relative producer prices and suggest measuring of productivity by the inverse of producer price index taken from the Groningen Growth and Development Centre (GGDC) Productivity Level Database. Since GGDC provides productivity data only for the year 1997, the estimation is cross-sectional and the empirical specification is eq. (5) but excluding time $t$.

**Table 5. Cross-section Results using IV Estimation**

| Dep. Variable: ln (value added in exports) | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| ln(productivity based on producer prices) | 8.856 (0.931)*** | | | |
| ln(productivity based on producer prices, dual TFP measure) | | 8.612 (1.007)*** | | |
| ln(productivity based on real gross output per worker) | | | 3.668 (0.268)*** | |
| ln(productivity based on real gross output, primal TFP measure) | | | | 6.846 (0.637)*** |
| Exporter-importer-year fixed effect | yes | yes | yes | yes |
| Importer-industry-year fixed effect | yes | yes | yes | yes |
| Observations | 5,124 | 5,124 | 5,124 | 4,155 |
| $R^2$ | 0.40 | 0.09 | 0.71 | 0.60 |

Note: Heteroskedasticity-robust standard errors are reported in parentheses. *** denotes significance at the 1% levels.

Source: Author's calculation

To address the potential endogeneity bias, we employ the IV regression method in which productivity is instrumented with R&D expenditures at the country-industry level as instruments for industrial productivity.[6] Table 5 presents the results by applying the IV estimation technique. We see in all columns using alternative productivity measures that each estimate of $\theta$ is positive and statistically significant at the 1% level. This implies that Ricardian comparative advantage is strongly valid for value added in exports.

Furthermore, the estimate of $\theta$ in column (1) is about 8.86, which is larger than 6.53 of CDK (2012). In addition, the coefficient reported in column (2) using total factor productivity is slightly lower at about 8.6, but larger than CDK (2012) estimate, 6.7. According to this estimate of the productivity to value added in exports, a 1% change in productivity is associated with 8.86% change in value added in exports. This magnitude of our estimate of $\theta$ approximates to the preferred estimate of 8.28 in Eaton and Kortum (2002) obtained from intra-OECD trade flows in 1995. The coefficients of $\theta$ in column (3) and (4) using alternative productivity measures also are larger than that of CDK (2012). The larger estimates of $\theta$ in the context of value added in exports than gross exports imply that Ricardian comparative advantage has greater influence on determining the patterns of trade in a world with global value chains.[7]

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[6] The stability of the labor share of income has been a fundamental feature of macroeconomic models. Karabarbounis and Neiman (2013) show, however, that the global labor share has significantly declined since the early 1980s. In this paper, we do not attempt to provide a theoretical model for the relation between offshoring and domestic value added or value added in exports. This remains for future research.

[7] In this paper we do not provide a theoretical framework for empirical examination of how relative productivity has different impacts on value added in exports and gross exports. It remains for future research.

# 4. Offshoring and Transaction Costs as a Source of Comparative Advantage

## 4-1. Empirical Model and Data

As discussed in Section 1 and 2, we test whether offshoring and transaction costs are important determinants of comparative advantage. The well-established determinants in the literature such as Heckscher-Ohlin effects and institution are included in the empirical model.

We control for Heckscher-Ohlin-style effects by including the capital and skill intensities. A number of studies on the sources of comparative advantage (Romalis 2004; Nunn 2007; Manova 2013) use the empirical equation which includes the interaction between the industry-level intensity and country-level endowment variable, for example, the interaction between the industry-level skill intensity ($h_i$) and country-level skill endowments ($H_c$), $h_i H_c$. This empirical set-up implicitly assumes that the characteristics of an industry are a worldwide constant. Typically the characteristics of U.S. industry are used mainly due to the availability of data.

