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Nonhomothetic Tastes and Missing Trade of Factor Services

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Abstract

The production mix and a country's consumption bundle might plausibly depend on the development level of the country. For example, in Markusen (1986) a developing country specializes in producing labor-intensive goods and allocates most of its income to the consumption of these goods. The recent literature on the Heckscher-Ohlin-Vanek (HOV) model has concentrated on the production side; and, the modified HOV model better conforms to the global data when the unrealistic assumptions of identical techniques and factor price equalization are relaxed. However, less is known about the demand side. In this paper, we study the assumption of identical and homothetic preferences as a cause of the empirical failures in the HOV prediction. While the relaxation in identical production techniques is still crucial to predict the direction of factor trade, nonhomothetic tastes are shown to play an important role in explaining why factor trade is "missing" in the sense of Trefler (1995) relative to the HOV prediction.

F11: Neoclassical Model of Trade
Keywords: Heckscher-Ohlin; Technology; North-South Bias in Development; Factor Abundance; Nonhomothetic Tastes; Per Capita Income

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1. Introduction

Recent advances in empirical international trade have increased our understanding of how the Heckscher-Ohlin-Vanek (HOV) model fails to predict the direction and volume of global factor trade. Most of the literature (e.g., Davis and Weinstein, 2001; Hakura, 2001; Schott, 2003; Choi and Krishna, 2004; Lai and Zhu, 2007) has demonstrated that the unrealistic assumptions of identical techniques and factor price equalization are responsible for previous empirical failures.[1] In particular, since developed countries employ more capital-intensive techniques than developing countries do, we cannot measure accurately the direction and volume of factor trade under the assumption of identical techniques everywhere.

While the development stage of a country affects both production and consumption (e.g., Markusen, 1986), little is known about the significance of HOV errors[2] caused by international differences in preferences. Linder (1961) is the first to emphasize the role of preferences in the direction of global trade.[3] Since consumers with similar per capita incomes consume similar bundles of goods, Linder argued that a country tends to export to and import from countries with similar per capita incomes (i.e., intra-industry trade). Markusen (1986) incorporated Linder's idea into a model combining nonhomothetic preferences, scale economies (e.g., Krugman, 1979), and factor abundance.[4,5] The model predicts that the labor abundant country, the South, not only specializes in producing labor-intensive goods but also consumes these goods intensively. Moreover, the volume of trade between developed and developing countries decreases as the degree of preference nonhomotheticity increases. This prediction suggests that the standard HOV model would over-predict the volume of factor trade from factor abundance if preferences

[1] The history of the empirical HOV that concentrated on modifications of the assumptions started with Maskus (1985) followed by Bowen, Leamer, and Sveikauskas (1987).

[2] These HOV errors represent Trefler's (1995) "missing trade." Factor services embodied in net exports are usually smaller than those predicted from the standard HOV model. The HOV errors in this paper are factor services embodied in net exports, measured factor contents of trade, minus those predicted from factor abundance, or predicted factor contents of trade.

[3] Linder's important idea also related to the role of product quality as a determinant of the volume and direction of trade. Hallak (2006) introduced a quality index into the Dixit-Stiglitz demand system and found evidence for nonhomothetic preferences within a product by keeping the identical and homothetic preferences across industries.

[4] Matsuyama (2000) incorporated nonhomothetic preferences into the Dornbusch-Fischer-Samuelson (1977) model.

[5] Hunter (1991) empirically addressed the statistical significance of the preference-driven trade by extending Hunter and Markusen (1988). She obtained the demand data for a group of 34 countries and developed the counterfactual consumption bundles under the assumption of identical and homothetic preferences to estimate inter-industry trade caused from differences in preferences. Her results provided strong evidence that nonhomothetic preferences play an important role in determining the direction and volume of global trade. In particular, the preference-driven trade accounts for as much as 25 percent of global net-trade flows.

were indeed nonhomothetic in this way across countries. Thus, nonhomothetic preferences alone could explain why factor trade is "missing" relative to its HOV prediction (Trefler, 1995).

In their seminal paper, Bowen, Leamer, and Sveikauskas (1987) did study identical and homothetic preferences as a potential cause of the empirical failure of the HOV model and concluded that this assumption is not as important as productivity differences and measurement errors in factors. The purpose of this paper is to revisit this question using a different approach and with a substantially more complete dataset of 28 countries including both developed and developing countries.[6] By using Hakura's (2001) pair-wise HOV framework combined with Davis and Weinstein's (2001) specifications, we develop an empirical method to estimate the amount of missing factor trade caused by nonhomothetic tastes and compare it with that caused by identical techniques. Specifically, we first divide country pairs into North-North pairs, South-South pairs, and North-South pairs according to labor compensation per capita. Next, we evaluate the standard HOV model performance by imposing all HOV assumptions. Then, we relax the assumption of identical techniques by introducing each country's actual techniques. The improvement in the HOV prediction from the standard model to the relaxed model is the volume of missing trade explained by identical techniques. Second, we develop an HOV specification that imposes only the assumption of identical and homothetic preferences.[7] Then, we drop this assumption by introducing a vector of deviations between one country's actual consumption vector and its counterfactual one under the assumption of identical and homothetic preferences. Now the improvement in the HOV prediction from the former to the latter is the volume of missing trade explained by cross-country differences in preferences. By comparing these deviations, we study the contributions of technique versus preference for Trefler's missing trade in the HOV model.

The findings in this paper are straightforward and somewhat surprising. While tastes are similar among the countries with similar per capita incomes, the HOV errors generated by assuming identical preferences become significant as income gaps of two countries increase. In fact, the preference-related missing trade for labor services is quantitatively more significant than the technology-related missing trade in North-South trade. Moreover, the direction of the

[6] The dataset consists of actual techniques, Input-Output tables, and bilateral imports for 28 countries.

[7] Indeed, this specification is Hakura's (2001) modified HOV model. Even though Hakura argued that her specification is evidence for technical differences across countries, it really imposes only the one assumption of identical and homothetic preferences in conjunction with the equations developed from the Input-Output tables which are in fact identities.

preference-driven HOV deviations is consistent with the prediction from Markusen's (1986) model. While preferences may be neither identical nor homothetic around the world, they are particularly strongly nonhomothetic between developed and developing countries. Thus, developed countries apparently consume relatively less of labor-intensive goods (i.e., agriculture products and food) and more of capital-intensive goods (i.e., automobiles and office machinery) and the volume of factor trade decreases as the difference in per capita income increases.

As in Davis and Weinstein (2001), the modification in identical techniques remains central in order to obtain the right direction of factor trade relative to the HOV prediction. By relaxing the restriction of identical techniques and using each country's actual techniques, the sign tests for North-South pairs improve from 37.8 to 80.6 percent for labor and from 87.2 to 95.6 percent for capital; the HOV model with technical adjustment precisely predicts that a developed country is an exporter of capital services and an importer of labor services relative to a developing country.[8] The relaxation in techniques is important even for the North-North or the South-South country pairs since measured factor contents of trade involves all trade-partners' techniques through bilateral imports. The difference in preferences, on the other hand, does not change the direction of factor trade but matters for the volume of factor trade between developed and developing countries. There is no noticeable change for the North-North country pairs when the assumption of identical and homothetic tastes is relaxed, indicating preferences are similar among developed countries.

One way to view our results is that we should expect the development stage of a country to affect various aspects of the country's economic activity. Countries accumulate capital stocks and skills, increase their productivity levels, employ more capital-intensive techniques, and specialize in capital- or skill-intensive subsets of goods as they develop (e.g., Fitzgerald and Hallak, 2004; Maskus and Nishioka, 2009). Nonhomotheticity in preferences is one such systematic mechanism on the demand side. Fitzgerald and Hallak (2004) found a strong correlation between factor accumulation and specialization by estimating the productivity-adjusted Rybczynski equation. However, they could not conclude whether the strong correlation is driven from factor proportions or from other development-related mechanisms. Nonhomothetic preferences, which also correlate with factor proportions, could be an explanation of such a mystery.

