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"Endowments Do Matter"
Relative Factor Abundance and Trade

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“ENDOWMENTS DO MATTER”
RELATIVE FACTOR ABUNDANCE AND TRADE*

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Abstract A test of the Heckscher-Ohlin-Vanek [HOV] hypothesis for the cases when factor price equalization does not hold is developed. For all the possible country pairs of the BLS (1987) and Trefler (1995) data set, I test whether trade reveals the *relative* factor abundance of one country compared to another. For the factor pairs capital-labor, labor-land and land-capital, I investigate whether the higher endowment ratio of one country compared to another is reflected in their multilateral trade. A strength of the method is that technology differences, measurement error or home bias are allowed for, but do not have to be estimated. For the hundreds of country pairs, the relative abundance of two countries is revealed in trade in about 75 percent of the cases. In other words, endowments do matter. The more different are country endowments, the stronger are the results. I explicitly study North-South trade and find that it reflects the North’s relative capital abundance in over 90 percent of the cases. The obtained sign test results are also analyzed with a probit model. A probit analysis helps to detect empirically other factors than endowment differences that affect the performance of the HOV prediction.

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1. Introduction

Do the factor endowments of countries matter for the pattern of international trade? This basic question is the starting point of my analysis. It is surprising that it has not yet found a satisfactory answer after 40 years of empirical research, especially as the question addresses the essence of the theory that is still the workhorse of international trade. Indeed, the main idea of the Heckscher-Ohlin [HO] theory is that endowment differences determine the pattern of trade. In the textbook 2x2x2 version, a country exports the good that uses intensively the factor with which it is relatively abundantly endowed. When a country has much capital relative to labor, it exports capital intensive goods. When more sectors, countries and factors are involved, as in the Heckscher-Ohlin-Vanek [HOV] model, we are no longer able to predict the specific commodities that countries will trade.[1] Yet, based on the endowments, the theory still can predict the factor services contained in their net multilateral trade.

Over the past years, a consensus has emerged that the HOV model is a preferred way to test HO, as it involves data on trade, technology and endowments. The empirical record of these tests is very poor, however. Bowen, Leamer and Sveikauskus [BLS] (1987) is generally referred to as the paper that established the empirical failure of HOV. Since BLS's publication the predictive power of the theory has been compared in the empirical literature to the toss of a coin. Indeed, only in about 50 percent of the cases do the country endowments predict the sign of the factor content of trade. As sign tests are weak tests of HOV (they do not tell whether endowments predict the right factor content *quantities*), this poor performance is considered strong evidence against the theory. In the discussion of the sources of comparative advantage, these empirical results have lent support to the view that "differences in technology, rather than differences in resources, are the most important determinant of comparative advantage" (Krugman, 1995).

These bleak empirical results have led to the relaxation of some of the HOV assumptions in the literature. BLS (1987) and Trefler (1993,1995) modified the assumptions of identical constant return to scale technologies and the requirement of factor price equalization [FPE], as they introduced differences in productivity. On the demand side, home bias has been incorporated and measurement error has been explicitly taken care of. The poor empirical performance of the standard HOV model has also led to a new way of looking at HOV. Trefler (1995) redefined the terms of the debate. He focused on the gap between the actual factor content of trade and the factor content as predicted by the endowments. He called this gap the "missing trade" phenomenon and introduced technological differences, home bias and measurement error to account for it. Several questions have risen, however, about the specifics of his implementation and the extent to which the modifications he invokes can explain the trade gap. Moreover, the focus on "missing trade" has diverted our attention from the basic question. From the perspective of HO, the question is not so much whether we can account for the gap of "missing trade", but rather whether we can do so in a way that preserves the essence of the HO theory. In other words, can we infer anything about countries' trade patterns from their endowments, or are factor content of trade predictions so much a function of technological differences, home bias or measurement error, that endowment data do not tell us anything? In other words, is anything left of the basic theory after all these proposed modifications? As the title already suggests, endowments do matter. This paper provides evidence that supports the basic intuition of the HO model and is meant to counter the negative results in the literature. It does not attempt to disentangle the HOV predictions of the direction of trade from predictions from models that might nest HOV with increasing returns.[2] To show that endowments play a central role for the pattern of trade, I develop a test of the HOV hypothesis that applies when not all HOV assumptions hold. FPE is not required for the world as a whole, and measurement error and a specific form of home bias are allowed for. The main advantages of my test are that its results are based on a large number of observations and do not depend on the estimation of any parameter. In the setup that

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[1] Except when the number of factors equals the number of sectors.

[2] See Trefler (1996).

yields the test condition, I combine two ideas. On the one hand, I generalize the two-country approach to the HOV model as found in Staiger, Deardorff and Stern (1987), Brecher and Choudri (1988) and Hakura (1996). This specification of the HOV model does not depend on the world endowments. On the other hand, I place the original notion of *relative* abundance back at the center of the analysis and introduce it in the country pair setting. In other words, for example in the case of capital and labor, I will check for any country pair whether or not trade reveals that one country has a higher capital to labor ratio than another country.[3] I generate all the possible country pairs of the data sets that have been used in BLS (1987) and Trefler (1995) for the factors capital and labor, labor and land, and land and capital. Both data sets contain developed and developing countries; the BLS data set is from 1966 and consists of 27 countries, whereas Trefler's data set was constructed with 1983 data of 33 countries. Analyzing country pairs has distinct methodological merits compared to the standard world version of the HOV hypothesis. I avoid any pitfalls related to using world endowment data. Moreover, I do not have to assume in advance that the HOV assumptions hold for the world as a whole. More important from an empirical point of view, however, is my focus on *relative* factor abundance in the country pair setting. It allows me to identify a central role for country endowments irrespective of Hicks neutral technological differences, country specific measurement error and a form of home bias that is the same across countries, without having to estimate any of these. For the hundreds of country pairs and for both data sets, I find that trade in about 75 percent of the cases reveals the relative factor abundance of a country with respect to another country.

Next, I explore the ability of the method to study groups of country pairs. A clear pattern emerges that confirms another basic tenet of the HO theory. The test results are

[3] Relative factor abundance has received only little attention. An important exception here is Leamer (1980) whose refutation of the Leontief Paradox for the US relies explicitly on the notion of the relative abundance of capital compared to labor that is revealed in the factor content of trade. Crafts (1986) checks these conditions for skilled and unskilled labor in the UK. For a discussion of BLS (1987) see footnote xi.

much stronger for two countries with very different endowment ratios. The relative abundance of capital to labor for example is almost always revealed in trade when comparing a developed and a developing country. In other words, the extent to which endowments differ matters. The presumption of a higher signal to noise ratio for very different countries makes me also investigate relative factor abundance of the *group* of the rich developed countries *as a whole* versus the rest of the world. This boils down to the first analysis of North-South trade within the framework of a HOV model. The North's relative capital abundance compared to labor is revealed in trade in more than 90 percent of the cases.

In a final step, I link the sign test results to the framework of a probability model. In this way I establish more formally that the extent to which endowments differ is a significant determinant of the success or failure of the HOV prediction. At the same time, this framework makes it possible to (indirectly) address a long-standing critique of (or frustration with) HOV analyses. So far, we have been unable to control sufficiently for other factors (such as government intervention) when assessing their performance of HOV predictions. A probit model opens up the possibility to identify empirically the determinants that make the HOV model perform better or worse.

The paper proceeds as follows. In Section 2 the country pair approach to the HOV model is presented and compared with the standard world version. The methodological merits of the setting are discussed. The next section introduces *relative* factor abundance into the country pair framework. Again, the methodological advantages are explained and it is shown how a test in my setup can identify a central role for endowments while relaxing some of the standard HOV assumptions. The empirical support for relative factor abundance is provided in section 4. In section 5 different groups of country pairs are analyzed. Section 6 addresses the question whether North-South trade reveals the relative capital abundance of the North. In section 7 the scope is broadened and it is studied how variables other than endowments determine the performance of the HOV hypothesis in the framework of a probability model. The last section concludes.

2. Absolute Abundance in a Country Pair Approach to the HOV model

I briefly review the standard world version of the HOV model and derive its country pair version. The focus in this section is on the notion of "(absolute) factor abundance," which involves a comparison of the factor content of trade and the endowments *for one factor at a time*. I turn to "relative factor abundance" in the next section where the factor endowment ratios are studied in the same country pair setting. The derivation of the world version of the model critically hinges on the traditional HO assumption of (1) identical homothetic preferences, (2) identical constant returns to scale production technology, (3) perfect factor mobility between the sectors within a country, (4) free and frictionless trade with perfect competition, and (5) factor price equalization across the world. Some of these assumptions will be relaxed in the next section.

Assume that there are N factors, M sectors and Z countries. Take the vector identity (1) for a country c as a starting point. It says that a country trades the part of its production that it does not consume.

$$T_c = Q_c - C_c, \tag{1}$$

where T, Q and C are respectively $M \times 1$ vectors of net exports, output and consumption. As identical homothetic preferences, perfect competition, and free and frictionless trade are imposed, each country consumes a constant share α_c of world production, i.e. $C_c = \alpha_c Q_w$.[4] Now consider for a country c an $N \times M$ technology matrix matrix A. Its elements $a_{i,j}$ indicate how much of a factor i is needed to produce one unit of output of sector j. With FPE and identical constant return to scale production functions, the technology matrix A_c is the same for all the countries.[5] In that case, the factor content of net trade, F_c, that tells us how much capital, labor, etc. are contained in a country's net exports equals $F_c = AT_c$. We also know that the factor content of production AQ is equal to the endowment V when assuming FPE, identical technologies and full employment. This

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[4] $\alpha_c = (Y_c - B_c)/Y_w$. Y_c and Y_w are country c's and the world's GDP and B_c country c's trade balance.

is the case for an individual country and for the world as a whole. Hence, when premultiplying equation (1) by A while imposing the conditions mentioned above, we obtain equation (2) that relates for each factor separately a country's net factor content of trade to its own and the world's endowments. This is the standard world version of the HOV hypothesis.

$$F_c = V_c - \alpha_c V_w \qquad (2)$$

The absolute abundance of country c is said to be revealed in trade for a factor A ($F_{A,c}>0$), when the country consumes less of that factor than it is endowed with ($V_{A,c} - \alpha_c V_{A,w}>0$). I will reserve the term relative abundance for the case in the next section when the endowment ratios of two factors are compared.

Now consider equation (2) for any pair of countries i and j as in expression (3) and (4).

$$F_i = V_i - \alpha_i V_w\,, \qquad (3)$$

$$F_j = V_j - \alpha_j V_w\,, \qquad (4)$$

Eliminate the world endowments V_w from them and obtain the country pair version of the HOV hypothesis (5) that relates the traded factor services of any pair of countries to their endowments.

$$F_i - {\alpha_i}/{\alpha_j}\, F_j = V_i - {\alpha_i}/{\alpha_j}\, V_j \qquad (5)$$

Country i 's (absolute) abundance in factor A compared to country j is revealed in trade ($F_{A,i}-\alpha_i/\alpha_j F_{A,j} >0$) if i's endowment of A exceeds country j's after correcting for consumption shares ($V_{A,i}-\alpha_i/\alpha_j V_{A,j} >0$). The expressions (2) and (5) form the basis for the

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[5] In the empirical implementation, the technology matrix A is based on US data.

sign tests in which *for each factor one at a time* the sign of the right-hand side is compared with the sign of the left-hand side. The factor abundance is considered revealed by trade when the signs of both sides of the equation match. In a world of *Z* countries, one has to evaluate *Z* equations (2) per factor of production in the standard approach and *Z(Z-1)/2* different equations (5) per factor in a country pair analysis. It is also possible to perform a rank order test.[6]

BLS and Trefler have primarily used the world version of equation (2) in their work on HOV. What is the methodological advantage of assessing the success of HOV by studying all possible country pairs instead? On the one hand, one does not have to employ and construct endowment data for the world as a whole. More specifically, the world endowment number is wrong as soon as countries are missing, or as soon as the data for a particular country are unreliable. On the other hand and more importantly, it can be shown that the two-country version only requires that the specific HOV assumptions hold for the two countries considered.[7] As soon as the assumptions of HOV do not hold for the world as a whole, relying on world endowments is again not right. One could argue that a reformulation of HOV for a smaller group of countries (yet larger than two) should be a viable alternative to the world HOV approach, yet here again one faces a similar problem.[8] The success of HOV will be affected by whether all the countries rightly fit into the group (because they satisfy the HOV requirements and because their data are reliable).