However, the characteristics of an industry may be different from country to country. The intermediate inputs differ in factor intensity and factor prices differ between a rich and a poor country. As Helpman (2011, p.130) notes, the least skill-intensive activities in the rich country can be more skill-intensive than the most skill-intensive activities in the poor country. As Chor (2010) notes, "industries vary in the technological and institutional conditions needed for production, and countries differ in their ability to provide for these industry-specific requirements. Comparative advantage therefore stems in practice from such country-industry matches." Instead of using the representative factor intensities in each industry such as from the U.S. Input-Output Table, we measure the skill and capital intensities over all countries, industries and years using the World Input-Output Table.[8]

In addition, the recent growing literature shows that institution could be an important source of comparative advantage. Industries may differ in their institutional intensity that causes productivity differences across industries within a country. In particular, Nunn (2007) tests whether a country's ability to enforce written contracts is an important determinant of comparative advantage. He finds that countries with good contract enforcement specialize in the production of goods for which relationship-specific investments are most important. Intuitively, countries with better contract enforcement have less under-investment, so they will have a cost advantage in the production of goods requiring relationship-specific investments.

To test the hypothesis that offshoring and transaction costs are important sources of comparative advantage, we estimated the following equation:

$$\ln(VA_{ict}) = \alpha_{it} + \alpha_{ct} + \beta_1 h_{ict} + \beta_2 k_{ict} + \gamma_1 z_i Q_c + \gamma_2 TC_{ict} + \eta_1 MO_{ict} + \eta_2 SO_{ict} + \varepsilon_{ict}, \quad (7)$$

where $VA_{ict}$ is value added in exports in *i* from country *c* to all other countries in the world; $h_{ict}$ and $k_{ict}$ are the skill and capital intensities of production in industry *i* and country c measured as the share of the skilled labor and capital compensation in value added; $z_{it}$ is contract intensity of industry $i$; $Q_c$ is judicial quality of country $c$; $TC_{ict}$ represents transaction costs in the industry *i* and country *c*; $SO_{ict}$ and $MO_{ict}$ represent services and material offshoring defined as the share of off-shored services and materials in the total

[8] One may argue that the interaction term $h_{ict}$*$H_{ct}$ should be used to capture countries' factor endowment. However, this type of interaction has the problem that factor endowment is double counted. The skill intensity $h_{ict}$ in this paper reflects the characteristic of factor endowment, because it differs from country to country.

intermediate input in the industry *i*, respectively (see Romalis 2004); $\alpha_{it}$ and $\alpha_{ct}$ denote industry-year fixed effects and country-year fixed effects.[9]

There are some empirical issues to be discussed. OLS estimation of eq. (7) may suffer from endogeneity bias. As Nunn (2007) indicates, $zQ$ is endogenous because countries with good judicial systems also tend to have high incomes and be abundant in skilled labor. Services and material offshoring also are assumed to be endogenous. Countries that specialize in services intensive industries may have a greater incentive to develop and maintain a good environment for services offshoring. As a result, there may be feedback effects from specialization to services offshoring. Furthermore, causality may run in both directions, and these regressors may be correlated with the error term. In addition, there may be important determinants of comparative advantage that are omitted from eq. (7).

To alleviate this problem, IV techniques are often used if valid instrument variables are known. If appropriate instrument variables are unknown, however, a commonly employed estimation procedure to estimate the parameters in a panel model is to take first differences to eliminate the unobserved individual heterogeneity and to use all the past information of the dependent variable for instruments. In this case the eq. (7) is transformed into the dynamic panel model including the lagged dependent variable.

$$\ln(VA_{ict}) = \alpha_{it} + \alpha_{ct} + \mu \ln(VA_{ict-1}) + \beta_1 h_{ict} + \beta_2 k_{ict} + \gamma_1 z_i Q_c + \gamma_2 TC_{ict} + \eta_1 MO_{ict} + \eta_2 SO_{ict} + \varepsilon_{ict} \ , \quad (8)$$

[9] Chor (2010) simultaneously tests five of the comparative advantage channels such as property rights institutions, financial development and labor-market-related institutions and shows that all the determinants are significant. Since the purpose of this paper is to examine whether offshoring and transaction costs are another sources of comparative advantage, we do not include all institutional determinants. Thus the estimated coefficients of offshoring and transaction costs may be overestimated. As Chor (2010) shows, however, the significance of explanatory variables does not change, although the contribution of each determinant to the variation in trade patterns becomes smaller.