[8] See Leontief's original paradox (1953) and Leamer's (1980) and Davis and Weinstein's (2001) solutions.

The remainder of this paper is organized into three sections. In Section 2, we develop the four HOV specifications developed from Hakura (2001) and Davis and Weinstein (2001), and provide the empirical strategy to measure the volume of missing trade attributable to technique and taste. Section 3 provides some insight on how consumption bundles differ across countries and studies empirical regularities by sorting country pairs according to the differences in two countries' per capita incomes. We present concluding remarks in the last section.

2. Theoretical Framework

We begin by deriving the standard HOV model in a world with *F* factors, *C* countries, and *N* products. For each country *c*, the net export vector is the difference between net production ($\mathbf{Y}^c$) and final consumption ($\mathbf{D}^c$):

(1) $$\mathbf{T}^c = \mathbf{X}^c - \left[\sum_{c' \neq c} \mathbf{M}^{cc'}\right] = \mathbf{Y}^c - \mathbf{D}^c$$

where $\mathbf{T}^c$ is an $N\times1$ vector of net exports, $\mathbf{X}^c$ is an $N\times1$ vector of total exports for country *c*, and $\mathbf{M}^{cc'}$ is an $N\times1$ vector of imports from country *c'* to country *c*.

As documented in the previous literature (e.g., Bowen, Leamer, and Sveikauskas 1987; Trefler 1995; Davis and Weinstein 2001), the standard HOV model is hopeless without adjusting for efficiency differences across countries. Total factor productivity (TFP) is the simplest measure to adjust for unobserved differences in factor performance across countries. We implement the TFP adjustment for all HOV specifications in this paper by normalizing productivity differences to the United States.[9]

$\mathbf{B}^c$ is the $F\times N$ technical matrix and each element (a^c_{fi}), representing the unit effective factor requirement, corresponds to the amount of a factor *f* required to produce one unit of net output for sector *i*. Equation (1) is pre-multiplied by the technical matrix $\mathbf{B}^c$, and using the factor-exhaustion assumption $\mathbf{B}^c\mathbf{Y}^c=\mathbf{V}^c$ where $\mathbf{V}^c$ is an $F\times1$ vector of effective factor endowments, we obtain:

(2) $$\mathbf{B}^c\mathbf{T}^c = \mathbf{V}^c - \mathbf{B}^c\mathbf{D}^c$$

That is, a country's factor contents of trade are the difference between a country's factor endowments ($\mathbf{B}^c\mathbf{Y}^c=\mathbf{V}^c$) and factors absorbed in final consumption ($\mathbf{B}^c\mathbf{D}^c$).

[9] To save space, we do not report the estimation results of TFP. We employ the procedure proposed by Davis and Weinstein (2001).

Here, equation (2) is an *identity equation* for each country since $\mathbf{B}^c\mathbf{Y}^c$=$\mathbf{V}^c$ and $\mathbf{T}^c$=$\mathbf{Y}^c$-$\mathbf{D}^c$ always hold by data construction.

Assuming identical and homothetic tastes, along with identical prices of goods and services, the final consumption vector is proportional to the world output vector ($\mathbf{Y}^w$):

(3) $$\mathbf{D}^c = s^c \mathbf{Y}^w$$

where s^c is a scalar representing the share of country *c* in world expenditure.

Since the standard HOV assumption is identical techniques worldwide ($\mathbf{B}^c$=$\mathbf{B}^{c''}$), the techniques matrix of country *c* is arbitrarily chosen to derive $\mathbf{B}^c\mathbf{D}^c$=$s^c\mathbf{B}^c\mathbf{Y}^w$=$s^c\mathbf{V}^w$. Then, the standard HOV model with the TFP adjustment follows:

(4) $$\mathbf{B}^c\mathbf{T}^c = \mathbf{V}^c - s^c\mathbf{V}^w$$

where $\mathbf{B}^c\mathbf{T}^c$=$\mathbf{B}^c\mathbf{X}^c$-[$\Sigma_{c'\neq c}$ $\mathbf{B}^c\mathbf{M}^{cc'}$] is the *measured factor contents* of trade and $\mathbf{V}^c$-$s^c\mathbf{V}^w$ is the *predicted factor contents* of trade. The HOV theorem predicts that the measured factor contents of trade for any country must equal the difference between the country's factor endowments and the product of that country's consumption share and world factor endowments. This is the HOV prediction identified by Leamer (1980).

The standard HOV model is further modified to develop the pair-wise model (e.g., Staiger, Deardorff, and Stern 1987; Hakura 2001). For any two arbitrarily chosen countries *c* and *c*", take the ratio of consumption shares so that the world output ($\mathbf{Y}^w$) in equation (3) can be eliminated to yield:

(5) $$\mathbf{D}^c = s^c / s^{c''}\mathbf{D}^{c''} = s^{cc''}\mathbf{D}^{c''}$$

Then, by combining equation (4) for these two countries with equation (5), the pair-wise version of the HOV model follows:

(6) $$\mathbf{B}^c\mathbf{T}^c - s^{cc''}\mathbf{B}^c\mathbf{T}^{c''} = \mathbf{V}^c - s^{cc''}\mathbf{V}^{c''}$$

where $\mathbf{B}^c\mathbf{T}^c$-$s^{cc''}\mathbf{B}^c\mathbf{T}^{c''}$ is the measured *relative* factor contents of trade with country *c*'s techniques and $\mathbf{V}^c$-$s^{cc''}\mathbf{V}^{c''}$ is the predicted *relative* factor contents of trade.

Equation (6) reveals that the measured relative factor contents of trade can be predicted from the relative factor abundance between any two countries. The primary advantage of the two-country HOV model is that the testing equation does not include any world aggregate. In addition, since our dataset consists of 28 countries, we have 378 observations for each factor, which can be organized into combinations of country pairs with various stages of development.

Deviations from Identical Techniques

Davis and Weinstein (2001) found substantial improvements in the predictive power of the HOV model when national techniques are relaxed according to technical differences and a breakdown in factor price equalization. The Dornbusch-Fischer-Samuelson (1980) model is the first specification that relaxes the unrealistic assumption of identical techniques. Since the DFS model predicts that a capital abundant country exports capital-intensive goods and imports labor-intensive goods,[10] exports from a capital abundant country in a given industry are more capital-intensive than world production in that industry. These insights are introduced into the following specification wherein the factor contents of exports are measured with the exporter's actual techniques and those of imports are measured bilaterally with the producer countries' techniques.

(7) $$\mathbf{B}^c\mathbf{X}^c - \left[\sum_{c'\neq c}\mathbf{B}^{c'}\mathbf{M}^{cc'}\right] = \mathbf{V}^c - s^c\mathbf{V}^w$$

By combining equation (7) for two countries with equation (5), the pair-wise HOV model that allows for technical differences follows:

(8) $$\mathbf{B}^c\mathbf{X}^c - \left[\sum_{c'\neq c}\mathbf{B}^{c'}\mathbf{M}^{cc'}\right] - s^{cc''}\ \mathbf{B}^{c''}\mathbf{X}^{c''} - \left[\sum_{c'\neq c''}\mathbf{B}^{c'}\mathbf{M}^{c''c'}\right] = \mathbf{V}^c - s^{cc''}\mathbf{V}^{c''}$$

Thus, a comparison of equation (8) with equation (6) will allow an assessment of the role of technology differences in explaining errors in the HOV prediction.

