ITI
7/31/06
11:00 AM

BILATERAL PREDICTIONS IN A MULTILATERAL WORLD? REVISITING THE THEORY[1]

Daniel M. Bernhofen[2]

School of Economics and GEP
University of Nottingham

July 12, 2006

Abstract

This paper examines the theory, originally developed by Helpman (1984), that underlies Choi and Krishna's (2004) recent empirical test of the factor content of trade of bilateral trade. I show that the logic leads to a multitude of predictions on bilateral and multilateral factor flows with no meaningful economic interpretations. I revisit the logic and prove that Helpman's bilateral prediction is compatible with the concavity property of the neoclassical trade model only if the equilibrium is characterized by either (i) factor price equalization or (ii) no trade. This implies that the basic lesson from the comparative advantage commodity trade literature applies also to the factor content of trade: bilateral comparisons are not relevant in a multilateral world.

1. Introduction

In a recent paper Choi and Prishna (2004) claim to provide a significant advancement in testing the Heckscher-Ohlin theory of international trade. The authors provide empirical support for a prediction on the bilateral factor content of trade, originally developed by Helpman (1984). Helpman's predictions have the attractive features of relying on 'post-trade' factor price comparisons and claim to hold under nonequalization of factor prices and in the absence of any assumptions regarding consumer preferences. However, these features seem at odd with the messages from the pioneering general equilibrium trade literature from the 1950s, in particular the seminal work of Lionel McKenzie (1954, 1955). Introducing activity analysis as a tool to analyze international specialization in what is now known as the "multi-cone Heckscher-Ohlin framework", McKenzie (1954, p. 180) has stressed that "…*it is not possible through merely bilateral comparison to develop a…theory of efficient multilateral specialization*". In addition, McKenzie (1955) has brought to light the

[1] I am grateful to Rod Falvey and Peter Neary for insightful comments on an earlier draft of this paper.
[2] Address for Correspondence: School of Economics and Leverhulme Centre for Research on Globalization and Economic Policy, University of Nottingham, University Park, Nottingham, NG7 2 RD, UK. Tel: 44 115 846 7055, Fax: 44 115 951 4159, email: daniel.bernhofen@nottingham.ac.uk.

central role of factor price equalization in a general equilibrium trading system and has stressed that (McKenzie, 1955, p. 245) "*in the set of goods price vectors which do not permit equalization of factor prices no assured statement about specialization can be made without stronger assumptions* [on production and preferences]".

The purpose of this paper is to reconcile these conflicting views on the neoclassical trade model. I show that, contrary to current belief, Helpman's bilateral prediction is not a result of the concavity property of the neoclassical trade model; in contrary, it is at odds with it.[3] The main result of the paper shows that Helpman's bilateral prediction will be compatible with the concavity property of the neoclassical trade model only if there is either factor price equalization or no trade.

The development of the arguments is organized as follows: section 2 sets-up the theoretical framework. Section 3 revisits Helpman's proof and shows that his 'thought experiment' leads to a multitude of predictions on bilateral and multilateral trade flows. Section 4 revisits Choi and Krishna's (2004) empirical implementation and illustrates the difficulty of interpreting the thousands of predictions implied by Helpman's 'thought experiment'. Section 5 shows that the 'thought experiment' is at odds with the concavity property of the revenue function. Section 6 derives theoretically unique shadow price restrictions on the bilateral factor content of trade and shows that they will coincide with Helpman's restriction only if there is either factor price equalization or no trade. Section 7 concludes with a discussion on the informational role of prices.

2. Theoretical background

Helpman's theoretical prediction builds on Deardorff (1979) and Brecher and Choudhri (1982). The central theme in these papers is to provide predictions in the spirit of Heckscher-Ohlin, but in the absence of factor price equalization. All three papers investigate the property of a competitive free trade equilibrium with two key characteristics. First, all countries possess identical production functions. Second, countries' factor endowments are assumed to be sufficiently dissimilar so that countries' free trade factor prices are different.

[3] Helpman and Krugman (1985, pp. 24-27) and Feenstra (2004, pp.58-60) provide detailed discussions of Helpman (1984); Staiger (1986) extends Helpman's analysis to deal with intermediates. Building on Choi and Krishna (2004), Lai and Zhu (2006) provide further empirical support for a modified prediction that incorporates technological differences.