There are two representative estimators: the first-difference GMM (Arellano and Bond 1991) and system GMM (Blundell and Bond 1998; Arellano and Bover 1995). While in the first-difference estimator sequential moment conditions are used where lagged levels of the variables are instruments for the endogenous differences, the system GMM estimator for dynamic panel data model combines moment conditions for the model in first differences with moment conditions for the model in levels. Blundell and Bond (1998) show that the first-difference GMM estimator can have very poor finite sample properties in terms of bias and precision when the series are persistent, as the instruments are then weak predictors of the endogenous changes. Furthermore, Blundell and Bond (1998), Blundell, Bond and Windmeijer (2000) find that the system GMM model improves on the GMM estimator in the first differenced model in terms of bias and root mean squared error. Since our country-level panel data are characterized by a relative small number of countries and time periods, we employ the system GMM.

We use data on value added in exports, transaction costs, material offshoring, and services offshoring at the country and/or industry-level for the period 1995-2009 calculated from World Input-Output Table which covers 40 countries and 14 manufacturing industries. As we mentioned in Section 2, transaction costs consists of net product tax and international transport margins. We exclude the international transport margins for our test due to the multicollinearity and proportionality to the country-specific distance. Country and industry-level measures of the capital and skill intensities are calculated using World Socio Economic Accounts. Since data on high-skilled labor compensation over the period 2010-2011 are not provided, we limit the analysis period to 1995-2009.

Following Nunn (2007), we measure contract intensity as follows:

$$z_{it} = \sum_{j} \theta_{ijt} R_j^{diff} \ .$$

$\theta_{ijt} = u_{ijt} / u_{it}$, where $u_{ijt}$ the value of input *j* used in industry *i* and $u_{it}$ is the total value of all inputs used in industry *i*; $R_j^{diff}$ is the proportion of input *j* that is, differentiated products. We construct, for each good, the measure of the proportion of its intermediate inputs $\theta_{ijt}$ that are relationship-specific over all countries, industries and years. Data on $R_j^{diff}$ according to ISIC industry classification are obtained in Nunn (http://scholar.harvard.edu/nunn/pages/data-0). As the measures of judicial quality $Q_c$, we use the "rule of law" from Kaufmann, Kraay, and Mastruzzi (2003) obtained from Worldwide Governance Indicators (World Bank).[10]

Summary statistics for the data used in the estimations are presented in Table 6. Material offshoring amounts to 38 percent of total intermediate input on average over all countries, industries and years, while service offshoring represents 6 per cent of total inputs.

**Table 6. Summary Statistics**

| | Mean | Std. D. |
|---|---|---|
| ln(VA) | 6.87 | 2.15 |
| Capital intensity | 0.38 | 0.25 |
| Skill intensity | 0.13 | 0.08 |
| Contract intensity * Judicial quality | 0.05 | 0.07 |
| Transaction Costs | 0.03 | 0.02 |
| Services offshoring | 0.06 | 0.07 |
| Material offshoring | 0.38 | 0.24 |

Source: Author's calculation.

10 Data on rule of law for 1995 are not provided, thus we replace them in 1995 with those from 1996.

## 4-2. Estimation Results

Table 7 shows the OLS regression results of eq. (7). The dependent variable is the natural log of value added in exports. Column (1) reports estimates of the specification that includes capital intensity, skill intensity, transaction costs, services offshoring and transaction costs. The coefficient of transaction costs and services offshoring are statistically significant at the 1% or 5% level, implying that differences in transaction costs and services offshoring affect the pattern of trade across countries and industries measured by value added. The interaction between contract intensity and judicial quality is additionally included in column (2), but its coefficient is not significant. Column (3) reports estimation results for all sources of comparative advantage considered in this paper. While the coefficients of capital intensity, skill intensity, transaction costs, services offshoring, and material offshoring are significant, the estimate of judicial quality interaction is not different from zero.