Deviations from Identical and Homothetic Tastes

Hakura (2001) developed the modified version of the HOV model by combining equation (2) for two countries with the corresponding countries' relative consumption shares, equation (5), under the assumption of identical and homothetic preferences:

(9) $$\mathbf{B}^c\mathbf{T}^c - s^{cc''}\mathbf{B}^{c''}\mathbf{T}^{c''} - (\mathbf{B}^{c''} - \mathbf{B}^c)\mathbf{D}^c = \mathbf{V}^c - s^{cc''}\mathbf{V}^{c''}$$

Equation (9) represents the standard HOV relationship in equation (6) adjusted by the difference in the techniques multiplied by the country *c*'s consumption vector. Hakura (2001) argued that the assumptions of identical and homothetic preferences, no barriers to trade, zero transport cost, and perfect competition in product and factor markets are imposed to obtain equation (9) and that the vector $(\mathbf{B}^{c''}\text{-}\mathbf{B}^c)\mathbf{D}^c$ captures how differences in techniques across two

[10] The specifications, such as Helpman's (1999) multiple-cone production model, assume a similar idea. A capital abundant country employs more capital-intensive techniques across all industries. Instead of estimating techniques and employing the fitted values from estimation as in Davis and Weinstein (2001), we take advantage of using actual techniques as in Hakura (2001).

countries modify the standard HOV prediction.[11] However, equation (9) is developed from the *identity equations* of national accounts, equation (2) for two countries, and the assumption of identical and homothetic preferences between countries c and c", equation (5). Therefore, good performance of equation (9) provides evidence solely for identical and homothetic tastes. In particular, Hakura's evidence is based on four European countries: Belgium, France, Germany, and the Netherlands. It is then not surprising to find strong support for equation (9) since consumers' preferences across these four European countries might be similar.

As discussed previously however (e.g., Linder, 1961; Markusen, 1986; Hunter, 1991; Matsuyama, 2002), low-income countries might spend more on labor-intensive goods, suggesting a violation of identical and homothetic preferences. To study preference-driven errors in the HOV prediction, we introduce a vector $\mathbf{E}^{cc''}$ in order to construct the following identity equation:

(10) $$\mathbf{D}^{c} + \mathbf{E}^{cc''} = s^{cc''}\mathbf{D}^{c''}$$

If two countries' preferences are identical and homothetic, $\mathbf{E}^{cc''}$ must be a zero-vector. The deviation in the consumption bundle relative to the other country is captured by $\mathbf{E}^{cc''}$. By using equation (2) for two countries and equation (10), equation (11) follows:

(11) $$\mathbf{B}^{c}\mathbf{T}^{c} - s^{cc''}\mathbf{B}^{c''}\mathbf{T}^{c''} - (\mathbf{B}^{c''} - \mathbf{B}^{c})\mathbf{D}^{c} - \mathbf{B}^{c''}\mathbf{E}^{cc''} = \mathbf{V}^{c} - s^{cc''}\mathbf{V}^{c''}$$

Equation (11) is an identity equation. Because equation (9) imposes a restriction $\mathbf{E}^{cc''}=\mathbf{0}$, the difference between these two equations, $-\mathbf{B}^{c''}\mathbf{E}^{cc''}$, represents the deviations in the HOV model generated from identical and homothetic tastes.

Empirical Strategy for Testing Technique and Taste

To study the empirical failures of the HOV model caused by identical techniques, we first define the pair-wise HOV errors from equations (6) and (8). In the empirical exercises below, we concentrate on tradable sectors since the consumption vector in nontraded sectors are subject to government spending such as national defense and since the introduction of nontraded goods

[11] Even though Davis and Weinstein (2001) and Hakura (2001) both argued that their favored models depend on the modification in identical techniques and factor price equalization, the successes of the two equations (9) and (8) are fundamentally different. While Davis and Weinstein (2001) employed all trade partners' techniques to measure factor contents of trade, Hakura (2001) used only two countries' techniques. Therefore, Hakura's technology adjustment term, $(\mathbf{B}^{c''}-\mathbf{B}^{c})\mathbf{D}^{c}$, is not consistent with Davis and Weinstein's technology modification. In particular, Hakura's specification generates systematic technology biases such that net factor trade of a developed country, $\mathbf{B}^{c}\mathbf{T}^{c}$, overstates capital services and understates labor services imported from developing countries.

is an important independent element of Davis and Weinstein's success. These HOV errors are then given by:

$$\mathbf{E}_S^{cc"} = \mathbf{B}^{cT}\mathbf{T}^{cT} - s^{cc"}\mathbf{B}^{cT}\mathbf{T}^{c"T} - (\mathbf{V}^{cT} - s^{cc"T}\mathbf{V}^{c"T}) \tag{6'}$$

$$\mathbf{E}_P^{cc"} = \mathbf{B}^{cT}\mathbf{X}^{cT} - \left[\sum_{c'\neq c}\mathbf{B}^{c'T}\mathbf{M}^{cc'T}\right] - s^{cc"T}\ \ \mathbf{B}^{c"T}\mathbf{X}^{c"T} - \left[\sum_{c'\neq c"}\mathbf{B}^{c'T}\mathbf{M}^{c"c'T}\right]\ - (\mathbf{V}^{cT} - s^{cc"T}\mathbf{V}^{c"T}) \tag{8'}$$

where the superscript T indicates tradable sector.

The improvement in the HOV equation from equation (6) to (8), or $\mathbf{E}^{cc"}{}_P - \mathbf{E}^{cc"}{}_S$, is the amount of missing trade caused by identical techniques.

Second, to study the empirical failures of the HOV model caused by identical tastes, we define the pair-wise HOV errors from equations (9) and (11).

$$\mathbf{E}_M^{cc"} = \mathbf{B}^{cT}\mathbf{T}^{cT} - s^{cc"T}\mathbf{B}^{c"T}\mathbf{T}^{c"T} - (\mathbf{B}^{c"T} - \mathbf{B}^{cT})\mathbf{D}^{cT} - \ \mathbf{V}^{cT} - s^{cc"T}\mathbf{V}^{c"T} \tag{9'}$$

$$\mathbf{E}_I^{cc"} = \mathbf{B}^{cT}\mathbf{T}^{cT} - s^{cc"T}\mathbf{B}^{c"T}\mathbf{T}^{c"T} - (\mathbf{B}^{c"T} - \mathbf{B}^{cT})\mathbf{D}^{cT} - \mathbf{B}^{c"T}\mathbf{E}^{cc"T} - \ \mathbf{V}^{cT} - s^{cc"T}\mathbf{V}^{c"T} \tag{11'}$$

Here, we compare the pair-wise HOV model that imposes the assumption of identical and homothetic preferences, equation (9), with equation (11) that drops this assumption. Again, the improvement, $\mathbf{E}^{cc"}{}_I - \mathbf{E}^{cc"}{}_M$, is the amount of missing trade explained by nonhomothetic tastes. By comparing these deviations, $\mathbf{E}^{cc"}{}_P - \mathbf{E}^{cc"}{}_S$ and $\mathbf{E}^{cc"}{}_I - \mathbf{E}^{cc"}{}_M$, we discover the contributions of technique versus preference for the missing trade of the HOV model. We next divide the 378 country pairs into North-North pairs, North-South pairs, and South-South pairs and apply the four specifications of the pair-wise HOV models to each subset. This will allow us to isolate the contributions of technique differences and taste differences.

In order to understand the direction of the preference-driven and technology-driven errors, consider the simple 2x2x2 case wherein a developed country c and a developing country c" both produce labor-intensive and capital-intensive goods.[12] To produce each good, the two countries may employ different techniques, which may be adjusted by either factor-neutral TFP or factor-specific productivities (e.g., Trefler 1993). Since country c is capital abundant and country c" is labor abundant, country c exports the capital-intensive good and imports the labor-intensive good. If both countries consume under identical and homothetic preferences, we can predict the volume of factor trade from relative factor abundance since equations (5) and (9) must hold with strict equality. Now, consider the case of a violation of this assumption so that country c consumes

[12] A numeric example is in the Appendix.

relatively more of the capital-intensive good and less of the labor-intensive good.[13] Here, the volume of factor trade declines because countries consume their abundant factors more intensively. Moreover, the preference-driven errors, $\mathbf{E}_I^{cc"} - \mathbf{E}_M^{cc"} = -\mathbf{B}^{c"}\mathbf{E}^{cc"}$, are systematic: The element of the vector $\mathbf{E}_I^{cc"} - \mathbf{E}_M^{cc"}$ would be negative for labor and positive for capital.

