한국경제학보 제17권 제1호
The Korean Journal of Economics Vol. 17, No. 1(Spring 2010)

Do Trade Costs Affect the Factor Content of Trade?

Yeon Joon Kim*

Abstracts

This paper expands upon the original HOV model by considering trade costs. It deduces the original HOV model with trade costs and compares it with the HOV model without trade costs. It does so by including trade costs directly in the technology matrix, where the working assumption is that the trade costs are located in the original country. Additionally, this paper includes trade costs directly in the vector of the net exports. This paper concludes that the original HOV model with trade costs achieves better results than the model without trade costs using the data constructed for the purpose of this paper. These test results show that trade costs play an important role in explaining the factor content of trade.

KRF Classification : B030800
Keywords : Factor Content of Trade, Trade Costs, The HOV model

Ⅰ. Introduction

The original Heckscher-Ohlin (HO) model assumes two countries,

* I appreciate two anonymous referees for their helpful comments. All errors are mine. Correspondence: Yeon Joon Kim, Economist, Center for Green Growth Study, POSCO Research Institute, POSRI Bldg., (147, Samsung-dong) 514, Bongeunsa-ro, Gangnam-gu, Seoul 135-878, South Korea. Phone:82-2-3457-8233, Fax: 82-2-3452-8072, E-mail: yjkim@posri.re.kr

two factors, and two goods. Paul Samuelson transformed the HO model into a mathematical model, thus becoming the Heckscher–Ohlin–Samuelson (HOS) model. Vanek (1968) introduces multi-factors and multi-goods into this model, which becomes the Heckscher–Ohlin–Vanek (HOV) model. Many trade economists have used the HOV model to verify empirically whether and how well the HOV model explains the trade data.

The original HOV, also known as the strict HOV model, assumes the following: free trade (no trade costs), perfect competition, identical technologies across countries, constant returns to scale, different factor endowments across different countries, identical and homothetic preferences across all consumers in all countries, factors that are perfectly mobile in the long run across sectors, but perfectly immobile across countries, and finally no measurement error.

Strictly speaking, the free trade assumption is not realistic in our world. When two countries trade with each other, trade costs exist. What are these trade costs? With the assumption that there are consumers and producers, all costs except production costs are trade costs. Transportation costs, travel costs, and transaction costs are trade costs with distance effects: greater distance equals greater costs. Transportation costs are needed to relocate the goods.

Davis and Weinstein (2001) argue that trade costs exist in international trade, but in very small amounts. When Davis and Weinstein research the volume of trade, they use distance as a measure of trade costs in the same way that it is used in the gravity model. They use the following equation to add distance in their import equation:

$$d(M^{cc'}) = \alpha_0 + \alpha_1 \ln(sX^{c'}) + \delta \ln(d^{cc'}) + \ln(\epsilon^{cc'}).$$ [1]

1) Davis and Weinstein (2001), p.1429.

$M^{cc'}$ denotes predicted imports to country c from country c'. s means total domestic absorption. $X^{c'}$ denotes gross output in country c'. $d^{cc'}$ means distance between countries c and c'. ϵ means error term. α_0, α_1, and δ are parameters. When α and δ are zero, there are no trade costs. Davis and Weinstein (2001) add the effect of trade costs in their accounting, and conclude that trade costs can improve the explanatory power of the factor content of trade. However, it is very important to note, as they write in their paper, that the use of the gravity model[2)] is a major theoretical departure from the factor content methodology, and it is not clear that mixing the two methodologies allows for a clean model. In this paper, we do not attempt to mix the two methodologies, rather we attempt to incorporate the trade costs directly into the factor content methodology.

Deardorff (2004) argues that there are two kinds of theories, the law of Ricardian comparative advantage with no trade costs, and the law of Ricardian local comparative advantage with trade costs (p.15-17). In the case with no trade costs, he assumes that there are two countries, country c and $\hat{c}$, and two goods, good $q1$ and $q2$. The unit factor input a_{q1}^{c} denotes how many units of labor are needed to produce one unit of $q1$ in the country c. a_{q2}^{c} denotes how many units of labor are needed to produce one unit of $q2$ in the country c. With no trade costs, country c has a comparative advantage in producing $q1$ if the following condition is satisfied:

$$\frac{a_{q1}^{c}}{a_{q2}^{c}} < \frac{a_{q1}^{\hat{c}}}{a_{q2}^{\hat{c}}}. \qquad (1)$$

2) The gravity model studies bilateral trade flows as dependent of the size of economy and distance between two countries.