Table 7. OLS Regression Results

| Dep. Variable: ln(VA) | (1) | (2) | (3) |
|---|---|---|---|
| Capital intensity | 1.051<br>(0.165)*** | 1.047<br>(0.164)*** | 0.999<br>(0.160)*** |
| Skill intensity | 1.022<br>(0.461)** | 1.079<br>(0.456)** | 0.977<br>(0.451)** |
| Contract intensity * Judicial quality | | -0.368<br>(0.309) | -0.337<br>(0.307) |
| Transaction costs | -14.567<br>(1.043)*** | -14.504<br>(1.041)*** | -13.449<br>(1.073)*** |
| Services offshoring | 0.800<br>(0.357)** | 0.813<br>(0.357)** | 0.934<br>(0.354)*** |
| Material offshoring | | | -0.410<br>(0.087)*** |
| Country-year fixed effects | yes | yes | yes |
| Industry-year fixed effects | yes | yes | yes |
| $R^2$ | 0.79 | 0.79 | 0.79 |
| Observations | 8,316 | 8,316 | 8,316 |

Note: Robust standard errors are reported in parentheses and *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.

Source: Author's calculation.

As mentioned above, OLS estimator yields biased estimates when some explanatory variables are endogenous. To alleviate the endogeneity problem, we employed the system GMM estimator. The estimation results of eq. (8) are shown in Table 8. Each column is specified, like when applying the OLS estimation. We look at column (3) that includes all considered explanatory variables. The judicial quality interaction, services offshoring and material offshoring are treated as endogenous. In all columns the tests for first-order and second-order serial correlation show the expected diagnostics.

The coefficient of lagged dependent variable $\ln(VA)(-1)$ is positive as expected and statistically significant at 1% level. The coefficient of capital intensity is positive and highly significant, but that of skill intensity turns out to be insignificant. The interaction between contract intensity and judicial quality shows the positive and significant coefficient. This supports the hypothesis of Nunn (2007) that contract enforcement is important for comparative advantage.

The estimated coefficient of services offshoring remains positive and significant, implying that services offshoring is significant for comparative advantage and there is a complementarity between services offshoring and domestic value added of manufacturing industries. Furthermore, the material offshoring shows a negative and significant coefficient. This means that material offshoring is a substitute for domestic value added in exports of manufacturing industries. It also implies that services offshoring has larger scale effects and smaller substitution effects than material offshoring.

The empirical results in the previous literature on the productivity effects of offshoring are mixed. As Schwörer (2013) indicated, they tend to depend on *who* is offshoring and *what* is offshored. Using data on Irish manufacturing plants, Görg, Hanley, and Strobl (2008) find that service offshoring increases the productivity of exporting firms while there is no impact of material offshoring. Amiti and Wei (2009) use industry-level data for the United States over the period 1992-2000 and find a positive productivity effect of services offshoring and offshoring material inputs also has a positive effect on productivity, but the magnitude is smaller than services. Winkler (2010) also provides evidence for German manufacturing industries and finds productivity gains from service offshoring, but no strong evidence for gains from material offshoring. Michel, B. and F. Rycx (2014) estimates the impact of materials and business services offshoring on productivity in Belgium over the period 1995–2004, and show that materials offshoring has no effect on productivity, while business services offshoring leads to productivity gains in manufacturing.