Next, still in the context of the 2x2x2 model, consider the case of the technology-related HOV errors. The strict HOV model, or equation (6), does not generally hold and is associated with significant amounts of missing trade. Equation (8), which allows technique differences, can be used by separating the net export vectors ($\mathbf{T}^c$ and $\mathbf{T}^{c"}$) into export and import vectors ($\mathbf{X}^c$, $\mathbf{X}^{c"}$, $\mathbf{M}^{cc"}$, and $\mathbf{M}^{c"c}$). Then, substitute these vectors into equation (8). The amounts of missing trade would decrease, and the element of $\mathbf{E}_P^{cc"} - \mathbf{E}_S^{cc"}$ would be negative for labor and positive for capital since the developed country employs more capital-intensive techniques for both sectors than the developing country does.

3. Empirical Results and North-South Biases in Preferences

Evaluating the four HOV equations (6), (8), (9), and (11) requires data on actual techniques, Input-Output tables, and bilateral imports for multiple countries. Thus, we employ a comprehensive dataset assembled by Nishioka (2009) for a group of 28 countries in the year 2000.[14,15] There are two factors, aggregate labor and physical capital, and 30 industrial sectors. The dataset is similar to that in Davis and Weinstein (2001) who developed a 35-sector dataset of 10 advanced members of the OECD and a rest of the world aggregate. In contrast to theirs, this data set disaggregates the rest of the world aggregate into 18 countries, which enables testing the HOV models bilaterally and sorting the country pairs according to the differences between any two countries' development levels.

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[13] This prediction is related to Trefler's (1995) evidence on home-country bias in consumption and Davis and Weinstein's (2001) demand estimation from a gravity equation. All of these papers identify the importance of demand in the prediction of the HOV model.

[14] The detailed methodology to develop the data is in the appendix of Nishioka (2009). To estimate the pair-wise models, we use 28 countries by excluding China. Chinese techniques are employed to account for factor contents of bilateral imports from the rest of the world as well as from China.

[15] These countries are Australia, Austria, Belgium, Brazil (D), Canada, Czech Republic (D), Denmark, Finland, France, Germany, Greece (D), Hungary (D), Indonesia (D), Ireland, Italy, Japan, Korea (D), the Netherlands, New Zealand, Norway, Poland (D), Portugal (D), Slovak Republic (D), Spain, Sweden, Turkey (D), the United Kingdom, and the United States. (D) is marked for developing countries. We sort the countries according to labor compensation per worker. Countries with an average wage less than $20,000 U.S. dollars (2000, PPP) are deemed to be developing countries.

Deviations from Identical and Homothetic Preferences

Final demand ($\mathbf{D}^c$) in this paper is the sum of final consumption of households, final consumption and investment of government, gross fixed capital formation, and changes in inventories. Figure 1-1 provides a casual picture of the North-South differences in consumption bundles. Developing countries tend to consume more of agriculture products, food, and transportation services and less of motor vehicles, financial services, and business services (including real estate). The portion of income allocated for other sectors seems similar regardless of development levels.

To examine the significance of nonhomotheticity in preferences, we take empirical steps similar to Hunter (1991). We first develop a world consumption vector by aggregating all countries' consumption vectors and allocate it to each country by its consumption share (s^c). This procedure enables us to obtain the counterfactual consumption vector for country c under the assumption of identical and homothetic preferences, $\bar{\mathbf{D}}^{cT}$. We next develop the difference between the counterfactual consumption ($\bar{D}_i^{cT}$) and actual consumption (D_i^{cT}), and make a ratio of them $\varepsilon_i^c = (D_i^{cT} - \bar{D}_i^{cT}) / D_i^{cT}$. If $\varepsilon^c{}_i$ is negative (positive), a country consumes this good less (more) than the global average. Figure 1-2 provides the tendency of $\varepsilon^c{}_i$ across sectors for the subsets of developed and developing countries. The sectors are ordered by the differences of $\varepsilon^c{}_i$ between the North and the South. The deviations from counterfactuals are not negligible for most sectors. For example, developing countries spend 46.5 percent more and developed countries consume 19.0 percent less on food products. The deviations are relatively smaller for the North since most countries in the dataset are rich countries and the consumption share of the North relative to the world aggregate is quite large (84.0 percent). In addition, $\varepsilon^c{}_i$ for the South correlates positively, 0.410, with average labor techniques ($a^c{}_{iL}$) and that for the North correlates negatively, -0.548. Even though these correlations strongly reflect the values of the agricultural sector, these relationships are consistent with Markusen's (1986) assumption: Developing countries consume relatively more of labor-intensive goods.

Performance of the Pair-Wise HOV Models

To study the performance of the HOV model, standard testing procedures are developed (e.g., Bowen, Leamer, and Sveikauskas, 1987; Trefler, 1995; Davis and Weinstein, 2001). First, a sign test is used to elicit the probability of sign coincidences between measured and predicted relative factor contents of trade. If the specification holds perfectly, the sign would fit with 100 percent probability. A slope test involves regressing measured relative factor contents of trade on predicted ones without an intercept. If the pair-wise HOV specification holds, the regression coefficient would be unity. Finally, variance ratios are developed for each factor, computing the variance of measured relative factor contents of trade over the variance of the predicted ones. The ratio should be unity but previous literature has shown that this number tends to be close to zero. Here, we sort the countries from the richest, the United States, to the poorest, Indonesia, by per worker compensation so that country *c* is always richer than country *c*".

Table 1 provides the results for the HOV tests. The standard HOV model, equation (6), with efficiency adjustment performs poorly as previously shown. For the combinations of all countries, the sign fits are 54.5 percent for labor and 79.1 percent for capital, the slope coefficients are 0.063 for labor and 0.303 for capital, and the variance ratios are 0.020 for labor and 0.319 for capital. The results are slightly better than in the previous literature, reflecting the importance of allowing efficiency units and discarding nontraded sectors. The slope and the variance ratio tests indicate Trefler's (1993) missing trade, particularly for labor. Specifically, the poor performance of labor services stems from the country pairs of developed and developing countries; the sign fit is only 37.8 percent and the variance ratio is 0.006.

One of the most important contributions of Davis and Weinstein (2001) is the introduction of the Dornbusch-Fischer-Samuelson specification that allows the possibility of intra-industry factor trade.[16] As shown by them, equation (8) improves the sign fits tremendously. In other words, the HOV model predicts precisely the direction of measured factor trade. The same thing happens here. While the proportions of correct signs significantly improve to 73.3 percent for labor and 87.6 for capital, the variance ratios improve rather slightly to 0.070 for labor and 0.423 for capital. Of note, the great improvement in the direction of factor trade comes mainly from the success of the North-South country pairs; the sign fits improve to 80.6 percent for labor and 95.6 percent for capital. These results indicate not only the importance of allowing technical differences but also that technical gaps are significant between

[16] Note that we test the equations (6), (8), (9), and (11) only for the traded goods sectors. The unrestricted technology specification, equation (8), is almost identical to the multiple-cone production specification, (P5') and (T5) in Davis and Weinstein (2001). The difference comes from the fact that they used the fitted values of equation (P5) and we use actual techniques adjusted by the country-specific TFP units.

developed and developing countries. And, one might suspect that taste patterns are consistently different as well. We now turn to this issue.

Since equation (11) is the identity equation, all the HOV testing statistics fit almost perfectly. (The deviations from the strict equality come from the truncation of nontradable sectors from the whole economy.) We impose the assumption of identical and homothetic preferences on equation (11) to derive equation (9). That is, we mandate $\mathbf{E}^{cc''} = 0$. Therefore, the deterioration in testing statistics from equation (11) to (9) reported in Table 1 casts suspicion on the validity of identical and homothetic tastes. As it happens, the significant change is concentrated in labor services of country pairs involving developed and developing countries; while the proportion of correct signs does not change so much, the variance ratio is reduced from 0.873 to 0.325. Therefore, the difference in preferences does not change the direction of factor trade but matters a lot for the amount of factor trade between developed and developing countries.