Formally, consider a competitive equilibrium with *m* countries, *n* goods, *l* factors and a common technology matrix, $A(.)=<a_{v\tau}(.)>$, where $a_{v\tau}$ are the units of factor *v* necessary to produce 1 unit of good τ. Although identical technologies imply the same functional forms for $a_{v\tau}$, the equilibrium least-cost input coefficients will depend on country specific factor prices.

If T^{ij} denotes the vector of gross imports of country *j* from country *i*, F^{ij} denotes the factor content of T^{ij} evaluated at the exporter's input techniques, i.e. $F^{ij}=A(w^i)T^{ij}$, where w^i is the free-trade factor price vector of the exporting country *i*. For two countries, *i* and *j*, who are engaged in bilateral trade, Helpman derives the following prediction on the net bilateral factor content of trade:

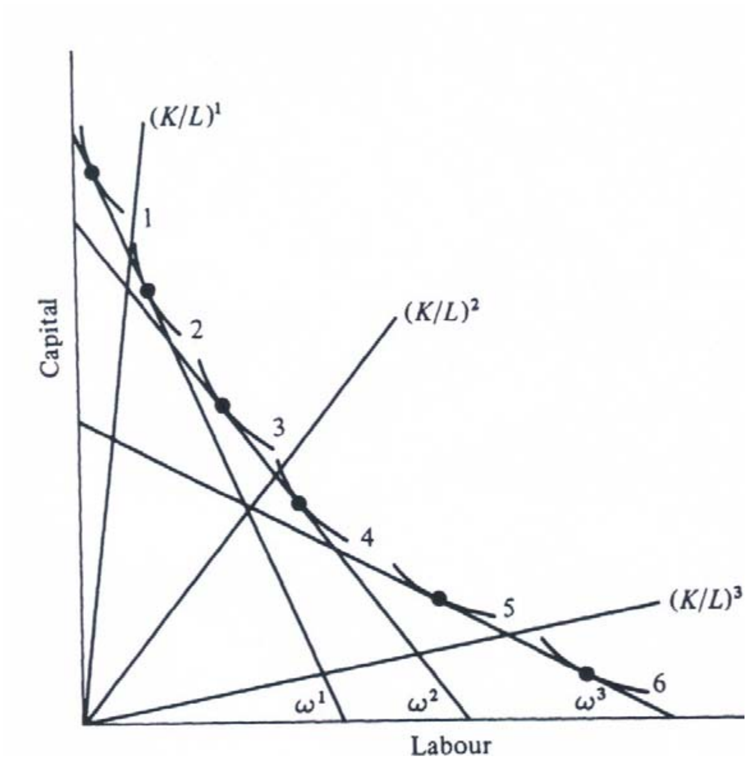
$$(w^j-w^i)' (F^{ij}-F^{ji}) \geq 0. \qquad (1)$$

Inequality (1) has been commonly interpreted as saying that factors embodied in trade should flow towards the country with the higher factor price. If factor ν has a higher absolute price in country *j*, $w^j_v-w^i_v >0$, then *j* will, 'on average', be a net importer of that factor relative to country *i*, i.e. $F^{ij}_v- F^{ji}_v > 0$.

Helpman claims that (1) is a direct generalization of Brecher and Choudhri (1982) to multiple countries. Helpman derives his intuition for (1) from the Lerner-Pearce diagram. Figure 1 considers the case of 3 countries, 6 goods and 2 factors. Countries are ranked according to their relative factor endowments: $(K/L)^1> (K/L)^2> (K/L)^3$. Since countries' factor endowments are assumed to be in different cones of diversification, the three countries will specialize in the production of different goods. The most capital-abundant country 1 will produce the most capital-intensive goods 1 and 2; country 2 will produce goods 3 and 4 and the least capital- abundant country 3 will produce the least capital-intensive goods 5 and 6. The intuition for (1) stems from the implicit assumption that there is a one-to-one correspondence between this factor endowment ranking and the ranking of free trade equilibrium factor price ratios ω^i $(=(w/r)^i)$: $(K/L)^1> (K/L)^2> (K/L)^3 \iff (w/r)^1> (w/r)^2> (w/r)^3$. In any pair-wise comparison, the more capital-abundant country will also have the higher equilibrium wage-rental ratio. In reference to Figure 1, Helpman (1984, p. 90) writes:
"It is now a simple matter to observe that the more capital-rich a country is, the more capital and less labour is uses per dollar output in all lines of production (more generally, it never uses less capital and more labour). Hence, whatever trade there

may exist between two countries, exports of the relatively capital rich country will embody a higher capital-labour ratio than exports of the relatively labour rich country. This describes a clear bilateral factor content pattern of trade (see Brecher and Choudhri, 1982)".