However promising the (absolute) country pair approach may be from a methodological point of view, the empirical results are still discouraging. I perform the sign test for equation (5) for all possible country pairs and for the three factors land, labor and capital (i.e. for 1584 observations). I find the factor abundance revealed in trade in only 49.5 percent of the cases for the Trefler countries and 53.5 percent for those from the

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[6] A rank test across factors is not meaningful because of the different units.

[7] Brecher and Choudri (1988), p. 8-9.

[8] When only considering a group of countries instead of the world as a whole, one should use AC_G, where C_G stands for the sectoral consumption vector for a particular group of countries, instead of the world endowments V_w.

BLS data set. There is significant variation across factors. For capital one obtains for the Trefler and BLS countries respectively 38 and 65 percent matching signs, for labor 44 and 27 and for land, which overall performs better, 72.5 and 66 percent.

Overall, this poor performance of the absolute version of the HOV prediction has lent support to the view that "differences in technology, rather than differences in resources are the most important determinant of comparative advantage" (Krugman, 1995). On the other hand, it has triggered innovative research by Trefler (1993,1995), Davis, Weinstein, et al (1997) and others. Trefler has reshaped the debate. He termed the gap between the actual and the predicted factor content of trade "missing trade." He has introduced factor specific and Hicks neutral technological differences, country home bias on the demand side and measurement error to account for the trade gap. This emphasis on "missing trade" and the proposed modifications of the HOV model have sidetracked us form the basic question, whether anything is left of the HO theory after all these modifications. Do endowments matter for the pattern of trade, or are factor content of trade predictions so much a function of the proposed modifications that the endowments do not tell us anything? To address this question, I derive a theoretically rigorous test that identifies a role for country endowments in international trade when some of the basic assumptions of the HOV model are relaxed.

3. Relative Factor Abundance for a Pair of Countries

In this section I first argue that relative factor abundance is most closely linked to the intellectual tradition of international trade. In a next step, I define relative factor abundance in the country pair setup. Finally, I discuss the methodological strengths of the proposed test. I show how the sign test of relative factor abundance in the country pair setting that is derived under the standard HOV assumptions is observationally equivalent to a test that relaxes some of these assumptions. More specifically, my test can identify a crucial role for factor endowments in the pattern of trade irrespective of certain forms of technological differences across countries, home bias and measurement error.

The distinction between ‘relative’ and ‘absolute’ differences among countries has been central to trade theory from its early beginnings. Most prominent is the debate between Smith and Ricardo, leading to the notion that the *relative* cost advantage of a country is more fundamental for the pattern of trade than its *absolute* advantage. In a two-sector world, it is not so important to know whether for example Portugal needs more units of labor to produce cloth than the UK. What matters is whether Portugal is more efficient at producing cloth in terms of its foregone wine production than the UK. In the 2x2x2 HO model, it is again the notion of *relative* abundance that proves to be central, as it enables us to determine which country will trade which particular good. The country that is endowed with more capital per unit of labor will export the good that uses capital intensively. When taking HO to higher dimensions as in HOV, we lose the ability to distinguish the commodities that countries will export and import. We can only talk in terms of the factor content contained in the net trade of countries. With this shift in emphasis, the (in terms of the classical debate) *absolute* HOV prediction as described in the previous section (that a country will export more of one factor when it is endowed with more than what it consumes), has gained new prominence over the link between the factors. There is no reason why this should be the case. In fact, from the point of view of HO’s intellectual history, the HOV hypothesis in terms of relative factor abundance may well be its most appropriate formulation. The reason why relative abundance has gained less attention is probably related to a desire in the empirical literature to focus on more and more factors of production.

In a multicountry, multifactor world a country c is by definition *relatively* abundant in a factor A compared to another factor B, if and only if its endowment ratio $V_{A,c}/ V_{B,c}$ exceeds the world endowment ratio $V_{A,w} /V_{B,w}$. As shown by Leamer (1980) this relative factor abundance is revealed in a country's factor content of trade, if and only if a country’s production contains more of factor A per unit of B than its consumption. As the factor content of consumption equals the factor content of production minus that of net trade, this condition can be written as follows

$$\frac{V_{A,c}}{V_{A,c} - F_{A,c}} > \frac{V_{B,c}}{V_{B,c} - F_{B,c}} \quad . \tag{6}$$

The definition of relative abundance is readily adapted for a pair of countries. Country *i* is relatively abundant in *A* with respect to *B* compared to country *j*, if and only if $V_{A,i}/V_{B,i} > V_{A,j}/V_{B,j}$. The derivation of the condition that reveals this relative abundance in trade is fairly straightforward. Take equation (5) for the factors *A* and *B* as in expression (7) and (8).

$$F_{A,i} - {}^{a_i}\!/_{a_j} F_{A,j} = V_{A,i} - {}^{a_i}\!/_{a_j} V_{A,j} \tag{7}$$

$$F_{B,i} - {}^{a_i}\!/_{a_j} F_{B,j} = V_{B,i} - {}^{a_i}\!/_{a_j} V_{B,j} \tag{8}$$

Divide equation (8) by the *A* endowment of country $j, V_{A,j}$, and equation (8) by the *B* endowment of country *j* $V_{B,j}$.

$$\frac{F_{A,i}}{V_{A,j}} - {}^{a_i}\!/_{a_j} \frac{F_{A,j}}{V_{A,j}} = \frac{V_{A,i}}{V_{A,j}} - {}^{a_i}\!/_{a_j} \tag{9}$$

$$\frac{F_{B,i}}{V_{B,j}} - {}^{a_i}\!/_{a_j} \frac{F_{B,j}}{V_{B,j}} = \frac{V_{B,i}}{V_{B,j}} - {}^{a_i}\!/_{a_j} \tag{10}$$

Next, substitute expression (10) in (9) and obtain after rearranging

$$\frac{F_{A,i} - {}^{a_i}\!/_{a_j} F_{A,j}}{V_{A,j}} - \frac{F_{B,i} - {}^{a_i}\!/_{a_j} F_{B,j}}{V_{B,j}} = \left(\frac{V_{A,i}}{V_{A,j}} - \frac{V_{B,i}}{V_{B,j}} \right) \tag{11}$$

Equation (11) is the basis of a sign test in which the sign of the left-hand side is compared with the right-hand side. It gives the condition that reveals relative factor abundance for a pair of countries. The relative abundance of country *i* in *A* (i.e. $V_{A,i}/V_{B,i} >$

$V_{A,j}/V_{B,j}$, so that the right-hand side of (11) is positive) is revealed by trade, if and only if

$$\frac{F_{A,i}-(a_i/a_j)F_{A,j}}{V_{A,j}}-\frac{F_{B,i}-(a_i/a_j)F_{B,j}}{V_{B,j}}>0 \qquad (12)$$

In the case of relative abundance of country *j* in factor *A*, the sign of the condition should be reversed. Another way to write (12) is

$$\left(\frac{F_{A,i}}{V_{A,j}}-\frac{F_{B,i}}{V_{B,j}}\right)-(a_i/a_j)\left(\frac{F_{A,j}}{V_{A,j}}-\frac{F_{B,j}}{V_{B,j}}\right)>0\,. \qquad (13)$$

In other words, for any two factors *A* and *B*, country *i* 's relative abundance in *A* compared to *B* is revealed in trade, if and only if its exports of *A* services compared to country *j* are larger as a share of country *j*'s *A* endowment than its exports of *B* services compared to country *j* as a share of country *j*'s *B* endowment. The inequality (13) expresses this relation in a different way. The condition says that, after adjusting for differences in size and expressed in terms of country *j*'s endowments, country *i*'s exports of *A* services minus its *B* services are smaller than for country *j*. As can easily be seen, the condition is directly satisfied when the factor content between the two countries are opposite in sign for the two factors. In that case, the net factor services between country *i* and *j* for the factor that country *i* is relatively abundant in must be positive, otherwise condition (12) is violated.

Now how can a sign test based on equation (11) be a test that identifies a role for country endowments in the presence of country specific measurement error, Hicks neutral technological differences or home bias that is the same across countries?

Consider the case of Hicks neutral technological differences across countries. In this case, we have to express the endowments in terms of their US productivity equivalents. Let the endowment of country *i* for any given factor and expressed in terms of the US productivity be p_i times the observed endowment V_i, i.e. p_i V_i. As the US endowments were used to construct the factor content of net trade of country *i*, the factor content for country *i* in terms of US productivity will remain unchanged, as before it equals F_i. [9] Hence, taking productivity differences into account will transform the equations (7) and (8) for the factors *A* and *B* into.

$$\left(F_{A,i} - {}^{a_i}\!/_{a_j}\, F_{A,j}\right) = p_i V_{A,i} - {}^{a_i}\!/_{a_j}\, p_j V_{A,j} \qquad (14)$$

$$\left(F_{B,i} - {}^{a_i}\!/_{a_j}\, F_{B,j}\right) = p_i V_{B,i} - {}^{a_i}\!/_{a_j}\, p_j V_{B,j} \qquad (15)$$

Divide (14) and (15) by $p_j A_j$ and $p_j B_j$ respectively and substitute one equation into the other to find (16).

$$\left(\frac{F_{A,i} - {}^{a_i}\!/_{a_j}\, F_{A,j}}{V_{A,j}} - \frac{F_{B,i} - {}^{a_i}\!/_{a_j}\, F_{B,j}}{V_{B,j}} \right) = p_i \left(\frac{V_{A,i}}{V_{A,j}} - \frac{V_{B,i}}{V_{B,j}} \right) \qquad (16)$$

It is easy to see that the role of country endowments in determining trade is independent here of Hicks neutral technological differences.[10] If the technology differences

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[9] Note that the factor content of trade of the countries should be evaluated with one common technology matrix, when the endowments are rescaled by p_i. This is necessary to fulfill condition (11) of Deardorff (1982) for generalizations of HOV. The condition states that "if endowments of factors are reduced by the amounts of factors regarded as exported and increased by the amount of factors regarded as imported, it would be possible to produce entirely domestically the same vector of goods that is consumed with trade". With Hicks neutral differences between countries, expressing the endowments with the p_i's in terms of their productivity equivalents and with an evaluation of the factor content of trade in one common standard this condition is satisfied.

[10] Remark that in the presence of technological differences across countries, the world endowments V_w and $V_{A,w}/V_{B,W}$ are no longer reliable to determine the (relative) abundance of a country with respect to the world. One should use the productivity adjusted measures Sp_cV_c and $Sp_cV_{A,c}/Sp_cV_{B,c}$ to express the world endowments instead. Note that p_c is a scalar that expresses the relative productivity of country *c* with respect to the US. This is probably the reason why in BLS (1987), which is written with the presumption that technological differences do play a role, the only reasonably positive results that are

were factor specific, no match for equation (16) could be derived and there would not be any independent role for endowments left. One may wonder how realistic the Hicks neutral technology differences are, however. The justification for this stylized way of introducing technological differences is based on the observation that technological differences across countries are much more significant than differences in factor specific productivity, especially when developed and developing countries are included in the same sample. In other words, allowing for Hicks neutral differences is close enough an approximation when for example US labor is seven times as productive as in a developing country and capital six times.[11] Note that the basic assumption of factor price equalization is relaxed with Hicks neutral technological differences. If the US is twice as productive as the UK, its factor returns will be twice as high. [12]

A similar exercise can be performed for country specific measurement error. Suppose that the true endowment of country i is, for any given factor, the fraction m_i times the observed endowment V_i, i.e. $m_i V_i$. As the US endowments were used to construct the factor content of net trade of country i, the factor content for country i equals $m_{us}F_i$. Hence, in equations (14) and (15) the p_i's are changed into m_i's and the left-hand side is premultiplied by m_{us}. Division of (14) and (15) by m_jA_j and m_jB_j and

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obtained for relative factor abundance are downplayed. They study per country whether the relative abundance of two factors is reflected in trade. They report that for 22 out of 27 countries "the proportion of correct orderings exceeds 50 percent" (p.797) To be precise, however, for all 27 countries the average is 64 percent correct orderings, and for the best 22 observations 70 percent.

[11] I thank Dan Trefler for stressing this point.