In the second case, Deardorff (2004) includes the trade costs, and the result is:

$$\frac{a_{q1}^{c} + tc_{q1}^{cc'}}{a_{q2}^{c} + tc_{q2}^{cc''}} < \frac{a_{q1}^{\hat{c}} + tc_{q1}^{\hat{c}c'}}{a_{q2}^{\hat{c}} + tc_{q2}^{\hat{c}c''}}. \quad (2)$$

Country c produces $q1$ and delivers it to country c' with additional trade costs, $tc_{q1}^{cc'}$. $tc_{q}^{cc'}$ means how many units of country c's labor are needed to deliver one unit of q from country c to country c'. Country c does not produce $q2$ and deliver it to country c''. Then there is a country $\hat{c}$ that satisfies equation 2.[3)]

Deardorff (2004) argues that if there are trade costs, the pattern of trade may not be well described by the usual measures of comparative advantage. Usual measures of comparative advantage mean comparing a country's costs or autarky price to those of the world (p.3). He explains his theory using comparative advantage methodology and researches the Ricardian model with trade costs. Deardorff also uses his previous research (1980) as well as Dixit and Norman's (1980) book to extend his research and to construct his model with trade costs. He researches the relationship between differentiation in the products and trade to uncover a previously unnoticed role of trade costs. He explains that a country's net trade depends upon production costs and trade costs. His conclusion is that factoring in trade costs works in real world trade.

This paper deduces the original HOV model with trade costs by

3) "The countries c' and c'' could be the same, and either or both could be the same as c or $\hat{c}$, in which case the associated trade cost would be zero. Likewise, good $q2$ could be the same as $q1$, although this would be meaningful only if it were delivered to a different country" (Deardorff (2004), p.15-17).

including trade costs directly in the technology matrix using Deardorff's (2004) basic idea. Additionally, this paper includes trade costs directly in the vector of the net exports.

The contribution of this paper is to show that modifying the HOV model by including trade costs inside of the technology matrix and trade costs in the vector of the net exports can establish considerable gains in the predictive performance of the HOV model.

Ⅱ. Methodology and Models

2.1. Method 1

This paper uses the original HOV model. The original HOV model assumes the following: 1) preferences are homothetic and identical across countries 2) all countries share identical technologies 3) there is perfect competition and 4) there are no trade costs.

We will expand upon the original HOV model in this paper by considering trade costs. This paper deduces the original HOV model with trade costs and compares the importance of the original HOV model with and without trade costs. It does so by including trade costs directly in the technology matrix, where the working assumption is that the trade costs are located in the original country. Trade costs depend positively on the amount of export. Exporters need to spend more trade costs as they export more.

To calculate the factor content of trade in the presence of trade costs, this paper explains how to derive computable expressions for the technology matrix, which includes the trade costs. This is inspired by the work of Deardorff (2004), who considers trade costs explicitly and includes them in the technology matrix.

Let us use the symbol B to represent the factor input matrix. For goods that are traded, we shall define C as the matrix of trade costs measured in factor services. For example, if there are two factors and three industries, the trade cost matrix is defined by the equation:

$$C=\begin{bmatrix} tc_{1K}, tc_{2K}, tc_{3K} \\ tc_{1L}, tc_{2L}, tc_{3L} \end{bmatrix}. \qquad (3)$$

Here, tc_{ij} denotes the trade cost in factor j to deliver one unit of good i abroad. Let us take each country c's vector of net exports T^c and divide it into two vectors, one which contains all rows of T^c that are positive and zeros (called T^{c+}), and one which contains all rows of T^c that are negative and zeros (called T^{c-}). Note that $T^c = T^{c+} + T^{c-}$. In other words, T^{c+} and T^{c-} are the vectors of net exports and net imports, respectively.4) Then, with the assumption that all trade costs are in the exporter country, country c's factor content of trade exports is:

$$F^c = (B+C)T^{c+} + BT^{c-}. \qquad (4)$$

Furthermore, country c's factor endowments are used for production and for exports, and therefore the country's endowments are given by:

$$V^c = B(D^c + T^{c-}) + (B+C)T^{c+}, \qquad (5)$$

where V^c is country c's vector of endowments. The first term on the right is the factor used in producing goods consumed domestically (where D^c is consumption and therefore $D^c + T^{c-}$ is

4) In this theory, we are ignoring the role of intra-industry trade.

the total consumption produced domestically), and the second term is total factor services used in the production and trade of the exported goods. This can also be written as:

$$V^c = B(D^c + T^c) + CT^{c+} = BY^c + CT^{c+}, \tag{6}$$

Here, Y^c is the net output vector for country c.