Figure 1: Lerner-Pearce Diagram



Brecher and Choudhri (1982) use a 2-country version of this diagram to prove that the factor content version of the Heckscher-Ohlin theorem holds also in the absence of factor price equalization: the relatively capital abundant country will be a net exporter of capital and a net importer of labor. Employing the price-definition of relative factor abundance, Brecher and Choudhri show that if $(w/r)^1>(w/r)^2$, then country 1 will be a net exporter of capital and a net importer of labor. Alternatively, if $(w/r)^1<(w/r)^2$, then the trading pattern will be just the opposite. To ease the comparison with (1), let us express this algebraically. If K^{ij} (L^{ij}) denotes the capital (labor) content of the gross import vector of country *j* from country *i*, (*i*,*j* =1,2), Brecher and Choudhri's (1982) prediction can be written algebraically as:

$$\left[\left(\frac{w}{r}\right)^1 - \left(\frac{w}{r}\right)^2\right]\begin{bmatrix} K^{12} - K^{21} \\ L^{21} - L^{12} \end{bmatrix} \geq \begin{bmatrix} 0 \\ 0 \end{bmatrix}. \tag{2}$$

If Helpman's prediction in (1) were a true generalization of (2) to multiple countries, then (1) should coincide with (2) for two countries and two factors. For the case of two dimensions, (1) becomes then

$$\left[r^1 - r^2, \quad w^1 - w^2\right]\begin{bmatrix} K^{21} - K^{12} \\ L^{21} - L^{12} \end{bmatrix} \geq 0\,. \tag{3}$$

The predictions (2) and (3) are quite different. Inequality (2) provides sign predictions on *individual factors* based on country-specific differences in *relative* factor prices. In contrast, inequality (3) makes a sign prediction on the entire net factor content of trade vector F^{21}-F^{12}: $(r^1-r^2)(K^{21}-K^{12})+(w^1-w^2)(L^{21}-L^{12}) \geq 0$. The latter inequality, however, does not appear to have a meaningful economic interpretation. It pertains to a weighted average of the net factor content of trade with the weights being the difference in *absolute* factor prices. But we know that it is the difference in *relative* not absolute factor prices that determines the pattern of international specialization in neoclassical trade theory.

3. Revisiting Helpman (1984): Additional predictions

Helpman arrives at (1) through two steps: (i) a 'thought experiment' on a factor endowment gift and (ii) the concavity property of GDP function.[4] In a free trade equilibrium a country's GDP can be written as $G(p,V^j)= p' Y^j=w^{j\prime} V^j$, where V^j denotes the country's endowment vector, Y^j its production vector and p the free trade equilibrium goods price vector. Helpman derives then the following relationships:

$$G(p,V^j)+p' T^{ij}= w^{j\prime} V^j + p' T^{ij} \leq G(p,V^j+F^{ij}) \tag{4}$$
$$G(p,V^j+F^{ij}) \leq w^{j\prime} V^j+ w^{j\prime} F^{ij}. \tag{5}$$

The second inequality (5) is a direct implicaton of the concavity of the GDP function with respect to factor endowments. Helpman's justification for inequality (4) is based

[4] In what follows, I revisit Helpman's proof by adopting the user-friendly notation used by Feenstra (2004, p. 58-59).

on the following thought experiment: If country *j* were given a factor endowment gift of F^{ij}, then the assumption of identical technologies implies that it would be feasible for country *j* to produce T^{ij} itself. However, since factor prices in country *j* are different than in *i*, country *j* could do 'potentially better' than that. Specifically, country *j*'s GDP from its 'gift-augmented' endowment $G(p,V^j+F^{ij})$ will be at least as large as the sum of its pre-gift GDP $G(p,V^j)$ and the market value of the corresponding imports $p' T^{ij}$. Combining inequalities (4) and (5), one obtains $p' T^{ij} \leq w^{j\prime} F^{ij}$. Using the zero profit condition, $p' T^{ij} = w^{i\prime} F^{ij}$, one obtains a relationship between the factor content of bilateral exports and the bilateral difference in factor prices:

$$(w^j - w^i)' F^{ij} \geq 0. \tag{6}$$

Applying the same logic to the factor content of exports from country *j* to *i*, F^{ji}, one obtains

$$(w^i - w^j)' F^{ji} \geq 0. \tag{7}$$

Inequality (1) results then from adding (6) and (7). For *m* countries, Helpman's logic implies a total of *m*(*m*-1)/2 bilateral predictions.