[12] From (16) I can calibrate the relative productivity measures p_i for each country, while assuming that technological differences are the only modification of the standard HOV model needed to account for the difference in magnitude between the left and the right-hand side of equation (11). In this way I can address the controversy about factor price equalization in productivity equivalents with equation (16) and test whether technological differences can account for “missing trade” as found in one (though not the preferred) specification of Trefler (1995). In theory, the productivity differences should equal the differences in factor returns with other countries and the productivity measure for the US should be one.

substitution yield expression (17). Note that in the presence of factor specific measurement error as in Trefler (1995), one cannot derive an expression such as (16). In other words, a mere comparison of the relative endowments does not necessarily tell us anything about the trade of countries. A high capital labor ratio of a country for example may simply be due to a huge upward bias in the capital figures of that country.

$$m_{us}\left(\frac{F_{A,i} - {}^{a_i}\!/_{a_j} F_{A,j}}{V_{A,j}} - \frac{F_{B,i} - {}^{a_i}\!/_{a_j} F_{B,j}}{V_{B,j}}\right) = m_i\left(\frac{V_{A,i}}{V_{A,j}} - \frac{V_{B,i}}{V_{B,j}}\right) \tag{17}$$

As shown in Appendix B, the sign test based on (11) is also compatible with the form of home bias that Trefler (1995) introduced in the HOV model, when the home bias is taken to be the same across countries. Here again, if home bias were country specific as in Trefler (1995), one would not be able to establish a separate role for the country endowments in determining international trade. Note that my method circumvents a controversial issue. Trefler (1995) considers his preferred specification of the HOV world model, the version that combines Hicks neutral technological differences and country specific home bias. One may wonder, however, what these estimated home bias coefficients indicate. Davis, Weinstein et al. (1997) questioned in a study of the multilateral trade of Japan's regions whether home bias could play the prominent role it is supposed to. The advantage of my setup is that the role for endowments is not conditional on the particular estimation of any of the factors mentioned above, as home bias is merely allowed for.

In sum, the results of the proposed sign test of equation (11) will be observationally equivalent to equation (18), in which the left-hand side is multiplied by a scalar b and the right-hand side by g

$$sign\left[b\left(\frac{F_{A,i} - {}^{a_i}\!/_{a_j} F_{A,j}}{V_{A,j}} - \frac{F_{B,i} - {}^{a_i}\!/_{a_j} F_{B,j}}{V_{B,j}}\right)\right] = sign\left[g\left(\frac{V_{A,i}}{V_{A,j}} - \frac{V_{B,i}}{V_{B,j}}\right)\right] \tag{18}$$

As shown, the *b* or *g*'s can be rationalized as country specific measurement error, Hicks neutral technological differences, home bias that is the same across countries or any characteristic that affects the factor content of trade or the endowments in a similar fashion. In other words, equation (18) provides a test that identifies a role for the country endowments independent of such considerations. Put differently, a role for the country endowments is derived under assumptions that are less stringent than in the standard HOV model.

4. Empirical Evidence for Relative Factor Abundance

As mentioned above the data sets of BLS and Trefler are used for the implementation of the empirical test.[13] Both data sets include developed and developing countries. For capital and labor, labor and land, and land and capital I construct all the possible country pairs. As there are 27 countries in BLS and 33 in Trefler, I obtain a sizable set of observations. For each of the three factor combinations I generate respectively 702 and 1056 country pairs. Trivial comparisons of a country with itself are dropped. Note that equation (11) for the country pair *i*,*j* is different from the pair *j*,*i*. (In the first case one divides by the endowments of country *j* to obtain the equation (11), in the second case by those of country *i*). The general results are reported in Table 1. For the Trefler data I find 70.5 percent matching signs for capital and labor, for capital and land 75.5 percent and for labor and land 77.5 percent. In the case of BLS, the figures are of the same order of magnitude. Tables 2 and 3 illustrate for the Trefler and BLS data the sign match results for all possible country pairs. The factors considered are capital and labor. A one indicates a sign match, a zero no sign match. The bottom row and the last column sum up the number of times the relative endowments are revealed in trade for a country.[14] For Trefler and BLS data set and for all three of the factor combinations

[13] In BLS (1987) and Trefler (1993) an extensive description of the data sources is found.

[14] One may notice that a couple countries perform poorly. In the Trefler data set the countries that obtain for one of the three factor pairs and in both the bottom row and the last column less than fifty percent matching signs are: for labor and capital Singapore, and

separately, the hypothesis of independence between the sign of the factor contents (the left-hand side) and the endowments (the right-hand side) can easily be rejected using Fisher's Exact Test at the 95 percent level.[15]

Now, why are these results so much better than the plain rejection of the theory in the absolute factor abundance case? The major reason is directly related to the merits of combining a country pair approach with relative factor abundance. Recall that the sign test for relative factor abundance is insensitive to country specific measurement error, Hicks neutral technology differences, home bias that is the same across countries, or any other factor that may affect endowments in a similar way. This cannot be said, however, about the absolute version as found for example in equation (14). It is easy to see how country specific measurement error, (the m_i and m_j's) scale up or down the observed endowments on the right-hand side of the equation. Hence, not correcting for measurement error in the implementation can easily yield a different sign from when measurement error is taken into account. The same is true for Hicks neutral differences. Rescaling the endowments in terms of their productivity equivalents can easily change the

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for labor and land the Netherlands and Sri Lanka. Israel, Trinidad and Uruguay are borderline for labor and capital. For the BLS countries Argentina and Brazil are the outliers for capital and labor, and the Netherlands (again) and Denmark for land and capital. One could investigate whether there are particular reasons for their poor performance.

[15] The large sample approximation of Fisher's test has a *N (0,1)* distribution. The test statistic is $Z= [B-(N/2)]/(N/4)^{1/2}$, where *N* is the sample size and *B* the number of right signs. A rejection of the independence hypothesis against the alternative of a positive association between factor contents and endowments only requires for the Trefler data set more than 53 percent matching signs. In the case of BLS, one needs more than 53.7 percent to reject the independence hypothesis.

sign on the right-hand side and hence improve the poor performance of the absolute version.

As mentioned before, the sign test based on equation (11) yields a different condition for the country pairs *i,j* and *j,i*. Note that in condition (12) country *i* is compared to country *j* and we divide by *j*'s endowments to obtain the inequality. For the pair *j,i* country *i*'s endowments are used and condition (19) is obtained, when country *i* is the relatively capital abundant country. Note that in case country *i* is relatively abundant in *A*, equation (12) will give much more weight to the difference in the factor contents for factor *A* ($F_{A,i} - (a_i / a_j)F_{A,j}$) than equation (19). The reason is fairly straightforward. In equation (12) I divide by the endowments of *j* and in (19) by those of *i* and $V_{A,j}$ is relatively small in terms of $V_{B,j}$ compared to $V_{A,i}$ in terms of $V_{B,i}$.

The relative abundance of country *i* in factor *A* is revealed by trade, if and only if

$$\frac{F_{A,j} - (a_j / a_i)F_{A,i}}{V_{A,i}} - \frac{F_{B,j} - (a_j / a_i)F_{B,i}}{V_{B,i}} < 0 \qquad (19)$$

In the case of abundance in *B*, the sign is reversed.

From an empirical point of view, it is important to check the consistency of the results between condition (12) and (19). In theory the results for both equations should be the same but in practice this is not always the case. It is clear for example that Table 2 is not perfectly symmetric with respect to the (blank) diagonal. The first row of zeros and ones indicates that the relative abundance of Bangladesh with respect to all the countries is reflected in the trade pattern in 24 out of 32 cases. In the first column of zeros and ones, on the other hand, one finds a sign match in 23 out of 32 times when a country is compared with Bangladesh. Comparing the first row and column, one finds an inconsistency for the pairs with Israel, Trinidad and Denmark. One has to subtract these inconsistencies from the overall result. This consistency check is essential. Theoretically, one might obtain 50 percent right signs and zero consistent signs. As can be seen in Table

1, the score normally drops by about 5 percent points when we correct for inconsistencies.[16,17]

A strength of my approach is that I do not have to estimate home bias or technological differences or any factor that affects the endowments in a similar way, so that the results are not dependent on a particular estimate of these.[18] After having established a central role for endowments in a country's pattern of trade, the results are investigated in greater detail in the next section. I explore another feature of my method. I study different groups of country pairs and whether the *extent to which endowments differ* matters for the outcome of the HOV prediction. The analysis almost naturally leads to an

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[16] The exact percent of consistent sign matches for capital-labor in Trefler is 64.5 and 72 percent for BLS, for land and labor one obtains 70.5 and 72.5 percent respectively. Finally for the factors land and capital 60 and 70 percent are found.

[17] One may wonder when inconsistencies occur. In appendix C the following conditions for inconsistencies are found. A country pair in which country *i* is relatively abundant in *A* compared to country *j* will satisfy condition (12) but violate (19), if and only if

$$F_{B,j} - (a_j / a_i) F_{B,i} < 0,$$
$$F_{A,j} - (a_j / a_i) F_{A,i} < 0,$$
and
$$\frac{V_{A,i}}{V_{B,i}} > \frac{F_{A,j} - (a_j / a_i) F_{A,i}}{F_{B,j} - (a_j / a_i) F_{B,i}} > \frac{V_{A,j}}{V_{B,j}}$$

In the case of relative factor abundance in *B*, the inequality signs revers. Note that these conditions imply that an inconsistency never occurs when the difference in the factor content of trade between the two countries for *A* and for *B* are of opposite sign. When the differences between the factor contents have the same sign, an inconsistency is found if the ratio of the factor content differences lies in the range spanned by the endowment ratios of the two countries.

[18] The approach is flexible enough, however, to test whether there is evidence for factor price equalization in productivity equivalents and whether Hicks neutral differences could ever be invoked as the sole origin of missing trade as in one of the specifications of Trefler (1995). In Appendix A I calibrate the productivity differences from equation (16) and then relate them to relative factor returns. As argued there, my way of testing FPE in productivity equivalents is not subject to Gabaix' (1997) critique of Trefler (1993). I find only some tentative support for FPE. I also show in Appendix A that Hicks neutral

explicit assessment of North-South trade in section 6. In the last section the sign test results will be analyzed more extensively in the framework of a probability model.

5. The Dissimilarity of Countries and Heckscher-Ohlin

First, I focus on the Trefler data and show how the extent to which endowments differ affects the success of the HOV prediction. After explaining why this is an important result, the difference between the BLS and Trefler data sets will be highlighted in a graphical analysis.

Condition (18) performs much better when countries with very different endowment ratios are compared than when checked for similarly endowed countries. Consider the case of capital and labor. Divide the data set in two groups. On the one hand, take the rich developed world together, and on the other hand, the rest of the world (roughly speaking the South with mostly developing countries).[19] Table 4 shows the members of each group and the sign match results for the 33 Trefler countries. I find within the group of developed countries (North-North) 57.5 percent sign matches and within the mainly developing countries (South-South) 54,5 percent. For mixed country pairs (North-South) I obtain 83.5 percent corresponding signs. Overall, these numbers suggest that the extent to which the endowments differ is crucial for the success of the HOV prediction.

Nevertheless, even though the basic pattern remains the same when slightly varying the definition of North and south, one could argue that the subdivision into two groups is somewhat arbitrary. Also, for the pairs of factors other than capital and labor, it is not necessarily true that the distinction between high and low endowment ratios coincides with

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differences cannot be the only factor that explains the gap of "missing trade."

[19] There is no standard way of defining the South. In this paper, the South will be any country that does not belong to the group of rich developed countries which are Austria, Italy, the UK, Japan, Belgium, the Netherlands, Finland, Denmark, West Germany, France, Sweden, Norway, Switzerland, Canada, the US. Enlarging the country group of the North with countries such as Portugal, Greece, Spain does not alter the basic conclusion of this section.

a meaningful distinction such as the one between developed and developing countries.[20] Hence, a more formal procedure is needed to show that the extent to which endowments differ matters for the success or failure of the HOV prediction, irrespective of country groups or factor pairs. In section 7 a probability model $F\ (Y_{i,j}=1 \mid X_{i,j}) = f(bX_{i,j})$ is estimated where the dependent variable $Y_{i,j}$ is one if there is a sign match for the country pair *i,j* and zero otherwise.[21] As discussed in section 7, the variable that measures the extent to which the country endowments differ between a country pair will be one of several variables that have a positive and significant contribution in the probability of a sign match, irrespective of any subdivision into country groups.[22]

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[20] For example, the US and Canada have a lot of land which brings them closer to countries like Indonesia in terms of the labor-land ratio. Hong Kong and Singapore, on the other hand, have almost no land which gives them the top position in terms of the capital to land or labor to land ratio.