If we add equation 6 for all countries of the world, we have:

$$V^W = BY^W + CT^{W+}, \tag{7}$$

where V^W, Y^W, and T^{W+} are world endowments of factors, world net output, and world net exports, respectively (i.e., $T^{W+} = \sum_c T^{c+}$). Comparison between equations 4 and 5 shows that:

$$F^c = V^c - BD^c. \tag{8}$$

The assumption of identical and homothetic preferences allows us to write one country's consumption as a proportion of the world, and therefore "$D^c = s^c D^W = s^c Y^W$". When we add D^c for all countries, we get D^W. We define country c's portion of the consumption by the notation: $s^c = GDP^c / GDP^W$.

Subsequently, using equation 8 first and then equation 7, we can write the factor content of trade:

$$F^c = V^c + s^c BY^W = V^c - s^c (V^W - CT^{W+}).$$

Finally, substituting for the factor content of trade from equation 4, we get our testable equation:

$$(B+C)T^{c+} + BT^{c-} = V^c - s^c(V^W - CT^{W+}). \tag{9}$$

This amends the basic Davis and Weinstein (2001) equation by taking into account the trade cost in factor services (matrix C).

All of the variables in equation 9 are given by the data of Davis and Weinstein, except the matrix of trade costs in factor services (C). We have discussed Deardorff (2004), who also employs a similar matrix. However, in the Ricardian methodology, Deardorff only considers one factor of production, labor, and therefore he does not have to model the separation of the cost of trade in labor and the cost of trade in capital. Here, we want this separation of the cost of trade in labor services and capital services. The data appendix of this paper shows how to calculate the trade costs matrix C.

We will use several different assumptions to do this. This paper's basic intention is to update the factor content of trade model by employing a trade cost matrix. We use Deardorff's (2004) basic idea to add the trade costs in the factor content of trade model.

2.2. Method 2

Method 1 is inspired by the work of Deardorff (2004), and method 2 is inspired by the idea that trade costs are applied to the net exports (T^{c+}) and not directly to the technology matrix (B). We know that T^{c+} is the vector of net exports and T^{c-} is the vector of net imports. This method 2 also ignores the role of intra-industry trade. With the assumption that all trade costs are located in the exporting country, we define country c's trade cost vector by the equation:

$$C^c = \begin{bmatrix} T_1^{c+} tc_1 \\ T_2^{c+} tc_2 \\ \vdots \\ \vdots \\ T_n^{c+} tc_n \end{bmatrix}, \tag{10}$$

where $T^{c+} = \begin{bmatrix} T_1^{c+} \\ T_2^{c+} \\ \vdots \\ \vdots \\ T_n^{c+} \end{bmatrix}$, n is the number of industries, and tc_i are the ad valorem trade costs for industry i.

With the above equation 10, country c's factor content of trade is:

$$F^c = BT^c + BC^c. \tag{11}$$

Moreover, country c's factor endowments are given by:

$$V^c = BY^c + BC^c, \tag{12}$$

where V^c is country c's vector of endowments. That is, the factor endowments are all the factors used in production, plus all the factors used in trade.

If we add equation 12 for all countries of the world, we have the world endowment vector:

$$V^W = BY^W + BC^W, \tag{13}$$

where V^W, Y^W, and C^W are the world endowment of factors, world net output, and world trade costs, respectively.

Note that from equation 11, we get:

$$
\begin{aligned}
F^c &= B(Y^c - D^c) + BC^c \\
&= BY^c + BC^c - s^c BY^W \\
&= V^c - s^c(V^W - BC^W),
\end{aligned} \tag{14}
$$

where use was made of equation 13.

Finally, substituting for the factor content of trade from equation 11, we get our testable equation:

$$BT^c + BC^c = V^c - s^c(V^W - BC^W). \tag{15}$$

Ⅲ. Empirical Analysis

We will now proceed to the empirical analysis of the factor content of trade model, following two procedures in section II. Table 1 lists the test results that are based on method 1 and method 2. We have performed the same tests as Davis and Weinstein (2001).