However, a closer look at Helpman's thought experiment, captured in inequality (4), is that the underlying logic is not specific to F^{ij}. It can be applied to any endowment gift for country *j* associated with the gross trade flow of country *i* to any third country or, in fact, any subgroup of trading partners. To keep the notation simple, let *k* index a destination. If T^{ik} denotes the gross trade flow from country i to destination k, where k pertains either to just a single country or any subgroup of countries, the factor content of trade is then defined as $F^{ik} = A(w^i)T^{ik}$. Applying the thought experiment logic to the endowment gift F^{ik}, we obtain the following inequality:

$$G(p,V^j) + p' T^{ik} \leq G(p,V^j+F^{ik}) \qquad \text{for all } i, j \text{ and } k \tag{8}$$

Applying the concavity property to V^j+F^{ik}, we obtain:

$$G(p,V^j+F^{ik}) \leq G(p,V^j) + w^{j\prime} F^{ik} \tag{9}$$

Combining (8) and (9) with the zero-profit condition, $p' T^{ik} = w^{i\prime} F^{ik}$, we obtain:

$$(w^j - w^i)' F^{ik} \geq 0. \qquad (10)$$

Inequality (10) implies that the factor price difference between countries *i* and *j* does not only restrict the bilateral factor content of trade between this country pair but also restricts the bilateral factor content of trade between *i* and any other third country *k* or subgroup of countries. As a result, $(w^j - w^i)$ restricts the factor content of *any bilateral and multilateral* exports by country *i*.

Alternatively, (10) implies that there are *m*-1 different restrictions for a given bilateral factor content of trade F^{ij}:

$$(w^k - w^i)' F^{ij} \geq 0, \text{ for any } k=1,\ldots,m,\ k \neq i. \qquad (11)$$

It is difficult to provide a meaningful interpretation of (11) since it implies that each bilateral factor price difference between countries *k* and *i*, $(w^k - w^i)$, provides a prediction on the factor content of exports from country *i* to country *j*.

4. Revisiting Choi and Krishna

Choi and Krishna (2004) investigate (1) for a sample of 8 countries which results into 28 bilateral comparisons.[5] Employing a variety of factor price measures, their data generate signs compatible with the theoretical predictions in about 80% of the cases. However, as argued above, the underlying theoretical logic yields many more predictions. Leaving aside how to interpret them, how many predictions could one investigate with Choi and Krishna's data set ? Applying (11) to two-way trade flows F^{ij} and F^{ji} one obtains:

$$(w^k - w^i)' F^{ij} - (w^j - w^l)' F^{ji} \geq 0, \text{ for } k \neq i \text{ and } l \neq j. \qquad (12)$$

It can be easily seen that (1) is a special case of (12) for *k*=*j* and *l*=*i*. For 8 countries the theory implies 49 different predictions on the bilateral trade flow on each country

[5] The country sample consists of the US, Canada, Denmark, France, Germany, UK, Netherlands and Korea.

pair, leading to a total of 1372 (=28 x 49) predictions. Consequently, Choi and Krishna have investigated only about 2% of all the predictions that are suggested in (12).

However, as mentioned above, bilateral factor-price differences restrict not only bilateral but also multi-lateral trade flows. Alternatively, we can ask ourselves how many factor flows are restricted by a given factor-price difference vector (w^j-w^i). Applying (10) to a destination index κ which identifies a subset of trading partners, one obtains:

$$(w^j-w^i)' F^{i\kappa} \geq 0, \text{ for any } \kappa \subset \{1,\ldots,8\}\backslash\{i\}. \qquad (13)$$

For a fixed *j* and *i*, (13) implies that (w^j-w^i) restricts 127 different gross exports of country *i*.[6] Varying *j* and *i* across the sample yields a total of 7112 (=8x7x127) predictions! To illustrate the nature of the predictions, assume *i*=US and *j*=Germany. Inequality (13) implies that the factor price difference betweeen Germany and the US, w^{Ger}-w^{US}, does not only predict the factor trade flow from the US to Germany but also the trade flow from the US to any other individual trading partner (i.e. Canada, France,…) or, in fact, any subset of trading partners, (Germany and France, Denmark UK and Netherlands, etc.). While the prediction on the factor flow from the US to Germany appears to make sense, the other 126 predictions lack any economic intuition. This already suggests that there must be some flaw with the underlying logic.