[21] One may wonder why one does not simply run a regression of equation (11). With both positive and negative variables on the right and left-hand side, it should be clear that we will not be able to identify country specific effects that would account for technological differences, home bias or country specific measurement error as specified by equation (16) or (17). Indeed, no logarithmic transformation of the equation can be taken. Another complication would be the fact that the left-hand variable also has measurement error. Note that the calibrated productivity measures of Table 4 give an idea of the magnitude of the left compared to the right-hand side of the equation. A productivity measure of 0.10 implies that the right hand side is ten times bigger than the left-hand side.

[22] Note also the following correlation result. A simple linear regression, probit and tobit model of the zeros or ones that mark the success and failure of the sign test on one of the following three variables that measure the extent to which endowments differ show a positive and significant coeffiecient. Table 5 reports the results.

In sum, the more different country endowments are, the more easily the relative abundance of countries is revealed in trade. Alternatively, countries can be too similar to have trade reveal their relative abundance.[23,24] Why is this an important result? Again, this observation confirms that a basic idea of HO is revealed in the data. We not only know that relative endowments matter, we also see that the extent to which they differ affects the ease with which relative abundance is revealed in trade. As shown in the next section, this regularity is related to the North-South trade literature. In fact, this observation is an illustration of a basic tenet of the HO theory. Figure 1 illustrates this for the two-country case. It displays the endowment box for a world of two countries. e_1 , e_2 and e_1*, e_2* stand for different combinations of capital and labor endowments for country

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$$X_1 = \left| \frac{V_{A,j}}{V_{B,j}} - \frac{V_{A,i}}{V_{B,i}} \right|$$

$$X_2 = \begin{cases} \dfrac{V_{A,j}/V_{B,j}}{V_{A,i}/V_{B,i}} \; if \geq 1 \\ \dfrac{V_{A,i}/V_{B,i}}{V_{A,j}/V_{B,j}}, \; otherwise \end{cases} .$$

X_3 ranks X_2 for each country i in increasing order.

X_1 is just the absolute value of the difference in the endowment ratios, whereas X_2 takes the ratios and X_3 ranks X_2 for each country i.

[23] In Debaere and Demiroglu (1997) we argued that HOV is likely to hold only for the rich OECD countries as we only found clear evidence for them that Deardorff's (1994) Lens condition holds. This lens condition is the higher dimensional counterpart to the textbook condition for the 2x2x2 case that the country endowments should "lie inside the diversification cone". In other words, it is a necessary condition for factor price equalization (a central assumption of HOV) that restricts the dissimilarity of country endowments. Note also the possibility left open in Debaere and Demiroglu (1997) that the violation of the Lens condition for developing countries may be due to an aggregation problem.

[24] In a probability regression with only the North-North and South-South country pairs and a dummy for the North and the South, the measures for the extent to which country

1 and 2. A parallelogram connects the endowments. As identical and homothetic preferences are basic assumptions of the HOV theory, we know that the countries' consumption points (denoted by c_1, c_2 and c_1*,c_2*) lie on the diagonal of the box. When the endowments e_1* and e_2* also lie on the diagonal, they equal the consumption points and no net factor exchange takes place through trade. The more different endowments are, however, the more factor exchange takes place and the easier it should be to observe this empirically. In this case, a nonzero net factor content of trade vector (with slope equal to the ratio of wage over the return to capital) connects the endowments e_1 , e_2 with the consumption points c_1, c_2.

In this paper the HOV model is approached in country pairs. Each time, the endowments and trade of two countries are compared. When two-country endowment boxes are drawn in a multicountry world as in Figures 2 and 3 for France and Germany, and Germany and Bangladesh, the interpretation of the graphs is somewhat different from the 2x2x2 world of Figure 1 discussed above.[25] In a multicountry world, it is not necessarily the case that there is no factor exchange through trade when two country endowments lie on on the diagonal of a two-country endowment box as in the case of France and Germany. Figures 4 and 5 illustrate this. Figure 4 displays the country endowment lens for a world with more than two countries. The country endowment lens consists of two chains of country endowment vectors $(V_{L,c}, V_{K,c})$. One chain connects these endowment vectors in increasing order of their capital-labor ratios starting from the origin. The other chain does the same but now in decreasing order. Figure 4 shows the nonzero factor content of net trade vectors that connect for each country i the endowment points e_i with the consumption points c_i.[26] In Figure 5 the two-country endowment box (this is the

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endowments differ are not significant.

[25] When there are Hicks neutral technological differences between countries, only the length of the endowment vectors, not the slope, will be affected.

[26] Note that as HOV holds for the world as a whole (our hypothetical world of four countries), the diagonal of the endowment box represents the capital-labor ratio of the factor content of consumption. The consumption c_i is found at the intersection of the

box in dashed lines) is explicitly integrated into the multicountry setting. The fat arrow in Figure 5 shows how one can distinguish the factor exchange through trade of two countries. The regular arrows show the net factor exchange between the countries and the rest of the world. It is easy to see how these regular arrows would be nonzero even when the endowments of country 1 and 2 were on the diagonal of the two-country endowment box (in which case the fat arrow would be zero). In other words, in a pairwise comparison of countries from a multi-country world, one should also be able to distinguish countries' factor exchange more easily, the further they are from the diagonal.

So far, the focus has been on the Trefler data set. For the BLS countries the results for sign tests between a rich developed country and a southern country is less outspoken. One obtains respectively among developed and developing countries 68 and 74.5 percent. When comparing a developed and a developing country one finds 76 percent sign matches. A possible reason why the obtained results for BLS are less pronounced can be seen when comparing the endowment distributions of the two datasets. In order to do so, the country lenses of both data sets are drawn in Figure 6 (the Trefler data are rescaled to match with BLS). For the Trefler country lens one sees how the majority of the capital abundant developed countries virtually lie on one line segment; the developing countries, on the other hand, group together at the other end of the spectrum on a line segment with a very different slope. In the BLS data set, however, there is much more curvature all over the endowment distribution, so that also among the different developed countries HO trade should be picked up more easily. One may wonder what the explanation for the difference between the data sets is. On the one hand, there is a slightly different set of countries considered. More importantly, however, the BLS data are from 1966, whereas Trefler's

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factor price line through the end point of the endowment vector of country *i* and the parallel line to the diagonal of the endowment box that runs through the starting point of the endowment vector of country *i*. In case HOV does not hold for the world as a whole, the consumption points of the countries should be drawn using parallels to the diagonal of the factor content of consumption box for these countries that will be different from their endowment box. In addition, there may be a net factor exchange between the group of countries as a whole and the rest of the world when HOV does not hold for the world as a whole.

were constructed in 1983, so that convergence among the developed countries may have made it much more difficult to distinguish HOV trade. A closer analysis of the 19 OECD countries that are common to both data sets confirms the possible impact of convergence. Figure 7 for that limited group shows the same pattern as Figure 6. Moreover, the coefficient of variation in the capital-labor ratios of the BLS data set is twice as high as the one for Trefler in this OECD group[27] In addition, after rescaling, the hypothesis that the capital-labor ratios of both data sets have the same variance is rejected in an F-test.[28]

The extent to which endowments differ matters. The more different endowments are, the easier it should be to observe their relative abundance revealed in trade. The presumption of a higher signal to noise ratio almost naturally leads to the analysis of North-South trade.

6. The Relative Abundance Between Groups of Countries and North-South Trade

The observation of large volumes of intra-industry trade among the developed countries and the discussion of increasing returns have led to some questioning of the relevance of the HOV model for explaining trade among the developed countries. In the case of North-South trade, however, there has always been a strong presumption that HO(V) should be a major driving force in North-South trade, as the gains from trade are believed to be the greatest between economies that are the least similar (in terms of endowments) and as North-South trade is mainly thought of as inter-industry rather than intra-industry trade.[29] The previous section brought a distinct country pattern to the fore. It is tempting to interpret that pattern directly as evidence that shows how North-South trade is most easily observed to be of the HOV type, reflecting the relative capital

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[27] The coefficient of variation for the K/L in the BLS data set is 0.0249 and for Trefler 0.012.

[28] The test statistic is 3.11. whereas the critical value amounts to 2.5.

[29] Ethier (1988) p. 37 and p. 45.

abundance of the North compared to the South. Still, one should be cautious before drawing such a conclusion. The country pair approach considers the factor content of *multilateral* trade. In other words, the net factor content of trade of a developed country includes not only the net trade with the South, but also the trade with the other industrialized countries. In this section, the relative factor content of North-South trade is assessed in the framework of a HOV model and in doing so I fill a gap in the North-South literature.[30] In order to address the issue of North-South trade, the equations are reformulated. I focus on the factors capital and labor, as differences in capital-labor ratios most clearly coincide with the distinction between the North and the South.

In the setup discussed in sections 2 and 3, the trade pattern of one single pair of countries was analyzed. In this section the trade pattern for groups of countries is studied. Define the factor content of trade for a group G of countries c as $F_G = å F_c$, its share of world consumption as $a_G = å a_c$ and its endowments as $V_G = å V_c$. In a world in which HOV holds $F_c = V_c - a_c V_w$, and hence, the factor content for a group of countries should equal $F_G = V_G - a_G V_w$. So far, this is nothing but an aggregation exercise. Now consider two groups of countries G_1 and G_2 for which HOV works. Then, the familiar equation (5) for these groups of countries is as follows,

$$F_{G1} - {}^{a_{G1}}\!/_{a_{G2}} F_{G2} = V_{G1} - {}^{a_{G1}}\!/_{a_{G2}} V_{G2}\,, \qquad (20)$$

and (one of) the conditions for revealed capital abundance in trade when G_1 is the relatively capital abundant group, is given by

[30] In an extensive survey of the North-South literature, Wood (1994) argues that it remains to be seen whether North-South trade will be consistent with factor abundance within the context of a HOV model.

$$\frac{F_{K,G1}-(a_{G1}/a_{G2})F_{K,G2}}{V_{K,G2}}-\frac{F_{L,G1}-(a_{G1}/a_{G2})F_{L,G2}}{V_{L,G2}}>0. \tag{21}$$[31,32]

Why is this group analysis helpful? In its simplicity, the modification allows me to tackle the factor content of North-South trade. Consider a first group G_1 that includes all the rich developed countries. Its multilateral trade will be identical with its net trade with the South as all trade between the developed world will be netted out. In terms of Figure 4 the North's endowment vector would be from the origin up to e_2 in case countries 1 and 2 constitute the group of rich developed countries. Next one could lump all the developing countries together in a group G_2. In Figure 4 the endowment vector of the South would start at e_2 and run up to the upper right corner of the box, should countries 3 and 4 constitute the South. We would have returned to the two-country case for both groups. Next, one should simply check the inequality (21). However theoretically appealing this approach is, it has drawbacks that make it unattractive from an empirical point of view. One could argue that the developed countries share more or less the same technology (one could even claim that there is factor mobility among them), so that lumping them together is justifiable. For the very heterogeneous group of developing countries, this is not the

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[31] Here again HOV only has to hold for the two groups of countries. Hicks neutral differences between the groups of countries are possible, but within a specific group they should be the same.

[32] For the sake of clarity, let me spell out why a mere summation of the factor contents for a set of countries yields the appropriate factor content for a group of countries. Consider the case where G consists of country 1 and 2. Then, define for country 1 F_{12} as the factor content of the net bilateral trade between country 1 and 2 and $F_{1(2)}$ as the factor content of net trade of country 1 with the rest of the world, excluding country 2, i.e. $F_{1(2)} = F_1 - F_{12}$. Define similarly for country 2 F_{21} and $F_{2(2)}$. The sum of the factor content of country 1 and 2, $F_G = F_1 + F_2$, can be rewritten as $F_G = F_{1(2)} + F_{12} + F_{2(1)} + F_{21}$. As F_{12} and F_{21} both refer to the same bilateral trade and are of opposite sign (country 1's exports are country 2's imports), $F_G = F_{1(2)} + F_{2(1)}$, which is exactly the factor content of trade of the group with the rest of the world.

case.[33] Therefore I opt for another strategy. I stick to G_1 as the group of developed countries and choose for G_2 each time a particular southern country. As major part of the trade of developing countries is with the developed world anyway this introduces only a slight bias.[34] Table 6 reports my results. When comparing Southern countries with the North (i.e. when dividing by the North's endowments), one obtains 89 percent right signs. Otherwise, 95 percent. In other words, the relative capital abundance of the North is clearly reflected in trade.