【Table 1】 Test Results of Trade Test

	Method 1	Method 2	Davis and Weinstein (2001) (T1)[5]	Davis and Weinstein (2001) (T7)
Slope Test	0.12	0.0023	-0.002	0.82
Standard Error	0.01	0.0022	0.005	0.03
R^2	0.83	0.052	0.01	0.98
Sign Test	0.65	0.60	0.32	0.91
Variance ratio Test	0.02	0.00017	0.0005	0.69
Observations	20	20	22	22

Notes: Dependent variable is the Measured Factor Content of Trade (MFCT). Theoretical value for the sign test, and the slope test, and the variance ratio test is unity.

5) T1 assumes the original HOV model with US technology. T1 is $B^{US}T^c = B^{US}(Y^c - D^c) = V^c - s^c V^W$.

The data in this paper came from the Input-Output (IO) tables and Structural Analysis (STAN) database of the OECD in 1985. All of the data in this paper are given by Davis and Weinstein (2001), except the matrix of trade costs in factor services.

Davis and Weinstein (2001) assume a gravity-based demand determination of demand[6] that is the most amendments model (T7) in their paper. T7 produces the factor content of consumption incorporating derived fitted values for import demand and complementary measures of one country's own demand. More specifically, Davis and Weinstein derive the factor content of trade as follows:

$$B^{cH}Y^{c}-\left[\hat{B}^{cH}D^{cc}+\sum_{c'\neq c}\hat{B}^{c'\hat{H}}M^{cc'}\right]=[V^{c}-s^{c}V^{W}]^{c} \\ -[V^{cN}-s^{c}V^{WN}]. \quad (16)$$

$\hat{B}^{cH}$ is the technology matrix of country c with the Helpman no-Factor Price Equalization (FPE)[7] model. Y^{cT} is the net output vector for country c and tradable goods. D^{cc} denotes the absorption by country c produced in country c, and $\hat{D}^{cc}$ means the predicted absorption by country c produced in country c. $M^{cc'}$ is the imports from country c to c'. $\hat{M}^{cc'}$ denotes the predicted imports from country c to c' by fitting from a gravity-model estimation.

The slope test is the result of running the trade specification as a regression, whose theoretical slope on the predicted factor content of trade is one. The sign test compares the sign of the measured factor content of trade (left-hand side of the trade

6) The gravity model investigates bilateral trade with size of economy and distance between two countries.

7) Each country's capital to labor ratio (K/L) will affect all input coefficients in the technology matrix.

specification) with the sign of the predicted factor content of trade (right-hand side of the trade specification) and theoretical value of the sign test is one, which means one hundred percent correct match between the measured and the predicted factor content of trade. Finally, the variance ratio test is the ratio between the variance of the measured and the predicted factor contents of trade, and has a theoretical value of one. For comparison, we also list the corresponding results from Davis and Weinstein's paper in Table 1.

For the original HOV model's specification with the trade costs in the technology matrix, method 1, the sign test fits and improves to 65 percent, as shown in Table 1. This is better than relying on a coin toss, and the slope coefficient measured on the predicted factor content of trade is 0.12, which shows that it is still short of the theoretical prediction of unity, but is greater than that of Davis and Weinstein's test result (T1) and it is an impressive statistic, because the slope coefficient is positive, while Davis and Weinstein's trade slope was negative. The variance ratio increases to 0.02, indicating that the variance of the predicted factor content of trade is about 50 times of that which was measured. The R^2 of 0.83 allows us to conclude that the predicted factor content of trade helps to explain 83 percent of the variation in the measured factor content of trade. When we compare the R^2 of method 1 with the R^2 of Davis and Weinstein's study (T1), method 1's result is greater than that of Davis and Weinstein. Therefore, method 1 has a better fit than Davis and Weinstein's result. This high R^2 is a result of the important size effects present when comparing measured and actual factor usage across countries. Standard error means standard error of that slope. Note that these results were obtained without relying on any major departure from the HOV model, which is what Davis and

Weinstein do in their theoretically dubious use of the gravity model. We emphasize that the last column of Table 1 was obtained not only by using the gravity model but also by amending the HOV model in several ways. We get comparable results by simply taking trade costs directly into account.