5. Revisiting Helpman's thought experiment

The predictions are derived from combining Helpman's thought experiment (TE) with the concavity property of the GDP function. The reason why one obtains so many predictions is that the thought experiment has more to do with the factor content of production than with bilateral trade flows. Specifically, the thought experiment involves a comparison between two gifts: a revenue gift of the 'money value' of the trading partner's production, valued at the trading partner's factor prices, and the 'physical gift' of the factor content of production. Helpman's conjecture is that the latter gift is more preferable than the former, expressed by the following inequality:

[6] As each trade flow corresponds to a subset of trading partners, the number of trade flows equals the total number of subsets of a set of size 7, which is 2^7-1.

$$G(p,V^j)+w^iS^i \leq G(p,V^j+S^i), \qquad \text{(TE)}$$

where S^i denotes the factor content of production, which is necessarily a subvector of V^i.[7] If $S^i=A(w^i)T^{ij}$, (TE) coincides with (4) and one obtains the bilateral predictions that Choi and Krishna utilize in their empirical work. If $S^i=A(w^i)T^{ik}$, (TE) coincides with (8) and we obtain thousands of additional gift comparisons. The assumption that (TE) will always hold independent of the underlying preference structures is simply too strong. In fact, one can use the concavity property of the GDP function to show that (TE) can be violated for some S^i. This is accomplished in proposition 1.

Proposition 1: If there is no factor price equalization and if G(p,V) is strictly concave, then there exists a subvector S^* of V^i which violates (TE) for some country pair *i* and *j*.

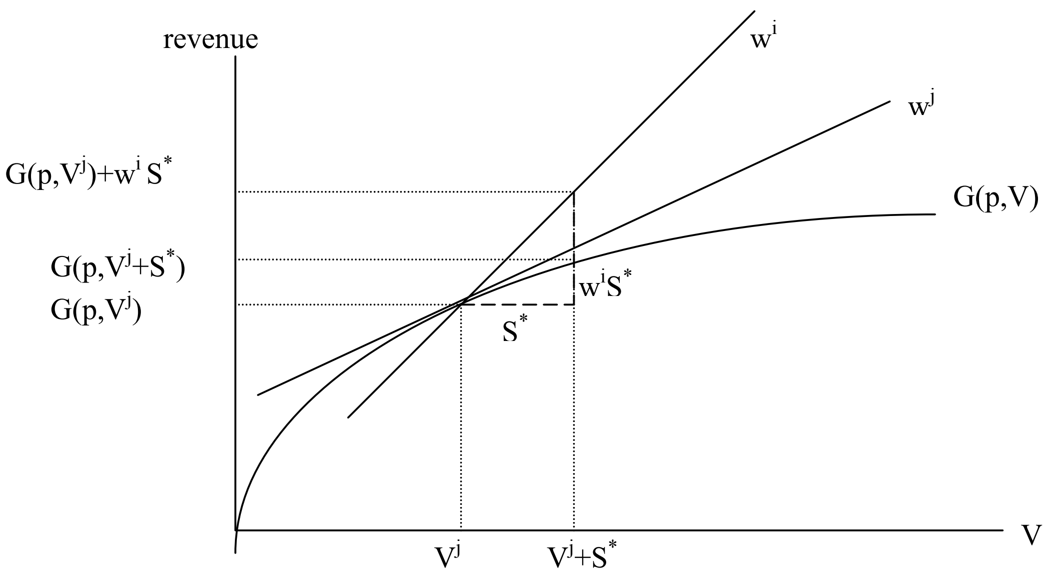
Proof: Lack of factor price equalization implies that there exist a country pair *i* and *j* such that $w^i \neq w^j$. We can choose indices such that $w^i_\nu - w^j_\nu > 0$ for some factor ν of which country *i* has a positive endowment. Now we can easily find a subvector S^* of V^i such that $(w^i-w^j)S^* > 0$. Combining the latter inequality with the concavity property, we obtain $G(p,V^j+S^*) < G(p,V^j)+w^jS^* < G(p,V^j)+w^iS^*$.

q.e.d.

Proposition 1 can be illustrated in Figure 2. Strict concavity implies that for a given endowment vector V^j, there will be a unique factor price w^j that characterizes the tangent to G(p,V) at V^j. Now choose a factor price vector w^i that corresponds to a steeper slope. From Figure 2, we can see that $G(p,V^j)+w^iS^*$ will be larger than $G(p,V^j+S^*)$ for any $S^*>0$. In higher dimensions, the geometry is a more complicated and (TE) is not expected to be violated for every vector S^*. However, the graph illustrates that (TE) is at odds with the concavity property of the GDP function. Because of diminishing returns, a social planner might prefer the money gift over the endowment gift.