7. The Success and Failure of the HOV Hypothesis

The previous sections have lent support to the basic propositions of the HOV hypothesis. Endowments play a central role in determining countries' patterns of trade, and the more different the endowments are, the more easily can the relative abundance be observed in trade. The latter quite naturally led to an analysis of North-South trade and the presumption that there is a higher signal to noise ratio in the trade patterns of countries with very different country endowment ratios. The probability model presented in this section should provide a more formal way of showing that the extent to which endowments differ matters for the success and failure of the HOV hypothesis. At the same time it will provide us with a tool to address the common critique of any HOV analysis which states that insufficient care is taken of other factors (such as for example government interventions) that may affect the HOV prediction.[35] To a certain extent, a probit analysis of the success and failure of HOV opens new perspectives. It allows me to find out empirically which country characteristics are correlated with a sign match and no sign match. To my knowledge no analysis has previously noticed this possibility. Given the scarce data available, the obtained results should be considered indicative of a new way of

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[33] In addition, I do not have data for all the developing countries.

[34] Ethier (1988) shows on page 37 that in 1985 about 73 percent of the exports of the less developed countries went to the developed countries.

[35] See Leamer (1994).

looking at the HOV predictions rather than definitive. I run a probit regression with the following variables for the Trefler dataset and for all factor combinations.

$$Y_{i,j} = a + V D_{LA/K} + t D_{LA/L} + b X_{i,j} + g O_{i,j} + h D_{i,j} + l YC_{i,j} + f T_{i,j} + e_{i,j}\,,$$

where the dependent variable $Y_{i,j}$ equals one if there is a sign match for a country pair i,j and zero otherwise, $D_{LA/K}$ and $D_{LA/L}$ are dummies for the factor combinations land-capital and land-labor, $X_{i,j}$ is the $X_{i,j}$ endowment differences between country i and j as explained below, $O_{i,j}$ is an oil dummy that is one if only one of the two countries is a net exporter of oil and zero otherwise, $D_{i,j}$ is the absolute value of the difference between the percents of GDP spent on military expenditures. $YC_{i,j}$ measures the absolute difference between the per capita GDPs of the two countries i and j, and $T_{i,j}$ is the absolute value of the difference between the average tariff rates of the countries i and j.

The $X_{i,j}$ variable measures the extent to which endowments of country i and j differ. It is defined as the third endowment measure from footnote 22. The significance of the variable should complement the finding of section 5 where we analyzed the sign test for groups of countries. It should establish in a more general way than section 5 did that a sign test of HOV is more likely to be successful when the endowment ratios of countries differ much. The tariff variable proxies most clearly for direct government intervention in trade. The estimated average post-Tokyo Round tariff rates are found in Deardorff and Stern (1990). The figures do not include non-tariff barriers. The difference in per capita GPD and in military spending should capture violations of the standard HOV assumption of identical homothetic preferences. The oil variable is included because oil exports are known to have affected factor content of trade calculations and are often excluded in factor content studies.

The results are presented in Table 7. The first regression is run on the full dataset of 3168 observations, yet does not include the *T*-variable. All coefficients, except for oil, are significant. The HOV performance is negatively affected by defense expenditures. Otherwise, the effects of all other factors are found to be positive. For a smaller group of 1804 country pairs the regression is run with the *T*-variable. Its coefficient is positive and significant. One should be very careful in interpreting its meaning, however. Trade policy seems to reinforce the pattern of comparative advantage as revealed by trade. On the other hand, non-tariff barriers are not included in the *T*-variable and they may play a prominent role especially for developing countries.

8. Conclusion

This paper has tried to answer a fundamental question that addresses the essence of the HO theory and that has not yet received a satisfactory answer in the extensive empirical literature: Do country endowments matter for the pattern of trade? To tackle this issue, I developed a theoretically rigorous test of the HOV hypothesis that identified a central role for country endowments in the pattern of trade, while relaxing some of the HOV assumptions. I tested the original notion of *relative* factor abundance that involves two factors at a time for country pairs. My approach had distinct methodological advantages compared to the standard world version of the HOV model. Most important from an empirical point of view was the fact that the focus on relative factor abundance made it possible to identify a role for endowments in a country pair setting, irrespective of Hicks neutral differences, home bias that is the same across countries or country specific measurement error. A major strength of the test was that none of these factors had to be estimated and that the hypotheses were supported by a large data set. Moreover, similar results are obtained for two data sets.

My results counter the negative results in the literature that compared the role of endowments in the HO prediction to the toss of a coin. Overall, I found empirical support for some of the basic propositions of the HO theory. Relative factor abundance is revealed in trade in about 75 percent of the hundreds of country pairs constructed from the Bowen, Leamer and Sveikauskus (1987) and the Trefler (1995) data sets. In addition, my method made it possible to study HOV for different groups of country pairs. The less similar countries are (for example, when comparing a developed and a developing country), the stronger the results. This led to the first assessment in the literature of North-South trade in a HOV model. The North's higher capital to labor ratio is revealed in trade in more than 90 percent of the cases.

In a final step, a probit model is used to analyze the sign test results. I established that the extent to which endowments differ determines the success or failure of the HOV prediction. In addition, the probit analysis showed a new way of analyzing the HOV test results as it identified other factors that affect the performance of the HOV model. As a result, I could address the long-standing criticism and frustration that HOV analyses insufficiently control for other factors (such as government intervention).

REFERENCES

Bernstein J.R. and Weinstein, D.E. (1997), " Do Endowments Predict the Location of Production. Evidence From National and International Data." Mimeo

Bowen, H.P., Leamer, E.E., and Sveikauskaus, L. (1987), "Multicountry, Multifactor Tests of the Factor Abundance Theory". *American Economic Review*, 77(5), p.791-809.

Brecher, R.A. and Choudri, E.U.(1988), "The Factor Content of Consumption in Canada and the United States : A Two-Country Test of the Heckscher-Ohlin-Vanek Model". in : Feenstra, R. C. (ed.), *Empirical Methods for International Trade*, MIT Press, Cambridge.

Crafts, N.F.R. and Thomas, M.(1986), "Comparative Advantage in UK Manufacturing Trade, 1910-1935". *Economic Journal*, 96, p. 629-645.

Davis, D. and Weinstein, D., Bradford, S., Shimpo, K. (1996), “Using International and Japanese Regional Data to Determine When the Factor Abundance Theory of Trade Works”, *American Economic Review*, 87(3), p. 421-446.

Deardorff, A. V. (1994), “The Possibility of Factor Price Equalization, Revisited”, *Journal of International Economics*, 36, p. 167-175.

Deardorff, A. and Stern, R. (1990), “Computational Analysis of Global Trading Arrangements, Michigan.

Deardorff, A. (1982), “The General Validity of the Heckscher-Ohlin Theorem”, *American Economic Review*, 72 (4), p. 683-694.

Debaere, P and Demiroglu U. (1997). “On the Similarity of Country Endowments in Developed Countries”. Umiversity of Michigan. Mimeo

Debaere, P. (1997), “Factor Abundance and Comparative Advantage in the Long-run. Belgium vs. the UK.”University of Michigan. Mimeo

Ethier, W. (1988), Modern International Economics, New York.

Gabaix, X. (1997), “The Factor Content of Trade. A Rejection of the Heckscher-Ohlin-Leontief Hypothesis.” Harvard University. Mimeo.

Hakura, D. (1996), “A Test of the General Validity of the Heckscher-Ohlin Theorem For Trade in the European Community, Essay II”, unpublished dissertation University of Michigan.

Kohler, W. (1991),”How Robust Are Sign and Rank Order Tests of the H-O-V Theorem? *Oxford Economic Papers*, 43(1), p. 158-171.

Krugman, P (1995), “Technological Change in International Trade”. in : Stoneman, P., *Handbook of the Economics of Innovation and Technological Change*, Blackwell, Oxford, p. 342 -365.

Leamer, E.E. (1995), “Factor-Supply Differences as a Source of Comparative Advantage”, *American Economic Review*, 83, May 93, p. 436-39.

Staiger, R.W., Deardorff, A.V.,Stern, R.M. (1987), “ An Evaluation of Factor Endowments and Protection as Determinants of Japanese and American Foreign Trade”, *Canadian Journal of Economics*, 20 (3), p. 449-463.

Trefler, D. (1996), “The Structure of Factor Content Predictions, Working Paper, March 26.

Trefler, D. (1995), “The Case of the Missing Trade and Other Mysteries”, *American Economic Review* vol 85(5), p. 1029-1046.

Trefler, D. (1993), “International Factor Price Differences : Leontief Was Right !”, *Journal of Political Economy*, vol 101 (6), p. 961-987.

Vanek J. (1968), “The Factor Proportions Theory : The N-Factor Case”. *Kyklos*, 21(4), p. 749-756.

Wood. A. (1994) “ Give Heckscher-Ohlin a Chance!” *Weltwirtschaftliches Archiv*, 130 (1), p. 20-49.

Appendix A. FPE in Productivity Equivalents and Hicks Neutral Differences

From equation (16) one can calibrate the Hicks neutral technological differences, while maintaining that they are the only factors that account for the difference in size between the left and the right-hand side of (11). For each of the *(Z-1)* equations in which country *i* is compared with another country *j*, one obtains a productivity measure p_i.

$$p_i = \left[\frac{F_{A,i} - (a_i / a_j)F_{A,j}}{V_{A,j}} - \frac{F_{B,i} - (a_i / a_j)F_{B,j}}{V_{B,j}}\right] / \left[\frac{V_{A,i}}{V_{A,j}} - \frac{V_{B,i}}{V_{B,j}}\right] \qquad \text{(A1)}$$

When considering the HOV model with Hicks neutral technological differences, the central assumption of factor price equalization is modified. In that case, the factor returns are the same across countries only after correcting for productivity differences. For example, when the US is two times more productive than the UK, its factor returns should be twice as high (i.e., in productivity equivalents they are the same). I calculate an average of all the calibrated p_i's of country *i*. Next, I follow Trefler (1993) and run a regression of the relative productivities p_i/p_{us} on the relative factor returns. A coefficient of one implies a non-rejection of FPE in productivity equivalents.

$$p_i/p_{us} = 0.11 + 1.16\, w_i / w_{us} + e_i \qquad \text{(A2)}$$[36]

(s.e=0.25)(se : 0.41)

R^2*:0.63* *n:27*

$$p_i/p_{us} = -0.59 + 1.33 r_i / r_{us} + e_i \qquad \text{(A3)}$$

---

[36] The productivity measures are put on the left-hand side as a way to handle the errors-in-variables problem. When the regressions are run with the relative factor returns on the left-hand side, one obtains the following results

$$w_i/w_{us} = 0.39 + 0.21 p_i / p_{us} + e_i$$

(s.e:0.08)(se:007)

R^2*:0.81* *n:27*

$$r_i/r_{us} = 0.88 + 0.17 p_i/p_{us} + e_i$$

(s.e.:0.06)(.s.e:0.06)

R^2*:0.95* *n: 27*

(s.e=0.52) (s.e:0.5)

R^2*:0.62* *n: 27*

A shown in regression (A2) for the relative wage w_i/w_{US} and in (A3) for the return to capital r_i/r_{US}, the constant is not significant and the coefficient of the factor returns is not significantly different from one when considering 27 Trefler countries. To give the hypothesis the most favorable chance (for the full data set none of the coefficients is significant), I dropped the three violating countries and the other three borderline violating countries from the Trefler data set when calibrating the p_i's.[37] Table A1 reports the productivity measures p_i/p_{us} for 27 Trefler countries and Figures A1 and A2 plot these.[38] Note that some of the measures are negative. This should not be too surprising as in about 20 percent of the cases the signs do not match, which automatically yields a negative productivity measure for a specific country pair. There is also a significant amount of variation among them, so that one can in at setting that is very favorable to the hypothesis at best call the evidence presented only tentatively support in favor of FPE in productivity equivalents.