As we can see from the test results with method 2 in Table 1, the fit of the sign test improves to 60 percent and the slope coefficient increases to 0.0023, relative to Davis and Weinstein's results (T1), which shows that it is still short of the theoretical prediction of unity. The difference of the slope test result between method 2 and Davis and Weinstein (T1) is very small and not very significant. However, it is an impressive statistic, because the slope coefficient is positive where Davis and Weinstein's trade slope was negative. The variance ratio decreases to the insignificant amount of 0.00017, indicating that the variance of the predicted factor content of trade still exceeds that of the measured factor content of trade by a factor of over 5,800. The R^2 of 0.052 implies that the regression equation explains 5.2 percent of the variation in the measured factor content of trade. The R^2 of method 2 is greater than Davis and Weinstein (T1)'s. We conclude therefore that method 1 seems to be the best method to account for trade costs.

Ⅳ. Conclusions

Departing from the Davis and Weinstein procedure, we expand upon the original HOV model by considering trade costs. This paper deduces the original HOV model with trade costs, and compares the importance of the original HOV model with and without trade costs. This first model, method 1, includes the trade costs directly in the technology matrix, where our assumption is that the trade costs are located in the original country. To calculate the factor content of trade in the presence of trade costs, this paper explains how to derive computable expressions for the technology matrix, which includes the trade costs.

This approach permits us to use the standard evaluations of the original HOV model: the sign test, the slope test, and the variance ratio test. Using the dataset of 10 countries, we find evidence supporting the fundamental idea of trade costs inside of the technology matrix, method 1, with a result of 65 percent for the sign concordance, of 0.12 for the slope coefficient, and 0.02 for the variance ratio. Our results indicate that the trade costs inside of the technology matrix are an appropriate modification of the HOV model.

Additionally, this paper includes trade costs directly in the vector of the net exports, method 2, and also finds evidence supporting the theory with the same data as method 1. However, the evidence is weak. With method 2, the sign fit of the sign test improves to 60 percent and the slope coefficient increases to 0.0023; however, the variance ratio test does not show better results than Davis and Weinstein. Our test results also indicate that the trade costs in the vector of the net exports are an appropriate modification of the HOV model, but not as much as the case that the trade costs inside of the technology matrix. If we have more observations with more countries, we expect to have better results with explanation power that explain above two methods.

Received: April 15, 2010. Revised: May 23, 2010. Accepted: May 27, 2010.

◈ *References* ◈

Anderson, James E. and Eric van Wincoop (2002), "Borders, Trade and Welfare," in Brookings Trade Forum 2001. Susan Collins and Dani Rodrik, eds. Washington: Brookings Institution, pp. 207-244.

Anderson, James E. and Eric van Wincoop (2004), "Trade Costs," *Journal of Economic Literature*, 42(3), pp. 691-751.

Bernard, Andrew, Bradford Jensen, and Peter Schott (2006), "Trade Costs, firms and productivity," *Journal of Monetary Economics*, 53, pp. 917-937.

Davis, D. R. and D.E. Weinstein (2001), "An Account of Global Factor Trade," *The American Economic Review*, 91(5), pp. 1423-1453.

Deardorff, Alan V. (2004), "Local Comparative Advantage: Trade Costs and the Pattern of Trade," University of Michigan Research Seminar in International Economics Working paper No. 500.

Dixit, A.K. and V. Norman (1980), *Theory of International Trade*, Cambridge, Nisbet/Cambridge University Press, Cambridge.

Feenstra, Robert C. (1996), "U.S. Imports, 1972-1994. Data and Concordances," NBER Working paper 5515.

OECD (Organization of Economic Cooperation and Development) (2002), "The OECD Input-Output Database, International Sectoral Data Base, and The OECD Structural Analysis (STAN) Data Base," OECD Economic and Statistic Division.

OECD (2005), "The OECD STAN database for Industrial Analysis," available at http://www.oecd.org/dataoecd/53/21/34464010.doc.

Penn World Table 6.2, University of Pennsylvania.

Samuelson, Paul A. (1952), "The Transfer problem and Transport Costs," *Economic Journal*, 62(246), pp. 278-304.

Schott, P., website available at www.som.yale.edu/faculty/pks4/sub_international.htm.