Using data for electronics firms in Ireland over the period 1990-1995, Görg and Hanley (2003) estimate the effect of outsourcing on labor productivity and find no clear productivity impact of offshoring in either materials or services. Görzig and Stephan (2002) examine a panel data set of about 43,000 German manufacturing companies over the period 1992-2000 and find that the productivity effect is strongest for material offshoring, but negative for services in the short run. Egger and Egger (2006) use industry-level data for the EU manufacturing over the period 1993-1997, and find that offshoring lowers the productivity of low-skilled workers in the short run. Using plant-level data of the Irish electronics sector between 1990 and 1995, Görg and Hanley (2005) find a positive impact of material offshoring on productivity for firms with low export intensities but no statistically significant impact of service offshoring.

On the other hand, the coefficient of transaction costs (TC) is negative as expected and statistically significant at 1% level in column (3) of Table 8. This result is different from the OLS regression results in Table 7 such that the coefficients of transaction costs are statistically significant at 1% level in all columns. The system GMM results on transaction costs indicate that the magnitudes of the estimated coefficient are less than the OLS results. These differences seem to be due to the characteristic of the system GMM model, that a lagged dependent variable $\ln(VA)(-1)$ is included in the list of independent variables.

Table 8. System GMM Results

| Dep. Variable: ln(VA) | (1) | (2) | (3) |
|---|---|---|---|
| Ln(VA)(-1) | 0.774<br>(0.053)*** | 0.780<br>(0.049)*** | 0.774<br>(0.011)*** |
| Capital intensity | 0.578<br>(0.140)*** | 0.546<br>(0.144)*** | 0.389<br>(0.041)*** |
| Skill intensity | -0.045<br>(0.649) | -0.042<br>(0.589) | -0.417<br>(0.574) |
| Contract intensity * Judicial quality | | 1.375<br>(0.671)** | 1.865<br>(0.303)*** |
| Transaction costs | -1.902<br>(1.228) | -1.721<br>(1.178) | -2.394<br>(0.541)*** |
| Services offshoring | 1.010<br>(0.528)* | 0.951<br>(0.484)** | 0.602<br>(0.169)*** |
| Material offshoring | | | -0.261<br>(0.063)*** |
| Country-year fixed effects | yes | yes | yes |
| Industry-year fixed effects | yes | yes | yes |
| $R^2$ | 0.79 | 0.79 | 0.79 |
| Observations | 7,751 | 7,751 | 7,751 |
| AR(1) | 0.00 | 0.00 | 0.00 |
| AR(2) | 0.16 | 0.14 | 0.13 |

Note: Robust standard errors are reported in parentheses and *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively. With robust standard errors the results of Sargan tests for over-identification are not calculated.

Source: Author's calculation.

The estimated coefficient of transaction costs in Table 8 turned out to be -2.394. Thus one percent point (=0.01) increase in transaction costs causes value added in exports change by -2.394%. That implies that there is a magnification effect of transaction costs on value added in exports.

This finding can also be confirmed by Tables 2 and 9. The induced value added $(V \cdot B)$ of country 1 results in a decrease of more than one percent, if value added (V) of country 1 decreases by one percent due to the increase in transaction costs. The induced value added of industry 1 and 2 of country 1 turns out to be 0.956 and 0.958, respectively, as shown in Table 9. When we compare the relevant numbers in Table 2 and 9, the magnitudes of the change (0.975-0.956, 0.976-0.958) turn out to be more than 1 percent, which is consistent with the mathematical derivation in Section 2. This result indicates that the effect of transaction costs on net value added in exports tends to be magnified due to the so-called "multiplier effect" of input-output analysis.

**Table 9. Simulation Result:**
**Magnification Effect of Transaction Costs on Induced Value Added**

<Scenario: 1% point reduction in value added of country 1 due to increase in transaction costs>

| | | Industry 1 of Country 1 | Industry 2 of Country 1 | Industry 1 of Country 2 | Industry 2 of Country 2 |
|---|---|---|---|---|---|
| Matrix V·B | Industry 1 of Country 1 | 0.586 | 0.022 | 0.006 | 0.007 |
| | Industry 2 of Country 1 | 0.345 | 0.913 | 0.064 | 0.118 |
| | Industry 1 of Country 2 | 0.011 | 0.007 | 0.736 | 0.082 |
| | Industry 2 of Country 2 | 0.014 | 0.016 | 0.183 | 0.771 |
| | Sum | 0.956 | 0.958 | 0.989 | 0.978 |

Source: Author's calculation using the data of Table 1 and Table 2.