Table 2 provides the statistics for the direction and volume of missing trade explained respectively by technique or taste. For the relaxation in identical techniques, the volume of missing trade is reduced for labor and capital since $\mathbf{E}^{cc''}{}_P - \mathbf{E}^{cc''}{}_S$ and $\mathbf{E}^{cc''}{}_S$ correlate negatively: -0.626 for labor and -0.783 for capital. But there is also a strong negative correlation between $\mathbf{E}^{cc''}{}_I - \mathbf{E}^{cc''}{}_M$ and $\mathbf{E}^{cc''}{}_S$ for labor (-0.902), which indicates the relaxation in identical tastes is critical in accounting for the volume of missing trade.[17] Furthermore, this tendency is stronger for the country pairs with larger per capita income differences. Moreover, the volume of missing trade explained by preferences is much greater than that explained by techniques for labor services; while the ratio of the variance of $\mathbf{E}^{cc''}{}_P - \mathbf{E}^{cc''}{}_S$ relative to $\mathbf{E}^{cc''}{}_S$ is 0.045, the ratio of the variance of $\mathbf{E}^{cc''}{}_I - \mathbf{E}^{cc''}{}_M$ relative to $\mathbf{E}^{cc''}{}_S$ is 0.196. That is, the development-related biases in preferences present here are significant as previous literature showed (e.g., Markusen and Hunter 1988; Hunter 1991) but are concentrated in labor services between countries with significant per capita income differences.

Figures 2-1 and 2-2 provide a comprehensive picture of the HOV errors generated from our four equations by plotting equations (6'), (8'), (9') and (11') on the vertical axis and the predicted relative factor contents of trade ($\mathbf{V}^c - s^{cc''}\mathbf{V}^{c''}$) on the horizontal axis. In these figures,

[17] The reason for weak correlation for capital is discussed in the next section. As shown in Nishioka (2009), there is no significant difference in capital techniques across sectors. Therefore, it is difficult to characterize capital-intensive sectors from capital-scarce sectors.

the 45-degree line is the case of zero factor trade -- error equals prediction -- and the horizontal line is the case of a perfect fit -- no error -- for the HOV models. Previous literature showed that these errors with the standard HOV model tend to be on the 45-degree zero-trade line, which is confirmed by our data. The improvements in the predictive power of the HOV model are clearly illustrated by the clock-wise rotations in trend-lines of each equation.[18] As in Trefler (1995) and Davis and Weinstein (2001), the relaxation from the strict HOV assumptions gradually mitigates the errors in the HOV prediction. In particular, Figure 2-1 confirms that the improvement from preferences is as significant -- actually more so -- as that from techniques for labor.

The Direction of HOV Errors Due to Preferences and Techniques

As is well known and recounted above, the strict HOV model results in prediction errors. Table 3 provides the signs of HOV errors generated from the assumptions of identical techniques ($\mathbf{E}_P^{cc"} - \mathbf{E}_S^{cc"}$) and identical tastes ($\mathbf{E}_I^{cc"} - \mathbf{E}_M^{cc"}$). As discussed before, the directions of these errors are expected to be systematic in the North-South context: negative errors for labor services and positive errors for capital.[19] Concerning the technology-driven HOV errors, 87.8 percent are negative signs for labor and 93.9 percent are positive signs for capital. These results support the idea that developed countries employ less labor and more capital than developing countries do. The relaxation in preferences generates 83.3 percent negative errors in $\mathbf{E}_I^{cc"} - \mathbf{E}_M^{cc"}$ for labor, suggesting preferences are indeed nonhomothetic as Markusen (1986) assumed. In the case of capital, however, the probability is closer to a coin-flip (55.0 percent). As in Nishioka (2009), this is because the variations in techniques, or capital-intensity, stem mainly from labor requirements; there are no significant differences in capital usages across sectors within a country. Therefore, regardless of the systematic differences in consumption bundles, the term -$B^{c”}{}_{Ki}E^{cc”}{}_{i}$ tends to be random for capital since the capital technique of industry i for country c”, $B^{c”}{}_{Ki}$, cannot clearly distinguish, for example, a “capital-intensive” automobile sector from a “labor-intensive” agricultural sector.

[18] Equation (6) is the strict HOV. From equation (6), identical techniques are modified to obtain equation (8). Equation (9) imposes identical and homothetic preferences. In other words, all assumptions except preferences are relaxed. Finally, no assumption is imposed for equation (11).

[19] Since we sort the countries from the richest to the poorest by per worker compensation, country c is always richer than country c”, which is consistent with the discussion in the previous section.

5. Conclusion

The development stage of a country affects not only its production specialization but also its consumption bundle. This paper concentrates on the demand side of the HOV model by developing an empirical method to measure the volume and direction of missing trade caused by the assumption of identical and homothetic preferences.

Countries seem to "specialize" in consuming relatively more capital-intensive goods (e.g., automobiles and real estate) as they develop. This development-related pattern of consumption creates missing trade in the HOV prediction: The more any two countries' income gap increases, the more the HOV model over-predicts the volume of factor trade. We also compare the volume of the preference-related missing trade with that of the technique-driven missing trade. Surprisingly, the imposition of identical and homothetic preferences causes more missing trade than does that of identical techniques. As in Davis and Weinstein (2001), the modification in identical techniques is crucial to obtain the right direction of factor trade relative to the HOV prediction. This paper confirms the importance of allowing technical differences and factor price differentials in the HOV model (e.g., Davis and Weinstein, 2001; Hakura, 2001; Schott, 2003; Choi and Krishna, 2004; Lai and Zhu, 2007). However, we further provide another important bias in the HOV prediction related to the development levels of countries. As in Fitzgerald and Hallak (2004), factor accumulations correlate strongly with across-industry specialization. But they cannot determine whether this correlation is caused from factor abundances or other development-related mechanisms. Nonhomotheticity in preferences is one such mechanism that has not been previously examined in the literature of factor abundance models.

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Appendix

Appendix 1: *Identity Equation in Hakura's (2001) Modified Model*

Assume there are two countries: a developed country *c* and a developing country *c*", two goods: agriculture sector *A* and manufacturing sector *M*, and two factor inputs: labor *L* and capital *K*. For simplicity, price of these two goods are unity. To produce each goods, two countries employ different techniques: $\mathbf{B}^c = \begin{bmatrix} a_{LA}^c & a_{LM}^c \\ a_{KA}^c & a_{KM}^c \end{bmatrix} = \begin{bmatrix} 2 & 1 \\ 2 & 3 \end{bmatrix}$ and $\mathbf{B}^{c"} = \begin{bmatrix} a_{LA}^{c"} & a_{LM}^{c"} \\ a_{KA}^{c"} & a_{KM}^{c"} \end{bmatrix} = \begin{bmatrix} 4 & 2 \\ 1 & 2 \end{bmatrix}$. The production vectors of both countries are $\mathbf{Y}^c = \begin{bmatrix} 2 \\ 6 \end{bmatrix}$ and $\mathbf{Y}^{c"} = \begin{bmatrix} 6 \\ 2 \end{bmatrix}$ and factor endowment vectors are $\mathbf{V}^c = \begin{bmatrix} 10 \\ 22 \end{bmatrix}$ and $\mathbf{V}^{c"} = \begin{bmatrix} 28 \\ 10 \end{bmatrix}$.

(1) Identical and Homothetic Preferences

Both countries consume 4 units of both goods under the assumption of identical and homothetic preferences: $\mathbf{D}^c = \mathbf{D}^{c"} = \begin{bmatrix} 4 \\ 4 \end{bmatrix}$. Therefore, net-trade vectors are $\mathbf{T}^c = \begin{bmatrix} -2 \\ 2 \end{bmatrix}$ and $\mathbf{T}^{c"} = \begin{bmatrix} 2 \\ -2 \end{bmatrix}$.