[7] S^i is a subvector of V^i if $S^i_\nu \leq V^i_\nu$ for each component ν.

Figure 2: Graphical illustration of Proposition 1



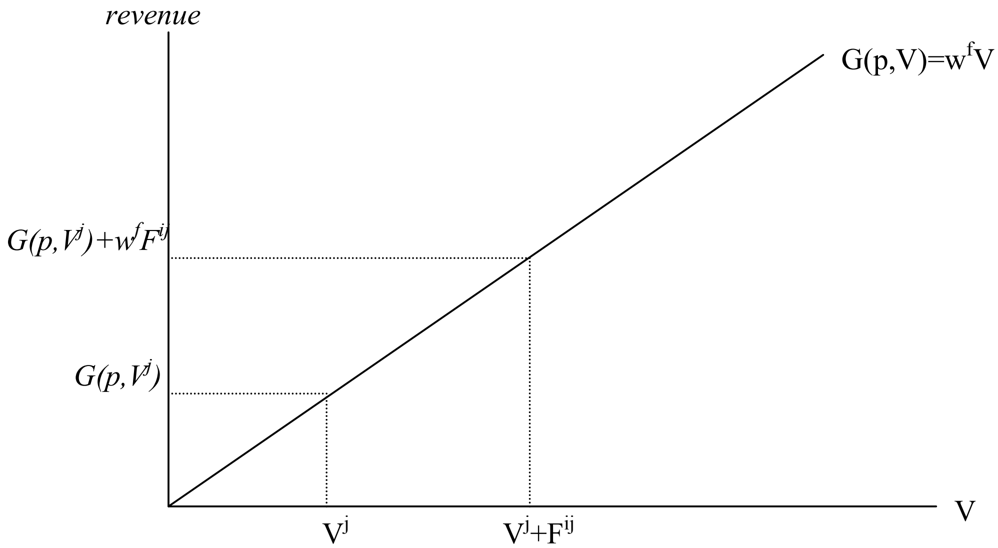
6. Deriving shadow price restrictions on the bilateral factor content of trade

Proposition 1 implies that Helpman's restriction (1) might not hold in equilibrium as it is based on the general validity of (TE). Now we use the concavity property of the GDP function to derive unique restrictions on the factor content of bilateral trade flows and investigate under what circumstances these restrictions will coincide with (1).

First we should notice that the shape of a country's GDP function in a trading equilibrium depends on the factor price equalization assumption. If factor prices are equalized, the GDP function is linear in endowment changes, as illustrated in Figure 3. If w^f denotes the common equilibrium factor price, (TE) will be satisfied as an equality, i.e. $G(p,V^j)+w^f F^{ij}=G(p,V^j+F^{ij})$, and (1) will always hold.

However, in the absence of factor price equalization, we can derive non-trivial restrictions on the bilateral factor content of trade. In order to derive analytical results, we need to make a few assumptions about the representative GDP function in a trading equilibrium.

Figure 3: Factor price equalization



Assumption 1: We consider a trading equilibrium characterized by a common GDP function, $G(p^*,V)$, where p^* is the equilibrium goods price vector. $G(p^*,V)$ is differentiable and strictly concave in V.

The implication of this assumption is captured in the following lemma.

Lemma: For each endowment vector V^k, there will be a unique equilibrium shadow price vector $w^k=w^k(V^k)$ such that $G(p^*,V^k)=w^kV^k$.

Assumption 2: The equilibrium goods price vector p^* is assumed to be fixed.

Although heroic, assumption 2 is essential for exploiting the concavity property of the GDP function. It guarantees that reallocating factor endowments does not lead to any 'shifts' in the GDP function.