## 5. Conclusion

This paper investigated the relationship between comparative advantage and value added in exports. First, we tested whether Ricardian comparative advantage is valid for value added in exports that does not include intermediate inputs imported from various industries in a number of countries. Using a panel data on valued added contents of bilateral exports, we find that changes in the labor productivity lead to growth of value added in exports. This implies that Ricardian comparative advantage is an important determinant of exports in longitudinal changes. In addition, we examined the robustness of our empirical results by using the same cross-sectional dataset of CDK (2012) and thus the same measures of the productivity, but measured the dependent variable by value added in exports. The empirical results show that all measures of Ricardian comparative advantage have profound effects on the patterns of trade measured by value added. Furthermore we found that the estimated coefficients of the observed productivity are larger than those of CDK (2012), implying that Ricardian comparative advantage has greater influence on determining the patterns of trade in a world with global value chains.

Second, we investigated the role of offshoring and transaction costs in comparative advantage. We use data on value added in exports, offshoring in materials and services and transaction costs at the country and industry-level for the period 1995-2009 calculated from World Input-Output Table which covers 40 countries and 14 manufacturing industries. Employing a system GMM estimator to alleviate the potential endogeneity problem, we find that services offshoring has positive effects on comparative advantage while material offshoring affects it negatively. Our results are in line with Egger and Egger (2006). This implies that services offshoring is complementary to value added in exports of manufacturing industries whereas material offshoring is substitute for it. We also find that transaction costs have a negative effect on comparative advantage. Moreover, it turned out that there is a magnification effect of transaction costs on the induced value added in exports.

As we mentioned earlier, this paper investigated the role of offshoring and transaction costs for comparative advantage controlling for Heckscher-Ohlin effects and contracting institution. However, we did not consider the interplay of these various sources. Their impacts on comparative advantage would be endogenously determined rather than interdependently. The endogenous relationship and the interconnections between these factors remain for future research.

# Appendix

Table A. 1. Country and Industry Classification

| Abbr. | Description | Industry | Description |
|---|---|---|---|
| AUS | Australia | SEC01 | Agriculture, hunting, forestry and fishing |
| AUT | Austria | SEC02 | Mining and quarrying |
| BEL | Belgium | SEC03 | Food, beverages and tobacco |
| BRA | Brazil | SEC04 | Textiles and textile products |
| BGR | Bulgaria | SEC05 | Leather, leather products and footwear |
| CAN | Canada | SEC06 | Wood and products of wood and cork |
| CHN | China | SEC07 | Pulp, paper, printing and publishing |
| CYP | Cyprus | SEC08 | Coke, refined petroleum and nuclear fuel |
| CZE | Czech Republic | SEC09 | Chemicals and chemical products |
| DNK | Denmark | SEC10 | Rubber and plastics |
| EST | Estonia | SEC11 | Other non-metallic mineral |
| FIN | Finland | SEC12 | Basic metals and fabricated metal |
| FRA | France | SEC13 | Machinery, not elsewhere classified |
| DEU | Germany | SEC14 | Electrical and optical equipment |
| GRC | Greece | SEC15 | Transport equipment |
| HUN | Hungary | SEC16 | Manufacturing, not elsewhere classified; recycling |
| IND | India | SEC17 | Electricity, gas and water supply |
| IDN | Indonesia | SEC18 | Construction |
| IRL | Ireland | SEC19 | Sale and repair of motor vehicles and motorcycles; retail sale of fuel |
| ITA | Italy | SEC20 | Wholesale trade, except of motor vehicles and motorcycles |
| JPN | Japan | SEC21 | Retail trade and repair, except of motor vehicles and motorcycles; |
| KOR | South Korea | SEC22 | Hotels and restaurants |
| LVA | Latvia | SEC23 | Inland transport |
| LTU | Lithuania | SEC24 | Water transport |
| LUX | Luxembourg | SEC25 | Air transport |
| MLT | Malta 2000 | SEC26 | Other supporting transport activities |
| MEX | Mexico | SEC27 | Post and telecommunications |
| NLD | Netherlands | SEC28 | Financial intermediation |
| POL | Poland | SEC29 | Real estate activities |
| PRT | Portugal | SEC30 | Renting of machinery & equipment and other business activities |
| ROM | Romania | SEC31 | Public administration and defence; compulsory social security |