Now, how does my test differ from Trefler (1993), and why is it not subject to Gabaix' (1997) objections? The central point in Trefler (1995) is that we observe "missing trade". In other words, the factor content of trade F_c is very small compared to the differences in endowments V_c- cV_w. Gabaix (1997) correctly remarked that in that case Trefler's test - a regression of relative *factor specific* productivities on the factor returns - is easily satisfied and is only very weak evidence in favor of FPE in productivity equivalents. To see why this is the case, consider the p_i*'s* when calculated from equation

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[37] See Footnote xiv for a list of poorly performing countries. Note that it is a particular feature of my setup that not all the countries of the world necessarily have to fulfill the HOV pattern of trade. Hence, it is possible to drop by way of exercise and to get rid of the nonsensical negative technology measures some countries from the list.

[38] For the calibration the borderline violating countries Trinidad, Israel and Uruguay are not included.

(16) for a specific factor labor. As F_c is very small, let's assume it is zero for both countries *i* and *j*. In this case $p_i/p_j = [(Y_i-B_i)/V_{L,i}]/[(Y_j-B_j)/V_{L,j}]$, which amounts to a regular productivity measure, namely the ratio of the per worker income between country *i* and *j*. Hence, it is not surprising to find that the coefficient is not significantly different from one in a regression of the relative productivities on the relative wages. A model without trade would easily yield similar results. Gabaix also showed that if the factor content changed sign, it would virtually have no impact on the productivity measure and on the result.

My calibration avoids all of the above pitfalls. First, I focus on Hicks neutral differences instead of factor specific technology differences. Second, when the traded factor services F_c are zero, the p_i's are zero in my case. Also, as the sign test is satisfied in a little more than 80 percent of the cases, I will have 20 percent of negative technology measures p_i . Trade does have a clear impact and the average of the technology measure will not necessarily fit the regression.

The analysis of Hicks neutral differences brings another aspect to the forefront. The p_i's were derived under the assumption that technological differences are the only factor causing "missing trade". In theory p_{us} should be one, yet in the data its value is about 0.15. In other words, Hicks neutral technological differences cannot be the only factor that drive "missing trade". This finding is also confirmed by Gabaix (1997) in the sense that proxying for technological differences by, for example, the relative wage rate does not remove the "missing trade" gap.

Appendix B. Home Bias

Trefler (1995) introduces home bias in the HOV model. Consumers distinguish between domestically produced goods (Q_c) which they prefer and foreign goods (Q_w - Q_c). Their consumption function is

$$C_c = a_c[\, a_{1,c}Q_c + a_{2,c}(Q_w-Q_c)] \tag{B1}$$

Let $a_{1,c}$ and $a_{2,c}$ be two positive scalars that sum up to two. There is a bias towards domestic products when $a_{1,c} > 1$. As shown in Trefler (1995) home bias yields the following relation between the endowments and the factor content of trade for a factor *A*, after imposing budget balance and the world market clearing condition:

$$F_{A,c} = V_{A,c} - \alpha_c \, [(1-a_{2,c})Y_w/Y_c + a_{2,c}V_{A,w}] \qquad \text{(B2)}$$

As before, consider (B2) for country *i* and *j* and eliminate the world endowments to obtain the two-country version

$$F_{A,i} - \alpha_i/\alpha_j \, (a_{2,i}/a_{2,j})F_{A,j} = a_{2,i} \, V_i - a_{2,i}\alpha_i/\alpha_j \, V_j \qquad \text{(B3)}$$

When home bias is the same across countries, one obtains

$$F_{A,i} - \alpha_i/\alpha_j \, F_{A,j} = a_{2,i} \, [V_i - \alpha_i/\alpha_j \, V_j], \qquad \text{(B4)}$$

which can be easily related to equation (18). Note that in case home bias were country specific as in Trefler (1995), ignoring it could change the sign of the left-hand side of equation (B3) and no equivalent relation to (18) could be obtained. In other words, without accounting for home bias, a comparison of the endowments does not necessarily tell us anything about the factor contents.

Appendix C. Conditions for Inconsistent Sign Matches

When $V_{A,i}/V_{B,i}$ exceeds $V_{A,j}/V_{B,j}$, condition (12) is satisfied as in (C1) and condition (19) is violated as in (C2),

$$\text{(C1)} \quad \frac{F_{A,i} - (\alpha_i/\alpha_j)F_{A,j}}{V_{A,j}} - \frac{F_{B,i} - (\alpha_i/\alpha_j)F_{B,j}}{V_{B,j}} > 0$$

$$\text{(C2)} \quad \frac{F_{A,j}-(a_j/a_i)F_{A,i}}{V_{A,i}} - \frac{F_{B,j}-(a_j/a_i)F_{B,i}}{V_{B,i}} > 0 \ ,$$

if and only if

(C3) $F_{B,j}-(a_j/a_i)F_{B,i} < 0$,

(C4) $F_{A,j}-(a_j/a_i)F_{A,i} < 0$,

$$\text{(C5)} \frac{V_{A,i}}{V_{B,i}} > \frac{F_{A,j}-(a_j/a_i)F_{A,i}}{F_{B,j}-(a_j/a_i)F_{B,i}} > \frac{V_{A,J}}{V_{B,j}}$$

Proof:

=> With the inequalities (C1) and (C2) the conditions (C3), (C4) and (C5) will be derived.

Multiply inequality (C1) by -(α_j/α_i) and obtain

$$\frac{F_{A,j}-(a_j/a_i)F_{A,i}}{V_{A,j}} - \frac{F_{B,j}-(a_j/a_i)F_{B,i}}{V_{B,j}} < 0 \qquad \text{(C6)}$$

Multiply inequality (C2) by $V_{A,i}$ and rearrange, to find

$$F_{A,j}-(a_j/a_i)F_{A,i} > \frac{V_{A,i}\left(F_{B,j}-(aj/ai)F_{B,i}\right)}{V_{B,i}} \qquad \text{(C7)}$$

Multiply (C6) by $V_{A,j}$ and get

$$\frac{V_{A,j}\left(F_{B,j}-(a_j/a_i)F_{B,i}\right)}{V_{B,j}} > F_{A,j}-(a_j/a_i)F_{A,i} \qquad \text{(C8)}$$

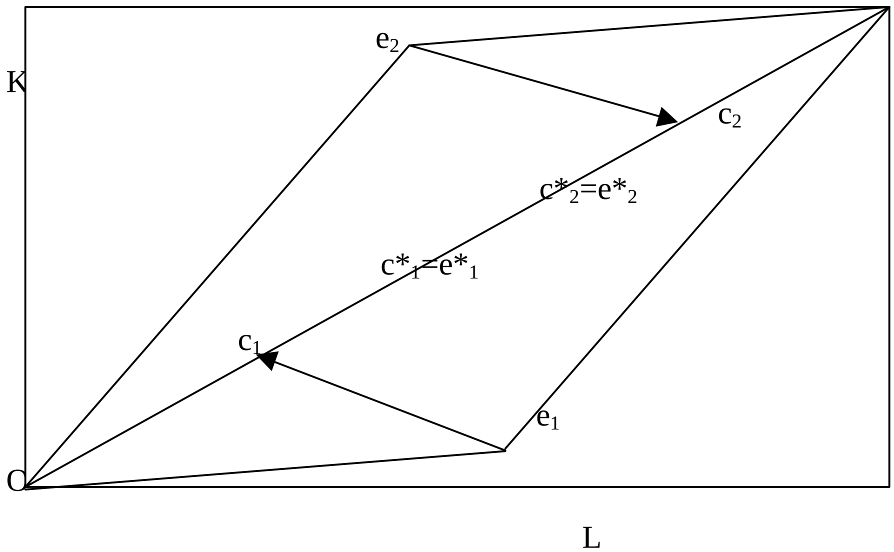
The inequalities (C7) and (C8)

$$\frac{V_{A,j}\left(F_{B,j}-(a_j/a_i)F_{B,i}\right)}{V_{B,j}} > F_{A,j}-(a_j/a_i)F_{A,i} > \frac{V_{A,i}\left(F_{B,j}-(a_j/a_i)F_{B,i}\right)}{V_{B,i}} \qquad \text{(C9)}$$

as $(V_{A,i}/V_{B,i})>(V_{A,j}/V_{B,j})>0$, the inequality between the first and last term of (C9) implies that $F_{B,j}-(a_j/a_i)F_{B,i} <0$, which is condition (C3). In that case, the middle term of (C9) $F_{A,j}-(a_j/a_i)F_{A,i}$, which is the condition (C4). Divide all the three terms of (C9) by $F_{B,j}-(a_j/a_i)F_{B,i}$ and obtain the condition (C5). þ

<= (C1) and (C2) are derived from the conditions (C3), (C4) and (C5). Take the second and third term of (C5), multiply them by $\frac{F_{B,j} - (a_i / a_j) F_{B,i}}{V_{A,j}}$, which is negative by condition (C3), and by $-(\alpha_i/\alpha_j)$ to find (C1). Take first two terms of (C5), multiply them by $\frac{F_{B,j} - (a_j / a_i) F_{B,i}}{V_{A,i}}$, which is negative by condition (C4), to find (C2). þ

Figure 1: Factor Exchange Through Trade: The Two-Country Case



e: endowment point of a country

c: consumption point of a country

→ :factor content of trade vector of a country

Figure 2 Country Endowments for Germany and France

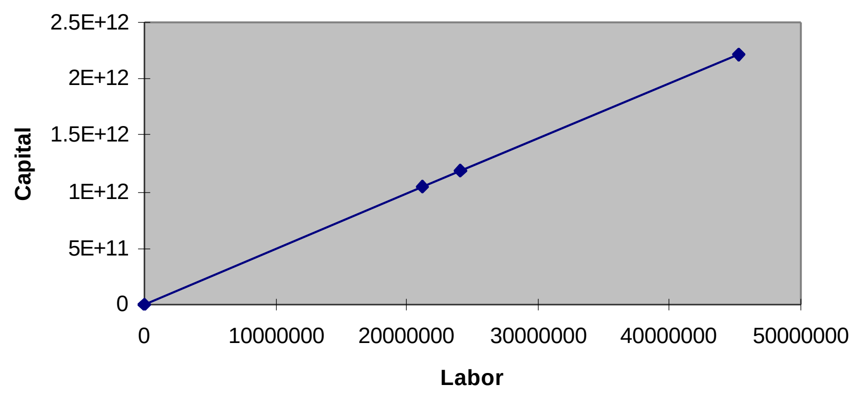


Figure 3 Country Endowments for Bangladesh and Germany

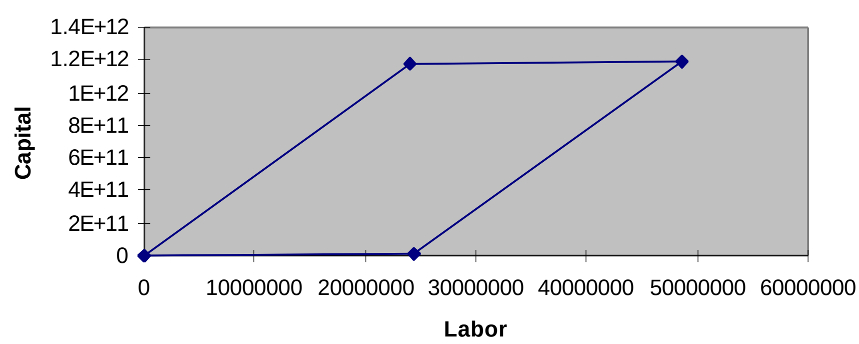
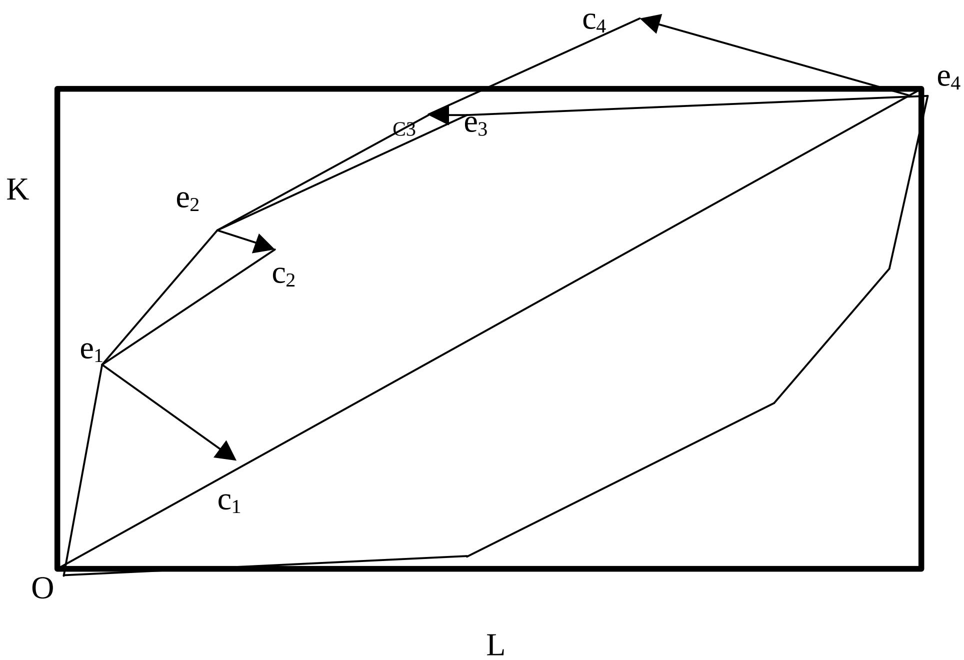