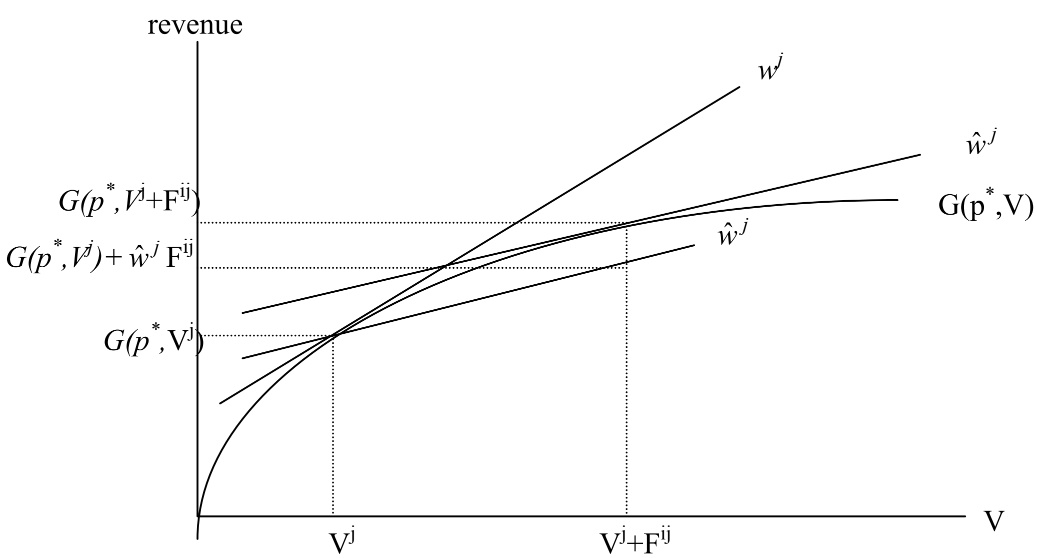
Consider now the augmented endowment vector V^j+F^{ij}. The Lemma implies that there exist a unique shadow price vector $\hat{w}^j$ defined as $G(p^*,V^j+F^{ij})= \hat{w}^j (V^j+F^{ij})$. Country *j*'s actual factor price vector w^j is given by $G(p^*,V^j)=w^jV^j$. Applying the concavity property to w^j and $\hat{w}^j$, we obtain the following inequalities:

$$G(p^*,V^j+F^{ij}) \le G(p^*,V^j) + w^{j\prime} F^{ij} , \tag{14}$$

$$G(p^*,V^j) + \hat{w}^{j\prime} F^{ij} \le G(p^*,V^j+F^{ij}). \tag{15}$$

Inequalities (14) and (15) are illustrated in Figure 4. Inequality (14) is a replication of (5) and captures the fact that the tangent at w^j will lie above the GDP function. Inequality (15) captures another aspect of concavity: a line with slope $\hat{w}^j$ through the point $(V^j,G(p^*,V^j))$ will always lie below the GDP function at V^j+F^{ij}.

Figure 4: Shadow price restrictions



Adding (14) and (15), we obtain

$$(w^j - \hat{w}^j)' F^{ij} \ge 0. \tag{16}$$

The factor content of bilateral gross imports of country *j* by country *i* is restricted by the difference between the importing countries actual factor price vector w^j and the shadow price $\hat{w}^j$ under the endowment V^j+F^{ij}. Similarly, F^{ji} is restricted by

$$(w^i - \hat{w}^i)' F^{ji} \ge 0, \tag{17}$$

where $\hat{w}^i$ is the shadow price given by $G(p^*,V^i+F^{ji}) = \hat{w}^i (V^i+F^{ji})$. Adding (16) and (17), we obtain:

$$(w^j - \hat{w}^j)' F^{ij} - (\hat{w}^i - w^i)' F^{ji} \geq 0. \qquad (18)$$

Since the shadow prices depend on the endowments of countries *i* and *j*, inequality (18) provides a unique restriction on the bilateral factor flows F^{ij} and F^{ji}. Since the shadow prices $\hat{w}^i$ and $\hat{w}^j$ are not observable, the restriction (18) cannot be implemented empirically. However, we can ask ourselves under which circumstances (18) will coincide with the restriction (1), which is based on the observable wage rates w^i and w^j.

Proposition 2: For a given country pair *i* and *j*, the shadow price restriction (18) will coincide with Helpman's restriction (1) if and only if there is either (a) factor price equalization or (b) no trade between the country pair.

Proof: Inequality (18) will coincide with (1) if and only if $\hat{w}^j = w^i$ and $\hat{w}^i = w^j$. In the case of factor price equalization, this will always be true as all factor prices are equal to a common w^f. In the absence of factor price equalization Lemma 1 implies that the shadow prices will coincide with the observed wage rates if and only if $V^i = V^j + F^{ij}$ and $V^j = V^i + F^{ji}$. But these equations will only hold if $F^{ij} + F^{ji} = 0$. However, since F^{ij} and F^{ji} are both nonnegative, this implies that $F^{ij} = F^{ji} = 0$

Proposition 2 is at the heart of this paper. It states that Helpman's prediction will be compatible with the concavity property of the GDP function if either there is no trade or the trading equilibrium is characterized by factor price equalization. As a result Choi and Krishna's empirical support of (1) can be interpreted as an indication of factor price equalization, but not as evidence of international specialization in the spirit of Heckscher-Ohlin.