Vanek, Jaroslav (1968), "The Factor Proportions Theory: The N-Factor

Case," *Kyklos*, 21(4), pp. 749-754.
World Development Indicators (2007), World Bank.

DATA APPENDIX

This data section explains briefly where Davis and Weinstein got their original data, and how we obtain trade costs.

A1. Data Sources:

The data for the total factor requirement matrix (B) used the 1985 OECD IO tables. The data for capital (K) and labor (L) used the 1997 OECD STAN database for manufacturing sectors and the 1996 International Sectoral Database (ISDB) for other sectors. Capital stock was calculated by the perpetual inventory method.[8] Sectoral labor inputs and total employment for the year 1985 were derived from the OECD STAN databases and the ISDB. Labor for manufacturing sectors data were taken from the STAN Numbered Engaged (NE) and, for non-manufacturing sectors of labor, the ISDB Total Employment was used.

The data for production (Y^c), demand (D^c), and trade (T^c, T^{c+}, T^{c-}) used the 1995 OECD IO database. The vector of factor endowments (V^c) for country c was calculated as: $V^c \equiv B^c Y^c$. The data for trade costs (tc_i) were taken from Bernard, Jensen, and Schott's (2006) data and were modified for this paper.

A2. Countries:

We used 10 OECD countries for a year circa 1985: Australia (1986), Canada (1986), Denmark (1985), France (1985), Germany (1986), Italy (1985), Japan (1985), the Netherlands (1986), the United

8) "The Perpetual Inventory Method (PIM) generates an estimate of the capital stock by accumulating past purchases of assets over their estimated service lives" (Measuring Capital, OECD Manual (2001), p.43).

Kingdom (1984), and the United States (1985).

A3. Industries:

Data for each of the 10 OECD countries are organized by their 16 industries. Table A1 shows classification of 16 industrial activities. These are the industries that can be matched between Bernard, Jensen, and Schott's (2006) and Davis and Weinstein's (2001) papers. Table A1 shows IO sectors, IO sectors' description, and International Standard Industrial Classification (ISIC) Revision 2 codes that match with IO sectors.

【Table A1】 Classification of Industrial Activities

IO Sector	Description	ISIC Rev. 2 codes
3	Food, beverages, and tobacco	31
4	Textiles, apparel, and leather	32
5	Wood products and furniture	33
6	Paper, paper products and printing	34
7	Industrial chemicals	351+352-3522
9	Petroleum and coal products	353+354
10	Rubbers and plastic products	355+356
11	Non-metallic mineral products	36
14	Metal products	381
15	Non electrical machinery	382-3825
16	Office and computing machinery	3825
20	Other transports	3842+3844+3849
21	Motor vehicles	3843
22	Aircraft	3845
25	Electricity, gas, and water	4
35	Other producers	

Note: Davis and Weinstein (2001), p.1446.

A4. Trade Costs:

Along with Davis and Weinstein's (2001) data, this paper also uses trade costs data from 1987. Because we cannot get data for trade costs from 1985, we assume that trade costs in 1987 were approximately similar to the trade costs in 1985.

Bernard, Jensen and Schott (2006) show that trade costs affect the manufacturing activities of the United States. They use ad valorem trade costs with a heterogeneous firm model. If the trade costs decrease, high productivity firms redistribute their economic activities. Firms with low productivity cannot survive when trade costs decrease. Firms with high productivity will increase their exports as trade costs are decreased. Bernard et al.'s contribution was to construct trade costs by industry (p.917). They calculate the following (p.922):

$$Trade\ Costs_{it} = d_{it} + f_{it},$$

where the left side represents the trade costs for industry i and year t. Thus, trade costs are the sum of any tariffs[9] and freight costs. In the expression above, d_{it} means ad valorem duty on industry i and year t and f_{it} means freight and insurance costs of industry i and year t. Bernard, Jensen and Schott (2006) obtained d_{it} and f_{it} from Feenstra's (1996) paper and database. This database is made up from the United States' import data. They construct the ad valorem duty (d) and ad valorem freight and insurance (f) according to the following formula (p.922):

$$d_{it} = \frac{duties_{it}}{fob_{it}}.$$

Thus, tariff costs (d_{it}) are the sum of duties collected in industry i in year t divided by fob_{it}. In the expression above, fob_{it} is the free on board value of imports. Furthermore, Bernard,

9) Here, tariff means ad valorem tariff.