By data construction, equation (2) is identity equation. To show that equation (9) must hold with identical and homothetic preferences, insert corresponding vectors in equation (9) with $s^{cc"}$=1.

$$\mathbf{B}^c\mathbf{T}^c - s^{cc"}\mathbf{B}^{c"}\mathbf{T}^{c"} - (\mathbf{B}^{c"} - \mathbf{B}^c)\mathbf{D}^c = \mathbf{V}^c - s^{cc"}\mathbf{V}^{c"}$$

$$\Leftrightarrow \begin{bmatrix} 2 & 1 \\ 2 & 3 \end{bmatrix}\begin{bmatrix} -2 \\ 2 \end{bmatrix} - \begin{bmatrix} 4 & 2 \\ 1 & 2 \end{bmatrix}\begin{bmatrix} 2 \\ -2 \end{bmatrix} - \left(\begin{bmatrix} 4 & 2 \\ 1 & 2 \end{bmatrix} - \begin{bmatrix} 2 & 1 \\ 2 & 3 \end{bmatrix}\right)\begin{bmatrix} 4 \\ 4 \end{bmatrix} = \begin{bmatrix} 10 \\ 22 \end{bmatrix} - \begin{bmatrix} 28 \\ 10 \end{bmatrix}$$

$$\Leftrightarrow \begin{bmatrix} -18 \\ 12 \end{bmatrix} = \begin{bmatrix} -18 \\ 12 \end{bmatrix}$$

(2) Violation in identical and homothetic Preferences

The developed country consumes 3 units of agriculture goods and 5 units of manufacturing goods; the developing country consumes 5 units of agriculture goods and 3 units of manufacturing goods. Therefore, $\mathbf{D}^c = \begin{bmatrix} 3 \\ 5 \end{bmatrix}, \mathbf{D}^{c"} = \begin{bmatrix} 5 \\ 3 \end{bmatrix}$ and $\mathbf{T}^c = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$ and $\mathbf{T}^{c"} = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$. As in Markusen (1986), North-South trade is reduced because of the nonhomothetic preferences.

To show that equation (9) does not hold without identical and homothetic preferences, insert corresponding vectors in equation (9) with $s^{cc"}$=1.

$$\mathbf{B}^c\mathbf{T}^c - s^{cc"}\mathbf{B}^{c"}\mathbf{T}^{c"} - (\mathbf{B}^{c"} - \mathbf{B}^c)\mathbf{D}^c \neq \mathbf{V}^c - s^{cc"}\mathbf{V}^{c"}$$

$$\Leftrightarrow \begin{bmatrix} 2 & 1 \\ 2 & 3 \end{bmatrix}\begin{bmatrix} -1 \\ 1 \end{bmatrix} - \begin{bmatrix} 4 & 2 \\ 1 & 2 \end{bmatrix}\begin{bmatrix} 1 \\ -1 \end{bmatrix} - \left(\begin{bmatrix} 4 & 2 \\ 1 & 2 \end{bmatrix} - \begin{bmatrix} 2 & 1 \\ 2 & 3 \end{bmatrix}\right)\begin{bmatrix} 3 \\ 5 \end{bmatrix} \neq \begin{bmatrix} -18 \\ 12 \end{bmatrix}$$

$$\Leftrightarrow \begin{bmatrix} -14 \\ 10 \end{bmatrix} \neq \begin{bmatrix} -18 \\ 12 \end{bmatrix}$$

The missing trade is generated by the violation of identical and homothetic preferences.

With the information above, the errors in consumption vector will be $\mathbf{E}^{cc"} = \begin{bmatrix} 2 \\ -2 \end{bmatrix}$. Therefore, the adjustment term of preference errors should be $\mathbf{B}^{c"}\mathbf{E}^{cc"} = \begin{bmatrix} 4 & 2 \\ 1 & 2 \end{bmatrix}\begin{bmatrix} 2 \\ -2 \end{bmatrix} = \begin{bmatrix} 4 \\ -2 \end{bmatrix}$.

Thus, $\mathbf{B}^c\mathbf{T}^c - s^{cc"}\mathbf{B}^{c"}\mathbf{T}^{c"} - (\mathbf{B}^{c"} - \mathbf{B}^c)\mathbf{D}^c - \mathbf{B}^{c"}\mathbf{E}^{cc"} = \mathbf{V}^c - s^{cc"}\mathbf{V}^{c"}$ holds since

$$\mathbf{B}^c\mathbf{T}^c - s^{cc"}\mathbf{B}^{c"}\mathbf{T}^{c"} - (\mathbf{B}^{c"} - \mathbf{B}^c)\mathbf{D}^c - \mathbf{B}^{c"}\mathbf{E}^{cc"} = \mathbf{V}^c - s^{cc"}\mathbf{V}^{c"}$$

$$\Leftrightarrow \begin{bmatrix} -14 \\ 10 \end{bmatrix} - \begin{bmatrix} 4 \\ -2 \end{bmatrix} = \begin{bmatrix} -18 \\ 12 \end{bmatrix}$$

Here, $\mathbf{E}_I^c - \mathbf{E}_M^c = -\mathbf{B}^{c"}\mathbf{E}^{cc"} = \begin{bmatrix} -4 \\ 2 \end{bmatrix}$ is the amount of missing trade explained by identical tastes.

Appendix 2: *Technical Difference and Factor Contents of Trade*

(1) The Standard HOV Model

Consider the case of identical and homothetic preferences: $\mathbf{D}^c = \mathbf{D}^{c"} = \begin{bmatrix} 4 \\ 4 \end{bmatrix}$.

$$\mathbf{B}^c\mathbf{T}^c - s^{cc''}\mathbf{B}^c\mathbf{T}^{c''} \neq \mathbf{V}^c - s^{cc''}\mathbf{V}^{c''}$$

$$\Leftrightarrow \begin{bmatrix} 2 & 1 \\ 2 & 3 \end{bmatrix}\begin{bmatrix} -2 \\ 2 \end{bmatrix} - \begin{bmatrix} 2 & 1 \\ 2 & 3 \end{bmatrix}\begin{bmatrix} 2 \\ -2 \end{bmatrix} \neq \begin{bmatrix} -18 \\ 12 \end{bmatrix}$$

$$\Leftrightarrow \begin{bmatrix} -4 \\ 4 \end{bmatrix} \neq \begin{bmatrix} -18 \\ 12 \end{bmatrix}$$

(2) Adjustment in Techniques

Now, we need to divide $\mathbf{T}^c = \begin{bmatrix} -2 \\ 2 \end{bmatrix}$ and $\mathbf{T}^{c''} = \begin{bmatrix} 2 \\ -2 \end{bmatrix}$ into export and import vectors: $\mathbf{X}^c = \begin{bmatrix} 0 \\ 2 \end{bmatrix}$, $\mathbf{X}^{c''} = \begin{bmatrix} 2 \\ 0 \end{bmatrix}$, $\mathbf{M}^{cc''} = \begin{bmatrix} 2 \\ 0 \end{bmatrix}$, and $\mathbf{M}^{c''c} = \begin{bmatrix} 0 \\ 2 \end{bmatrix}$.

$$\mathbf{B}^c\mathbf{X}^c - \left[\sum_{c'\neq c} \mathbf{B}^{c'}\mathbf{M}^{cc'}\right] - s^{cc''}\ \mathbf{B}^{c''}\mathbf{X}^{c''} - \left[\sum_{c'\neq c''} \mathbf{B}^{c'}\mathbf{M}^{c''c'}\right] \neq \mathbf{V}^c - s^{cc''}\mathbf{V}^{c''}$$

$$\Leftrightarrow \begin{bmatrix} 2 & 1 \\ 2 & 3 \end{bmatrix}\begin{bmatrix} 0 \\ 2 \end{bmatrix} - \begin{bmatrix} 4 & 2 \\ 1 & 2 \end{bmatrix}\begin{bmatrix} 2 \\ 0 \end{bmatrix} - \begin{bmatrix} 4 & 2 \\ 1 & 2 \end{bmatrix}\begin{bmatrix} 2 \\ 0 \end{bmatrix} + \begin{bmatrix} 2 & 1 \\ 2 & 3 \end{bmatrix}\begin{bmatrix} 0 \\ 2 \end{bmatrix} \neq \begin{bmatrix} -18 \\ 12 \end{bmatrix}$$

$$\Leftrightarrow \begin{bmatrix} -12 \\ 8 \end{bmatrix} \neq \begin{bmatrix} -18 \\ 12 \end{bmatrix}$$

Even though the amounts of missing trade decrease, the identity does not hold by data construction. Here, $\mathbf{E}_P^{cc''} - \mathbf{E}_S^{cc''} = \begin{bmatrix} 6 \\ -4 \end{bmatrix} - \begin{bmatrix} 14 \\ -8 \end{bmatrix} = \begin{bmatrix} -8 \\ 4 \end{bmatrix}$ is the amount of missing trade explained by identical technique.