**Table A.1. Continued**

| Abbr. | Description | Industry | Description |
|---|---|---|---|
| RUS | Russia | SEC32 | Education |
| SVK | Slovak Republic | SEC33 | Health and social work |
| SVN | Slovenia | SEC34 | Other community, social and personal services |
| ESP | Spain | SEC35 | Private households with employed persons |
| SWE | Sweden | | |
| TWN | Taiwan | | |
| TUR | Turkey | | |
| GBR | UK | | |
| USA | USA | | |

Source: Timmer *et al.* (2015), pp. 598-599.

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# 국문요약

본 연구는 리카르도의 비교우위론이 부가가치 수출에 대해서도 타당한지에 대해 실증분석하였다. 본 연구는 양자간 수출의 부가가치에 대한 패널데이터를 이용하여 노동생산성의 변화가 부가가치 수출 증가에 기여한다는 점을 발견하였다. 생산성의 추정계수는 기존연구에 비해 큰 것으로 나타났는데, 이는 글로벌 가치사슬에서 리카르도 비교우위가 무역패턴의 결정에 더 큰 영향을 미친다는 것을 의미한다.

또한 본 연구는 비교우위에 대한 옵쇼링과 거래비용의 역할을 분석하기 위해 1995~2009년 기간의 세계투입산출표를 이용하였다. 본 연구는 수출부가가치, 물적 옵쇼링, 서비스 옵쇼링, 거래비용 등에 대한 데이터를 산출하였으며, 잠재적 내생성 문제를 완화하기 위해 system GMM 추정기법을 이용하였다. 분석결과에 따르면 서비스 옵쇼링은 비교우위에 대해 긍정적인 영향을 미치는 반면, 물적 옵쇼링과 거래비용은 부정적인 영향을 미치는 것으로 나타났다.

**핵심용어**: 수출부가가치, 옵쇼링, 거래비용

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# Comparative Advantage of Value Added in Exports: The Role of Offshoring and Transaction Costs

CHOI Nakgyoon and PARK Soonchan

This study tests whether Ricardian comparative advantage is valid for value added in exports that does not include intermediate inputs imported from various industries in a number of countries. Using a panel data on valued added contents of bilateral exports, we find that changes in the labor productivity lead to growth of value added in exports. This implies that Ricardian comparative advantage is an important determinant of exports in longitudinal changes. The estimated coefficients of the observed productivity turn out to be larger than those of CDK (2012), implying that Ricardian comparative advantage has greater influence on determining the patterns of trade in a world with global value chains. This study also investigates the role of offshoring and transaction costs in comparative advantage. We use data on value added in exports, offshoring in materials and services, and transaction costs at the country and industry-level for the period 1995-2009 calculated from World Input-Output Table which covers 40 countries and 14 manufacturing industries. Employing a system GMM estimator to alleviate the potential endogeneity problem, we find that services offshoring has positive effects on comparative advantage while material offshoring affects it negatively. We also find that transaction costs have a negative effect on comparative advantage. Moreover, it turned out that there is a magnification effect of transaction costs on the induced value added in exports.

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