Jensen and Schott (2006) construct the freight and insurance of industry i and year t according to the following formula:

$$f_{it} = \frac{cif_{it}}{fob_{it}} - 1\,.$$

Freight costs[10] are the sum of freight and insurance charges in industry i in year t (i.e. the markup of the cost insurance freight value (cif_{it})) divided by fob_{it} (i.e. custom value of imports). They construct their trade costs as follows (see Table A2):

Bernard et al.'s (2006) paper concludes that when trade costs decrease by a large amount, then productivity growth increases by a large amount. When trade costs are decreased, low-productivity firms are met with destruction and high-productivity firms are met with prosperity. Bernard et al. find the relationship between free trade and an increase in productivity in the case of developed countries (p.934). This paper uses the trade cost data shown above in Table A2 ($Trade\ costs_{it} = d_{it} + f_{it}$) along with Peter Schott's (2002) data.[11]

Bernard et al. (2006) create a dataset of industry level trade costs for years, 1982, 1987, and 1992. They calculate industry-level data and construct ad valorem trade costs. These ad valorem trade costs data are changed by time and across industries. Bernard et al. (2006) define the trade costs variable for industry i and year t as, $Trade\ costs_{it}$. $Trade\ costs_{it}$ are the sum of the ad valorem duty(d_{it}) and the ad valorem freight and insurance (f_{it}). Bernard et al. calculate d_{it} and f_{it} from Feenstra (2006). They define the trade costs rate for industry i as the weighted average of trade cost rates across all products in industry i. Bernard et al. (2006)

10) Freight costs are ad valorem freight rates.
11) www.som.yale.edu/faculty/pks4/sub_international.htm.

explain tariff, freight, and total trade costs.

【Table A2】 Ad valorem Trade Costs by Two Digits SIC[12] Industry and Year

Two digit SIC industry	Tariff rate (d_{it}) (%)			Freight rate (f_{it}) (%)			Total rate ($d_{it}+f_{it}$) (%)		
	1982	1987	1992	1982	1987	1992	1982	1987	1992
20 Food	5.7	5.1	4.4	10.2	9.7	8.9	15.9	14.8	13.4
21 Tobacco	10.4	14.1	16.7	5.9	5.2	2.9	16.3	19.3	19.5
22 Textile	17.0	13.2	11.2	6.0	6.4	5.4	23.1	19.6	16.6
23 Apparel	23.3	20.7	16.9	8.6	7.6	6.3	31.8	28.3	23.2
24 Lumber	3.2	2.3	1.7	11.1	6.5	7.5	14.2	8.8	9.2
25 Furniture	5.9	4.1	4.1	9.4	8.6	8.5	15.3	12.8	12.6
26 Paper	0.9	0.8	0.6	3.9	3.1	4.4	4.7	4.0	4.9
27 Printing	1.7	1.2	1.1	5.9	5.5	5.1	7.5	6.6	6.2
28 Chemicals	3.8	4.3	4.4	6.4	4.8	4.5	10.1	9.1	9.0
29 Petroleum	0.4	0.5	0.9	5.2	5.1	8.3	5.6	5.5	9.3
30 Rubber	7.4	7.9	11.3	7.5	6.8	6.9	14.9	14.7	18.2
31 Leather	9.0	10.7	11.2	8.3	7.2	5.5	17.3	17.8	16.7
32 Stone	8.9	6.4	6.5	12.0	11.1	9.6	20.9	17.5	16.1
33 Primary Metal	4.6	3.8	3.4	6.9	6.3	6.0	11.5	10.1	9.4
34 Fabricated Metal	6.6	5.1	4.3	6.8	5.9	5.0	13.4	11.0	9.3
35 Industrial Machinery	4.2	3.9	2.4	4.0	4.0	2.9	8.2	7.9	5.3
36 Electronic	5.0	4.6	3.3	3.4	3.1	2.4	8.3	7.6	5.6
37 Transportation	1.9	1.6	2.3	4.5	2.5	3.1	6.4	4.1	5.4
38 Instruments	6.8	5.2	4.3	2.7	2.8	2.5	9.5	8.0	6.8
39 Miscellaneous	9.6	5.7	5.2	5.0	4.9	3.6	14.6	10.6	8.8
Average	4.8	4.4	4.2	5.6	4.4	4.1	10.4	8.8	8.3

Notes: This table summarizes ad valorem tariff, freight, and total trade costs across two-digit SIC industries. Costs for each two-digit industry are weighted averages of the underlying four digit industries employed in our empirical analysis, using U.S. import values as weights. Figures for each year are the average for the five years preceding the year noted (e.g., the costs for 1982 are the average of costs from 1977 to 1981). The final row is the weighted average of all manufacturing industries(Bernard et al. (2006), p.923).