FIGURE 4: Factor Exchange Through Trade



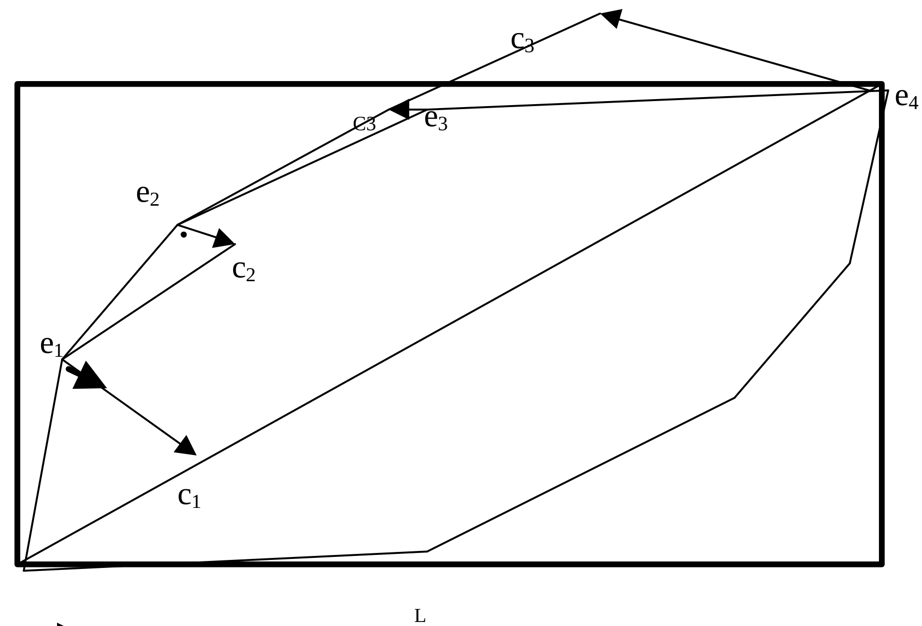
: factor content of trade vector of a country

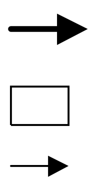
e: endowment point of a country

c: consumption point of a country

FIGURE 5

Factor Exchange Through Trade: The Two-Country Framework in the Setting Of World Trade





Observed factor content vector in two-country framework

Endowment box for country 1 and 2

Factor content of trade vector of a country

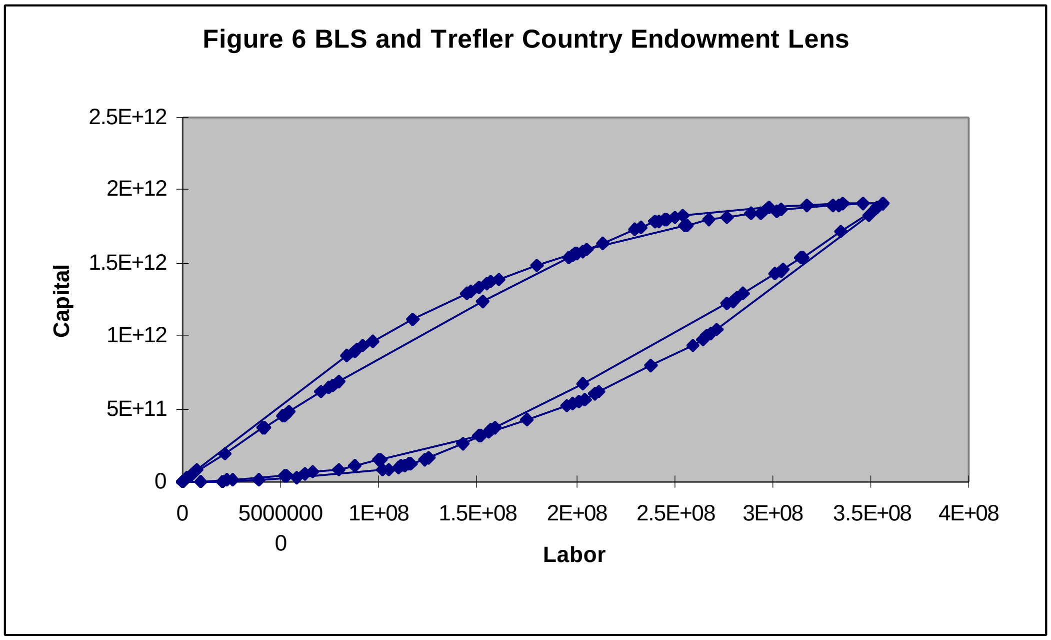


Figure 6 BLS and Trefler Country Endowment Lens
Capital
2.5E+12
2E+12
1.5E+12
1E+12
5E+11
0
0
5000000
0
1E+08
1.5E+08
2E+08
2.5E+08
3E+08
3.5E+08
4E+08
Labor

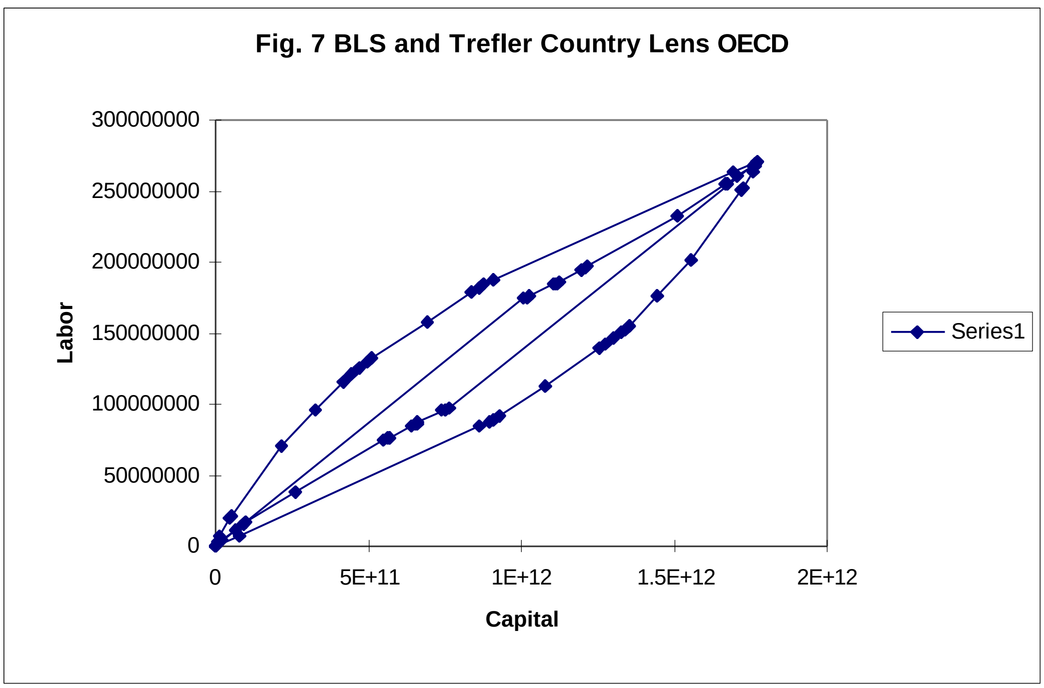


Fig. 7 BLS and Trefler Country Lens OECD
Labor
300000000
250000000
200000000
150000000
100000000
50000000
0
0
5E+11
1E+12
1.5E+12
2E+12
Capital
Series1

Figure A1 Relative Productivity and Relative Wages

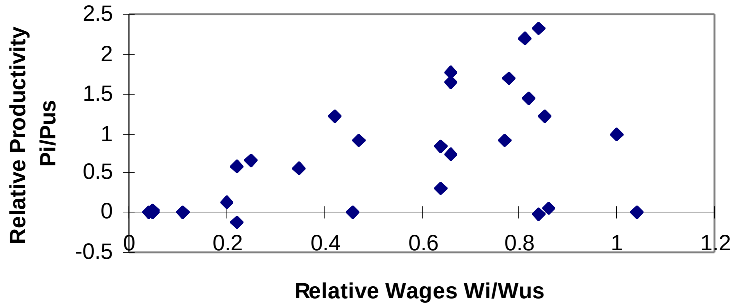


Figure A2 Relative Productivity and Relative Return to Capital

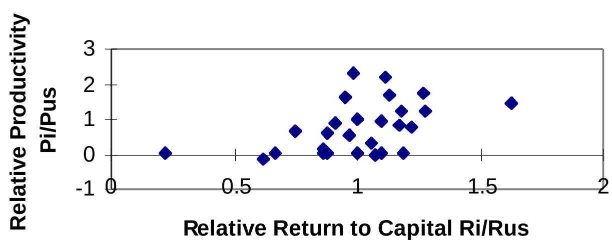


Table 1

Summary Sign Test Results
percent of matching signs

dataset	K/L	LA/K	LA/L
Trefler	70.5	75.5	77.5
BLS	74.5	66.5	77.5

K: capital
L: labor
LA: land

Table 3 : BLS Data Sign Correspondence, Capital and Labor

	versus	It	Jap	Kor	Mex	Net	Nor	Phi	Por	Sp	Swe	Swi	Uk	Us	Yug	Arg	Aul	Aus	Blx	Brz	Can	Den	Fin	Fr	Ger	Gre	Hk	Ire	tot	per
1	Italy		0	1	0	0	1	1	1	1	1	0	1	1	1	0	1	1	1	0	1	0	1	1	1	1	1	1	19	73
2	Japan	0		1	0	0	1	1	1	1	1	0	0	1	1	0	1	1	1	0	1	0	1	1	1	1	1	1	18	69
3	Korea	1	1		1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	24	92
4	Mexico	0	0	1		0	1	1	1	0	1	0	0	1	1	1	0	0	0	0	1	0	1	1	1	1	1	0	14	54
5	Netherlands	0	0	1	0		1	1	1	1	1	0	1	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	18	69
6	Norway	1	1	1	1	1		1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	0	0	1	1	1	1	22	85
7	Philipines	1	1	0	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25	96
8	Portugal	0	1	1	0	0	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	22	85
9	Spain	1	1	1	0	1	1	1	1		1	1	0	1	0	0	1	1	1	0	1	1	1	1	1	1	1	0	20	77
10	Sweden	1	1	1	1	1	1	1	1	1		1	1	0	1	0	1	1	1	0	1	1	0	1	1	1	1	1	22	85
11	Switzerland	0	0	1	0	0	1	1	1	1	1		1	1	0	0	0	0	0	0	1	0	0	0	0	1	1	1	12	46
12	UK	1	0	1	0	1	1	1	1	0	1	1		1	0	0	1	1	1	0	1	1	1	1	1	1	1	0	19	73
13	US	1	1	1	1	1	1	1	1	1	0	1	1		1	0	1	1	1	1	1	1	0	1	1	1	1	1	23	88
14	Yugoslavia	0	1	1	1	0	1	1	1	0	1	0	0	1		1	1	1	1	0	1	0	1	1	1	0	1	0	17	65
15	Argentina	0	0	1	1	0	0	1	1	0	0	0	0	0	1		0	0	0	1	1	0	1	0	0	1	1	0	10	38
16	Australia	1	1	1	0	1	1	1	1	1	1	0	1	1	1	0		1	0	0	1	1	0	0	0	1	1	1	18	69
17	Austria	1	0	1	0	0	1	1	1	1	1	0	1	1	0	0	1		1	0	1	0	1	1	1	1	1	1	18	69
18	Benelux	1	1	1	0	0	1	1	1	1	1	0	1	1	1	0	0	1		0	1	1	1	1	1	1	1	1	20	77
19	Brazile	0	0	1	1	0	1	1	1	0	1	0	0	1	0	1	0	0	0		1	0	1	1	1	0	0	0	12	46
20	Canada	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	26	##
21	Denmark	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	1	0	1	0	1		1	1	1	1	1	1	19	73
22	FInland	1	1	1	1	1	0	1	1	1	0	0	1	0	1	1	0	1	1	1	1	1		0	0	1	1	1	19	73
23	France	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	0	1	1	0	1	1	0		1	1	1	1	20	77
24	Germany	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	0	1	1	0	1		1	1	1	21	81
25	Greece	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	1	1	1	1		1	1	23	88
26	Hong Kong	1	1	0	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1		1	22	85
27	Ireland	1	1	1	0	1	1	1	1	0	1	1	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1		21	81
	total	17	17	24	14	16	23	25	25	20	23	13	20	23	17	8	18	21	20	7	26	18	19	21	22	24	23	20	524	
	percent	65	65	92	54	62	88	96	96	77	88	50	77	88	65	31	69	81	77	27	100	69	73	81	85	92	88	77		**75**