Tables and Figures

Table 1: Sign, Slope, and Variance Ratio Tests for Country Pairs

		All (28 countries)		North Pairs		South Pairs		North-South Pairs	
		Labor	Capital	Labor	Capital	Labor	Capital	Labor	Capital
	Observations	378	378	153	153	45	45	180	180
1. Modification in Technique									
	Sign Test	0.545	0.791	0.647	0.791	0.867	0.467	0.378	0.872
Standard HOV Model	Slope Test	0.063	0.303	0.495	0.598	0.161	0.093	0.051	0.121
Equation (6)	Standard error	0.006	0.024	0.043	0.041	0.019	0.041	0.004	0.023
(Hakura 2001)	R-squared	0.172	0.300	0.403	0.562	0.476	0.015	0.461	0.064
	Variance Test	0.020	0.319	0.503	0.620	0.041	0.085	0.006	0.140
	Sign Test	0.733	0.876	0.667	0.876	0.667	0.556	0.806	0.956
Technology Modification	Slope Test	0.207	0.554	0.155	0.802	0.271	0.353	0.208	0.401
Equation (8)	Standard error	0.008	0.016	0.058	0.022	0.026	0.056	0.008	0.018
(Davis and Weinstein 2001)	R-squared	0.605	0.747	0.044	0.890	0.648	0.479	0.746	0.654
	Variance Test	0.070	0.423	0.577	0.719	0.108	0.302	0.057	0.222
2. Modification in Tastes									
	Sign Test	0.931	0.955	0.909	0.895	0.956	0.978	0.944	1.000
Modified HOV Model	Slope Test	0.571	0.814	1.007	0.982	0.536	0.735	0.560	0.711
Equation (9)	Standard error	0.008	0.010	0.018	0.017	0.025	0.015	0.010	0.006
(Hakura 2001)	R-squared	0.922	0.943	0.949	0.952	0.881	0.980	0.933	0.982
	Variance Test	0.344	0.716	1.057	0.994	0.314	0.548	0.325	0.484
	Sign Test	0.952	0.987	0.915	0.974	0.956	0.978	0.983	1.000
Identity Equation	Slope Test	0.933	0.852	1.055	1.047	0.942	0.744	0.930	0.732
without IHP and IT	Standard error	0.003	0.010	0.020	0.014	0.010	0.014	0.003	0.006
Equation (11)	R-squared	0.996	0.948	0.941	0.972	0.994	0.982	0.998	0.982
	Variance Test	0.874	0.781	1.154	1.108	0.877	0.568	0.873	0.517

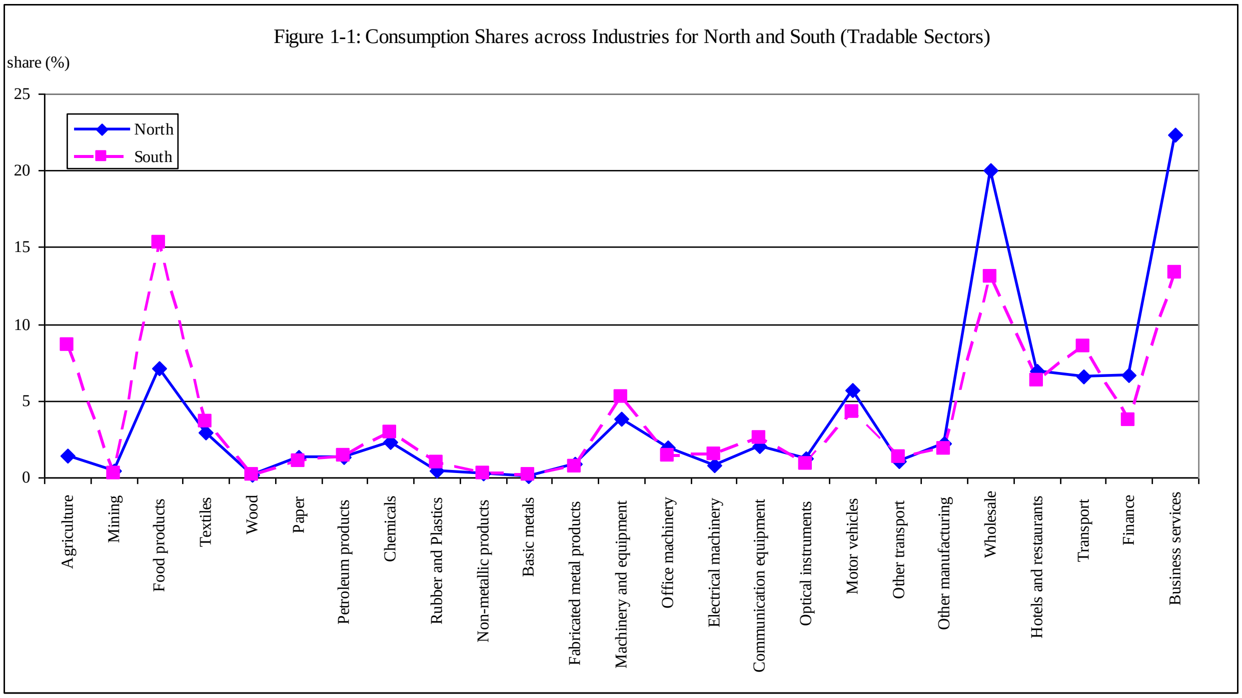
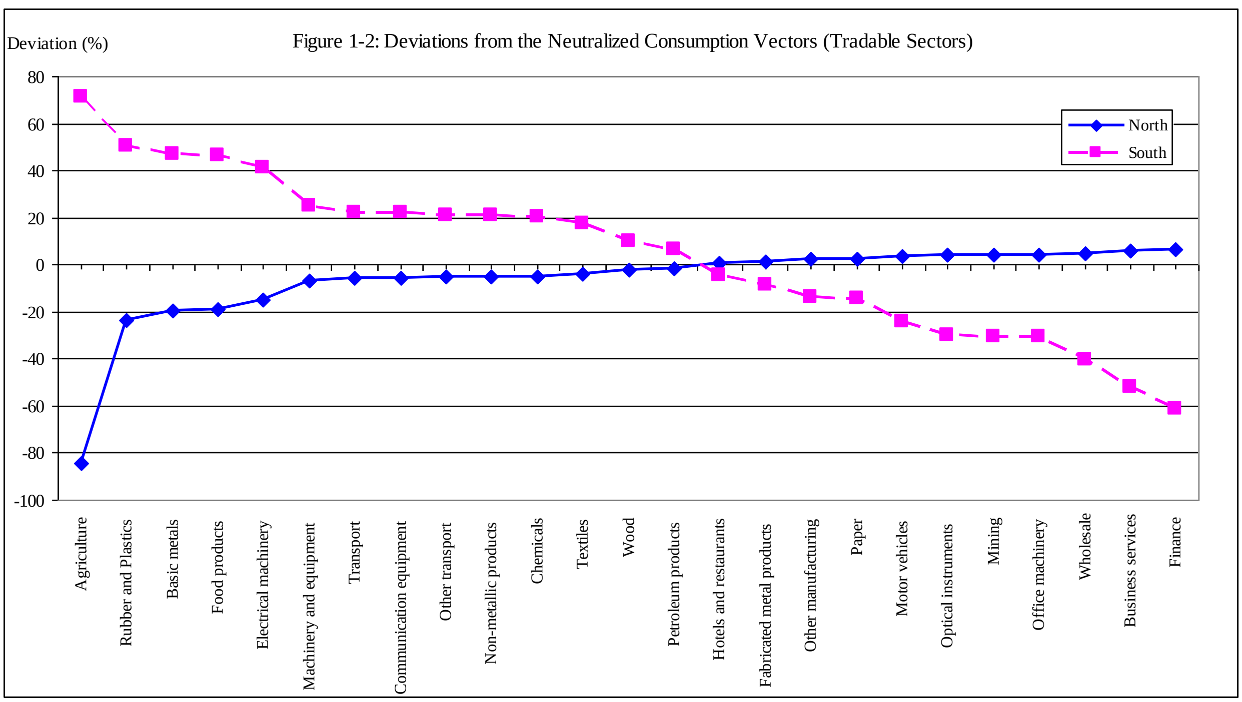