We now explain how to calculate trade costs, C for this paper. To calculate trade costs for industry i for the United States, we

12) SIC stands for Standard Industrial Classification.

used Bernard et al.'s (2006) data. First, we harmonized the two-digit SIC industry in Bernard et al.'s trade cost rates and the ISIC Rev.2 codes in Davis and Weinstein's paper.

When two or more industries (i, j) in Bernard et al.'s data correspond to only one of Davis and Weinstein's IO industries, we used the following equation:

$$Trade\ costs_{IO\,industry} = \frac{US\,trade\ in\ i \times Trade\ Costs_i + US\,trade\ in\ j \times Trade\ Costs_j}{US\,trade\ in\ i + US\,trade\ in\ j}. \quad (A1)$$

The United States' trade data for the above equation A1 came from Davis and Weinstein.

Finally, we can get the following trade cost rates with 16 concordant IO sectors.

【Table A3】Trade Costs Rate (%)

IO Sector	Trade costs rate (%)
3	16.3
4	22.4
5	9.7
6	6.4
7	9.1
9	5.5
10	14.7
11	17.5
14	10.2
15	7.9
16	7.9
20	4.1
21	4.1
22	4.1
25	7.6
35	10.6

Next, we need to model the separation of the cost of trade in capital and the cost of labor. Therefore, we want this separation of the cost of trade in capital services and labor services. We divided trade costs for industry i (tc_i) into labor and capital to calculate trade costs for capital, we used the following equation:

$$tc_{iK} = \frac{b_{iK} \times tc_i}{b_{iK} \times b_{iL}}. \tag{A2}$$

To calculate trade costs for labor, we used the following equation:

$$tc_{iL} = \frac{b_{iL} \times tc_i}{b_{iK} \times b_{iL}}. \tag{A3}$$

The sum of trade costs for industry i in capital services (tc_{iK}), and trade costs for industry i in labor services (tc_{iL}), is therefore equal the total trade costs for industry i:

$$tc_{iK} + tc_{iL} = tc_i. \tag{A4}$$

Furthermore, we have assumed that the division of trade costs into labor and capital services has followed the same proportion as production in the same industry. This is obviously a very strong assumption, but it is one that is dictated by the data.

무역비용이 Factor Content 이론에 영향을 미치는가?

김 연 준*

논문초록

본 연구는 국제무역에 있어서 factor content 이론을 설명하는 모형인 헥셔-오린-바넥 모형에 무역비용을 추가한 경우가 추가하지 않은 경우보다 설명력이 더 높아지는지 여부를 연구한다. 이를 위해 무역비용을 직접적으로 technology matrix에 추가하여 고려하는 방법과 무역비용을 net exports 벡터에 포함하는 두가지 방법으로 이론을 확장한 뒤, 무역비용을 추가할 경우 모형의 설명력을 얼마나 높였는가를 OECD의 10개 국가를 가지고 분석하였다. 분석을 위해 무역비용을 제외한 경우 Davis and Weinstein (2001)과 동일한 자료를 사용하였으며 이들이 사용한 sign test, slope test, variance ratio test 검증치를 구하여 이를 Davis and Weinstein의 결과와 비교하였다. 무역비용 데이타는 Bernard, Jensen and Schott가 이용한 데이타를 사용하였다. 비교분석결과, 무역비용을 고려한 모형, 특히 본 연구가 취한 두가지 확장 중 무역비용을 technology matrix에 포함시키는 방법의 설명력이 무역비용을 고려하지 않은 모형의 설명력보다 우월함을 보인다. 기존 국제무역론 연구의 관심이 되어온 무역의 factor content를 설명함에 있어서 무역비용이 중요한 역할을 한다는 점을 보여준다.

주제분류 : B030800
핵심 주제어 : 무역의 Factor Content, 무역 비용, 헥셔-오린-바넥 모델

* 포스코경영연구소 경제연구실 연구위원, E-mail: yjkim@posri.re.kr