7. Conclusion

In conclusion, I provide an informational argument why (1) does not constitute a prediction about the direction of international trade. The argument is rooted in Hayek's (1945) fundamental insight that in a market economy goods prices contain all the relevant information about underlying fundamentals. In the theoretical trade literature, the most general statements about the direction of international specialization are based on autarky prices. The reason for this is that an economy's autarky prices contain all the relevant information about the country's fundamentals (e.g. preferences, technologies or tastes) in the absence of international specialization. This information is used to evaluate, or restrict, an economy's vector of international specialization with its trading partners. If the focus is on commodity trade, the theory of comparative advantage implies that the commodity autarky price vector p^a restricts the economy's net commodity import vector T, predicting that $p^aT>0$ (Deardorff, 1980).[8] Alternatively, if the focus is on the the factor content of trade, defined as $F=A(.)T$, the theory implies that the corresponding autarky factor price vector w^a restricts F, predicting that $w^aF>0$ (Deardorff, 1982). In both cases, information from outside the trading regime (i.e. autarky) is used to predict the direction of international specialization in a trading regime.

In contrast, (1) is based on free trade factor price differences between two trading partners. Since free trade factor prices embody information about a regime where international specialization has already taken place, they do not provide enough information about country-specific fundamentals to predict which trading pattern should or should not occur in such a regime. In the absence of autarky price information, predicting the factor content of multilateral trade requires the strong assumption that all countries have the same homothetic preference structures (Vanek, 1968). Obtaining a prediction on the direction of the factor content of bilateral trade is expected to require assumptions that are too restrictive to be empirically meaningful.

[8] Confirmative evidence for this prediction is given in Bernhofen and Brown (2004).

References

Bernhofen, Daniel, M, and John C. Brown. 2004. “A Direct Test of the Theory of Comparative Advantage: The Case of Japan.” *Journal of Political Economy* 112 (February): 48-67.

Brecher, Richard A., and Ehsan U. Choudhri. 1982. “The Factor Content of International Trade without Factor Price Equalization.” *Journal of International Economics* 12 (May): 277-83.

Choi, Yong-Seok, and Pravin Krishna. 2004. “The Factor Content of Bilateral Trade: An Empirical Test.” *Journal of Political Economy* 112 (June): 887-913.

Deardorff, Alan, V. 1979. “Weak Links in the Chain of Comparative Advantage”. *Journal of International Economics* 9 (May): 197-209.

Deardorff, Alan, V. 1980. “The General Validity of the Law of Comparative Advantage”. *Journal of Political Economy* 88 (October): 941-57.

Deardorff, Alan, V. 1982. “The General Validity of the Heckscher-Ohlin Theorem”. *American Economic Review* 72 (September): 683-94.

Dixit, Aninash and Victor Norman, 1980. *Theory of International Trade*. Cambridge, UK: Cambridge University Press.

Feenstra, Robert C. 2004. *Advanced International Trade: Theory and Evidence*. Princeton, New Jersey: Princeton University Press.

Hayek, Friedrich A. von. 1945. “The Use of Knowledge in Society”. *American Economic Review* 35 (September): 519-30.

Helpman, Elhanan. 1984. “The Factor Content of Foreign Trade”. *Economic Journal*. 94 (March): 84-94.

Helpman, Elhanan, and Paul Krugman. 1985. *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy*. Cambridge, Mass: MIT Press.

Lai, Huiwen and Susan C. Zhu, 2006, “Technology, endowments, and the factor content of bilateral trade”, Michigan State University, mimeo.

McKenzie, Lionel, W. 1954. ”Specialization and Efficiency in World Production.” *Review of Economic Studies* 21: 165-80.

McKenzie, Lionel, W. 1955. “Equality of Factor Prices in World Trade”. *Econometrica* 23(3) (July): 239-57.

Staiger, Robert, W., 1986. "Measurement of the Factor Content of Foreign Trade with Traded Intermediates." *Journal of International Economics* 21 (November): 361-68.

Vanek, Jaroslav. 1968. "The Factor Proportions Theory: The N-Factor Case", *Kyklos* 24: 749-56.