Figure 1-1: Consumption Shares across Industries for North and South (Tradable Sectors)
share (%)
25
20
15
10
5
0
North
South
Agriculture
Mining
Food products
Textiles
Wood
Paper
Petroleum products
Chemicals
Rubber and Plastics
Non-metallic products
Basic metals
Fabricated metal products
Machinery and equipment
Office machinery
Electrical machinery
Communication equipment
Optical instruments
Motor vehicles
Other transport
Other manufacturing
Wholesale
Hotels and restaurants
Transport
Finance
Business services



Deviation (%)
Figure 1-2: Deviations from the Neutralized Consumption Vectors (Tradable Sectors)
80
60
40
20
0
-20
-40
-60
-80
-100
North
South
Agriculture
Rubber and Plastics
Basic metals
Food products
Electrical machinery
Machinery and equipment
Transport
Communication equipment
Other transport
Non-metallic products
Chemicals
Textiles
Wood
Petroleum products
Hotels and restaurants
Fabricated metal products
Other manufacturing
Paper
Motor vehicles
Optical instruments
Mining
Office machinery
Wholesale
Business services
Finance

Figure 2-1: Errors in Labor Services for Four Specifications relative to Predicted Relative Labor Contetns of Trade

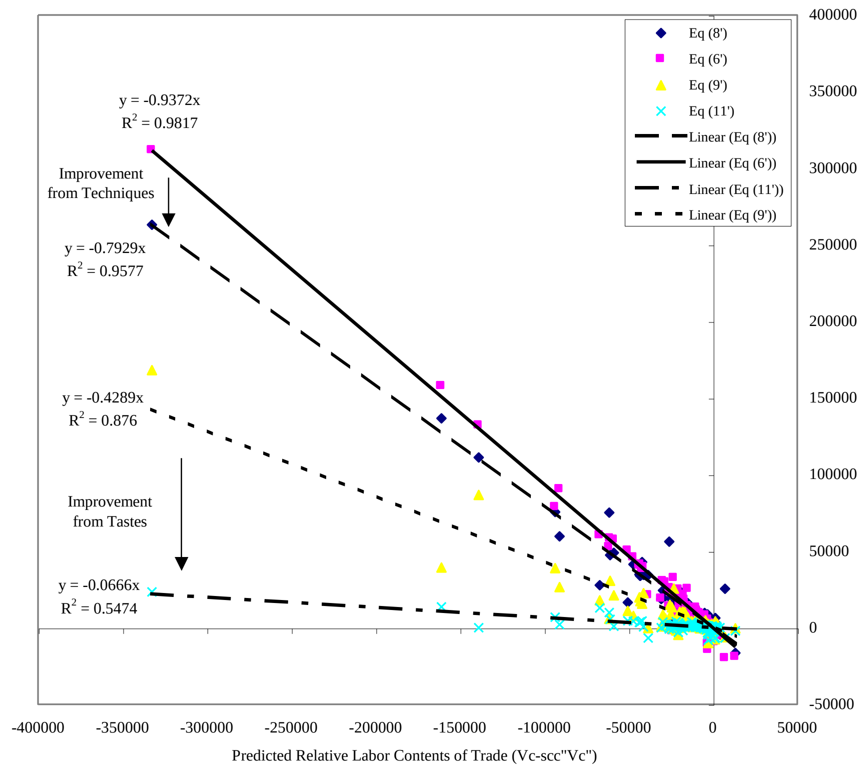


Figure 2-2: Errors in Capital Services for Four Specifications relative to Predicted Relative Capital Contetns of Trade

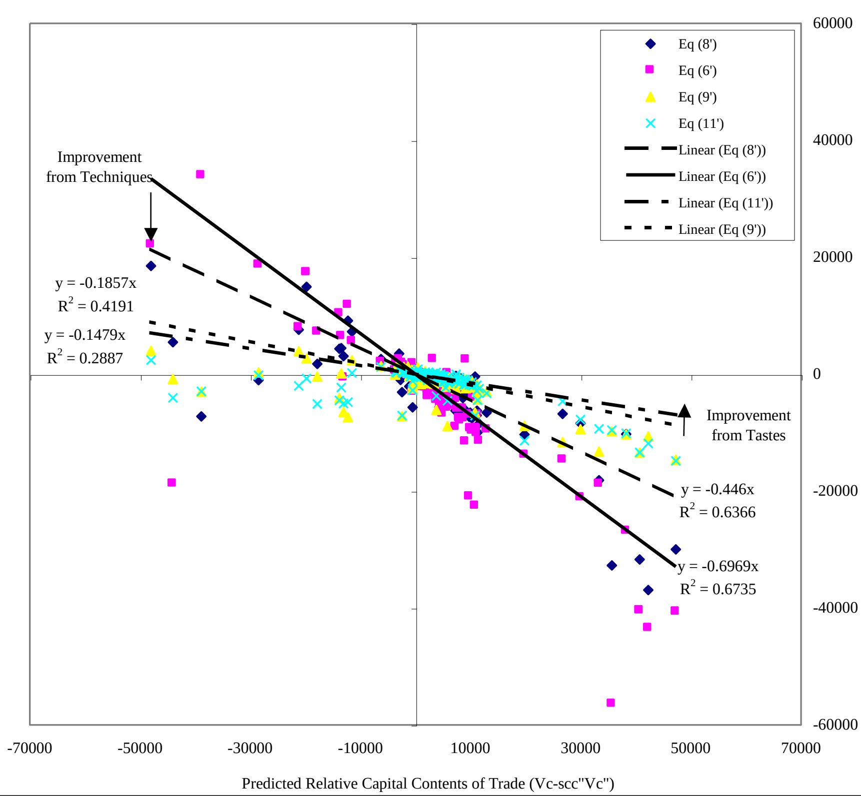


Table 2: Directions and Amounts of Improvements in HOV Errors

1. Modification in Identical Techniques		$[E^{cc''}_P - E^{cc''}_S, E^{cc''}_S]$ or [(8')-(6'),(6')]			
		All Pairs	North Pairs	South Pairs	North-South Pairs
Sign Mismatch	Labor Services	0.720	0.614	0.444	0.878
	Capital Services	0.839	0.765	0.622	0.956
Variance Ratio	Labor Services	0.077	1.657	0.103	0.045
	Capital Services	0.330	0.902	0.199	0.149
Correlation	Labor Services	-0.626	-0.181	-0.522	-0.754
	Capital Services	-0.783	-0.858	-0.683	-0.857
2. Modification in Identical Tastes		$[E^{cc''}_I - E^{cc''}_M, E^{cc''}_S]$ or [(11')-(9'),(6')]			
		All Pairs	North Pairs	South Pairs	North-South Pairs
Sign Mismatch	Labor Services	0.730	0.641	0.622	0.833
	Capital Services	0.542	0.588	0.378	0.544
Variance Ratio	Labor Services	0.186	0.087	0.299	0.196
	Capital Services	0.014	0.036	0.003	0.008
Correlation	Labor Services	-0.902	-0.148	-0.809	-0.913
	Capital Services	-0.148	-0.190	-0.169	-0.094

Table 3: Sign of Improvements in HOV Errors

		All Pairs	North Pairs	South Pairs	North-South Pairs
Errors in Technique (11')-(9')	Labor Services (negatives)	0.651	0.464	0.378	0.878
	Capital Services (positives)	0.730	0.569	0.444	0.939
Errors in Tastes (8')-(6')	Labor Services (negatives)	0.720	0.608	0.644	0.833
	Capital Services (positives)	0.513	0.536	0.289	0.550