1: sign match 0: no sign match

Table 4: Trefler Data: North versus the South, Sign Correspondence

SOUTH-SOUTH / SOUTH-NORTH

		Ban	Pak	Ind	Sri	Tha	Col	Pan	Yug	Por	Uru	Gre	Ire	Sp	Is	Hk	Nz	Tri	Sin	%	Aus	It	Uk	Jap	Bel	Net	Fin	Den	Ger	Fr	Swe	No	Swi	Cn	Us	%
1	Bangladesh		1	1	0	0	1	0	1	0	1	0	1	1	1	0	1	1	0	59	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	93
2	Pakistan	1		1	0	0	1	0	1	0	1	0	1	1	1	0	1	1	0	59	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	93
3	Indonesia	1	1		0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	35	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	93
4	Sri Lanka	0	0	0		0	1	0	1	1	1	1	1	1	1	0	1	1	1	65	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100
5	Thailand	0	0	1	0		1	0	1	0	1	1	1	1	1	0	1	1	0	59	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100
6	Colombia	1	1	0	1	1		0	0	0	1	0	0	1	1	0	0	1	0	47	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	93
7	Panama	0	0	0	0	0	0		1	1	0	1	1	1	1	1	1	1	1	59	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100
8	Yugoslavia	1	1	0	1	1	0	1		0	0	0	1	1	1	1	1	1	0	65	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	93
9	Portugal	0	0	0	1	0	0	0	1		0	1	1	1	1	0	1	1	1	53	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100
10	Uruguay	1	1	1	1	1	1	0	0	0		0	0	0	1	0	0	1	0	47	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	87
11	Greece	0	0	0	1	0	0	1	0	1	0		1	1	1	1	1	1	0	53	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	93
12	Ireland	1	1	1	1	1	1	1	1	1	0	1		0	1	1	1	1	0	82	1	1	0	1	1	1	1	0	1	1	0	1	1	1	1	80
13	Spain	1	1	1	1	1	1	1	1	1	0	1	1		0	1	0	1	0	76	1	0	0	1	1	1	1	0	1	1	1	1	1	1	1	80
14	Israel	0	0	0	1	0	0	1	0	1	0	1	0	0		1	0	0	0	29	0	0	0	0	0	0	0	1	1	1	0	1	1	1	0	40
15	Hong Kong	0	0	0	1	0	0	1	1	0	0	1	1	1	1		1	1	1	59	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100
16	New Zealand	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1		1	0	82	1	1	0	1	1	1	1	0	1	1	0	1	1	1	1	80
17	Trinidad	0	0	0	1	0	0	1	1	1	0	1	1	0	0	1	1			47	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	27
18	Singapore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	27
	%	44	44	39	61	39	44	44	61	44	33	56	67	61	72	44	61	83	22	**55**	83	78	61	83	83	89	89	39	94	94	72	94	94	94	83	**83**

NORTH-SOUTH / NORTH-NORTH

		Ban	Pak	Ind	Sri	Tha	Col	Pan	Yug	Por	Uru	Gre	Ire	Sp	Is	Hk	Nz	Tri	Sin	%	Aus	It	Uk	Jap	Bel	Net	Fin	Den	Ger	Fr	Swe	No	Swi	Cn	Us	%
19	Austria	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	83		0	1	1	1	1	0	1	1	0	0	1	0	1	1	60
20	Italy	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	89	0		0	0	1	0	0	1	1	1	0	1	1	1	1	53
21	UK	1	1	0	1	1	1	1	1	1	0	1	0	0	0	1	0	1	0	61	0	0		1	1	1	0	0	1	0	1	1	0	1	1	53
22	Japan	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	83	0	0	1		1	1	0	1	1	0	0	1	1	1	1	60
23	Belgium	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	0	0	78	1	1	1	0		0	1	1	1	0	0	1	0	1	1	60
24	Netherlands	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	89	1	0	1	1	0		1	1	0	0	1	1	0	1	1	60
25	Finland	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	83	0	0	1	0	1	1		1	1	1	0	1	1	1	1	67
26	Denmark	1	1	1	1	1	1	1	1	1	0	1	0	0	1	1	0	1	0	72	1	1	0	1	1	1	1		1	1	0	1	1	1	1	80
27	West Germany	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	94	1	1	1	1	1	0	1	1		0	0	1	0	0	1	60
28	France	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	89	1	1	1	0	0	0	1	1	0		0	1	1	0	0	47
29	Sweden	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	0	78	0	0	1	0	0	1	0	0	0	0		1	0	1	0	27
30	Norway	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100	1	1	1	1	1	1	1	1	1	1	1		1	0	1	87
31	Switzerland	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	89	0	1	0	0	0	0	1	1	0	0	0	0		0	0	20
32	Canada	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	94	1	1	1	1	1	1	1	1	0	0	1	1	0		1	73
33	USA	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	83	0	0	1	0	1	1	0	1	1	0	0	1	0	1		47
	%	##	##	93	##	##	##	##	##	##	33	##	80	87	47	##	80	73	27	**85**	47	47	73	47	67	60	53	80	60	27	27	87	40	67	73	**57**

Table 5

Probability Models

Dependent Variable Y:
Y = 1 if there is a sign match
Y = 0 if there is no sign match
Independent Variable X_i
X_i: measures for the extent to which endowments differ

$X_1 = |V_{A,j}/V_{B,j} - V_{A,i}/V_{B,i}|$

$X_2 = (V_{A,j}/V_{B,j})/(V_{A,i}/V_{B,i})$ if >1

otherwise = $(V_{A,i}/V_{B,i})/(V_{A,j}/V_{B,j})$

X_3 ranks X_2 for country i in increasing order

Estimated coefficients of X_i in a Probit, Logit and Linear regression of Y on Xi

	Probit		Linear Regression		Logit	
for capital and land						
X_1	0.0001* (0.000003)	Avg Lkh: 58	0.000003* (0.0000006)	R^2: 76	0.00002* (0.000006)	Avg Lkh: 58
X_2	0.0002* (0.0001)	Avg Lkh: 57.5	0.00005* (0.00002)	R^2: 75.5	0.0005* (0.0003)	Avg Lkh: 57.5
X_3	0.04* (0.005)	Avg Lkh: 59.5	0.01* (0.001)	R^2: 77	0.07* (0.008)	Avg Lkh: 59.5
for capital and labor						
X_1	0.00002* (0.000003)	Avg Lkh: 56.5	0.0000087* (0.0000009)	R^2: 72	0.00005* (0.000006)	Avg Lkh: 56.5
X_2	0.009* (0.004)	Avg Lkh: 54.5	0.003* (0.001)	R^2: 70.5	0.02* (0.007)	Avg Lkh: 54.5
X_3	0.03* (0.004)	Avg Lkh: 56	0.01* (0.001)	R^2: 72	0.06* (0.08)	Avg Lkh: 56
for labor and land						
X_1	0.001* (0.0002)	Avg Lkh: 60	0.003* (0.0003)	R^2: 77.5	0.002* (0.0004)	Avg Lkh: 60
X_2	0.0005* (0.0002)	Avg Lkh: 58	0.0001* (0.00004)	R^2: 76.5	0.001* (0.0007)	Avg Lkh: 58
X_3	0.03* (0.005)	Avg Lkh: 59	0.008* (0.001)	R^2: 77	0.05* (0.008)	Avg Lkh: 59

number of observations: 1056
standard errors in parentheses
*: significant at 0.95 level of significance

Table 6
Relative Factor Abundance and North-South Trade
Sign Correspondence (Trefler Data Set)

A Pairwise Comparison of a Country from the South with the Group of Rich Developed Countries
1: Sign Correspondence
0: No Sign Correspondence

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country	North*	North
Bangladesh	1	1
Pakistan	1	1
Indonesia	1	1
Sri Lanka	1	1
Thailand	1	1
Colombia	1	1
Panama	1	1
Yugoslavia	1	1
Portugal	1	1
Uruguay	1	0
Greece	1	1
Ireland	1	1
Spain	1	1
Israel	1	1
Hong Kong	1	1
New Zealand	1	1
Singapore	1	1
Trinidad	0	0
%	95	90

*: this column is based on equation (12), the next one on equation (19)

Table 7

Probability Model
Y: dependent variable:
Y = 1 if there is a sign match
Y = 0 if there is no sign match

Estimated Coefficients**

Variable	Estimate	Estimate
constant	0.5*	0.5*
	(0.02)	(0.3)
$D_{LA/K}$	0.05*	0.05*
	(0.02)	(0.025)
$D_{LA/L}$	0.06*	0.1*
	(0.02)	(0.025)
X_3	0.01*	0.01*
	(0.0008)	(0.001)
O_i	-0.008	-0.008
	(0.016)	(0.27)
D_i	-0.007*	-0.005
	(0.003)	(0.003)
YC_i	0.0000085*	0.000007*
	(0.000002)	(0.000003)
T_i		0.0028
		(0.0009)
	R^2: 76	R^2: 77
	n= 3168	n=1804

**: the reported coefficients are for a linear regression. The pattern of significance is the same for a Probit and Logit.

$D_{LA/K}$: dummy for land-capital
$D_{LA/L}$: dummy for land-labor
X_3: difference in endowment ratios of country i and j
O_i: oil dummy: one if one of the two countries exports oil
zero otherwise
D_i: difference in defense spending per GDP between country i and j
YC_i: difference in per capita GDP between country i and j
T_i : difference in the average tariff rates between country i and j

standard errors between parentheses
* : significant at 0.95 significance level

Table A1
Relative Factor Returns and Relative Productivity

country	W_i/W_{us}	P_i/P_{us}	R_i/R_{us}
Bangladesh	0.05	0.01	0.22
Pakistan	0.04	0.00	0.86
Indonesia	0.11	0.01	0.88
Thailand	0.05	0.03	0.67
Colombia	0.22	-0.12	0.62
Panama	0.25	0.66	0.75
Yugoslavia	0.22	0.58	0.88
Portugal	0.2	0.13	0.86
Greece	0.35	0.56	0.97
Ireland	0.46	0.00	1
Spain	0.47	0.91	0.91
Hong Kong	0.42	1.21	1.18
New Zealand	0.64	0.84	1.17
Austria	0.64	0.31	1.06
Italy	0.66	1.65	0.95
UK	0.66	0.75	1.22
Japan	0.66	1.77	1.27
Belgium	0.81	2.19	1.11
Finland	0.77	0.92	1.1
Denmark	0.78	1.70	1.13
West Germar	0.86	0.05	1.1
France	0.84	-0.02	1.07
Sweden	0.82	1.44	1.63
Norway	0.85	1.23	1.28
Switzerland	1.04	0.01	1.19
Canada	0.84	2.31	0.98
US	1	1	1

W_i/W_{us} : wage in country *i* compared to the US
P_i/P_{us} : productivity in country *i* compared to the US
R_i/R_{us} : return to capital in country *i* compared to the US