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Can International Trade Equalize Factor Prices?

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Abstract

This paper studies whether the Heckscher-Ohlin model's condition for factor price equalization holds. For this purpose information on national factor endowments and sectoral income shares is used to construct a theory-based quantitative criterion. In the context of two production factors, capital and labor, it is shown that the whole world cannot be a unique diversification cone, since the factor endowments of countries vary too much relative to the factor intensities of industries. The factor endowments of OECD countries instead are such that they can be under factor price equalization. These results cast doubts on the validity of the FPE model in favor of the complete specialization model both concerning empirical research on the net factor content of trade, and as an analytical workhorse to study many aspects of international trade, economic growth, etc. for large cross-sections of countries.

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1 Introduction

Due to its theoretical and empirical tractability the factor price equalization case of the Heckscher-Ohlin model has always received especial attention in the international trade literature. According to the factor price equalization hypothesis, even in the absence of international factor mobility countries can have their factor prices equalized through international trade as long as they share identical technologies and produce the same set of goods[1]. Factor price equalization (FPE hereafter) leads to the Heckscher-Ohlin-Vanek Theorem, according to which countries tend to export the services of the production factors in which they are relatively abundant. Many studies have analysed the empirical validity of the FPE case through the predictions of the Heckscher-Ohlin-Vanek Theorem on the net factor content of trade, rejecting it time and again[2].

It is thus remarkable that hardly any attempts have been made to assess whether FPE is a likely situation: the FPE hypothesis is not only based on the set of simplifying assumptions that characterize the Heckscher-Ohlin model (free trade, identical technologies and homothetic preferences across countries, no factor-intensity reversals, etc.), but also on a certain relationship between technologies and national factor endowments. Quoting Deardorff (1994), for FPE to happen "...the variation across countries in relative factor endowments must be less, in some sense, than the variation across industries of factor intensities." Otherwise, countries have different factor prices and specialize in different ranges of goods.

Thus, besides the possibility of testing the FPE hypothesis through any of its theoretical corollaries, we can also check whether the conditions for FPE hold for all or some countries in the world. This is the strategy followed here: abusing the Heckscher-Ohlin terminology, we define a set of countries that are completely specialized vis-à-vis the rest of the world and have identical factor prices as a diversification cone. We then derive a measurable criterion from the theory to assess whether a given group of countries can constitute a diversification cone; construct a series of hypothetical diversification cones;

[1] See Samuelson (1948).

[2] See Bowen, Leamer and Sveikauskas (1987), Trefler (1995) and Gabaix (1997). A thorough review of this literature can be found in Helpman (1998). Repetto and Ventura (1998) reject the FPE hypothesis using information on goods prices and factor-income shares.

and apply our criterion to check whether the relative factor endowments of countries abide to the FPE condition.

The closest references to this paper are Deardorff (1994) and Debaere and Demiroglu (1999). The former provides a theoretical criterion to assess the validity of the FPE condition for the many-country, many-factor case. In doing so, Deardorff shows how to reduce the many-factor case to the more tractable two-factor case. Based on these insights, Debaere and Demiroglu make a graphical assessment of the FPE condition for a group of 34 countries[3], and find that the OECD abides to it under the assumption that all goods are traded.

From a theoretical point of view, our paper shows that the Heckscher-Ohlin model's many-country case can be reduced to the two-country case when dealing with the FPE condition. This result, together with the insights provided by Deardorff, renders the problem at hand pretty tractable and intuitive, since it can be easily connected to the standard two-factor, two-country textbook treatment. In comparison with Debaere and Demiroglu (1999), this enables us to provide a precise quantitative criterion for the FPE condition, and to introduce nontraded goods in the analysis. Furthermore, the variables on which our empirical criterion is based help us approximate a hypothetical world diversification cone with data on more than one hundred countries.

On the empirical side we find that international trade cannot equalize factor prices all over the world: the factor endowments of countries violate the conditions for all of them to replicate the resource allocation of a hypothetical unique world diversification cone. This result provides a potential explanation for the failure of tests of the Heckscher-Ohlin-Vanek Theorem that are based on samples including rich and poor countries: the assumption of FPE underlying these tests is simply not a realistic scenario. If one wants to maintain the assumption of identical technologies across countries, one has to reformulate the Heckscher-Ohlin-Vanek Theorem for a world with different diversification cones. Rich countries, on the other hand, satisfy the FPE condition, and therefore may constitute a diversification cone.

Knowing the set of countries for which FPE may hold might be useful

[3] Davis and Weinstein (1998) and Schott (1999) argue against worldwide FPE based on evidence on differences in input-output matrices and specialization patterns across countries.

in other areas of economic research: applied analysis sometimes assumes all countries under FPE to study certain phenomena, such as the effects of globalization, economic growth, etc. Our results suggest that this can be misleading, since worldwide FPE is unlikely to take place, and the complete specialization case may have different theoretical implications.

The rest of the paper is structured as follows: Section 2 reviews the conditions under which FPE may take place, linking them to measurable quantities. Section 3 presents the data we use in the empirical implementation of our FPE criterion in Sections 4 and 5. Section 6 concludes, and Appendices I through III discuss proofs and derivations that we avoid in the main text for the sake of readability.

2 Factor Price Equalization

This section establishes a quantitative criterion to check whether the condition for FPE holds. We proceed in two steps. First, we review the concepts of integrated equilibrium and FPE set; in this context we discuss how to reduce the many-country case to the two-country case by aggregating countries in two groups. We then show how the FPE condition in the two-country case can be expressed with a set of measurable variables (GDP, sectoral shares in value added, aggregate and sectoral factor-income shares, and factor endowments).

2.1 Background: The Factor Price Equalization Set

Our exercise is based on the concept of integrated equilibrium[4], which is defined as the resource allocation the world would have if both goods and factors were perfectly mobile. The FPE set is the set of distributions of factors among countries that can achieve the resource allocation of the integrated equilibrium if we allow for free international trade, but no international factor mobility. If factor endowments lie within this set, the trading equilibrium will reproduce the integrated equilibrium's factor prices.

Let us start by characterizing the integrated equilibrium:

[4]See Dixit and Norman (1980), and Helpman and Krugman (1985).

i. Assume there are F inelastically supplied production factors. The F-dimensional vector $V = (V_1, V_2, ..., V_F)$ gives us the available quantities of these factors in the world.

ii. Goods $z \in Z$ are produced with quasi-concave, constant returns to scale production functions.

iii. Preferences are well behaved and homothetic.

iv. All markets are perfectly competitive.

v. All goods are produced in the integrated equilibrium.

The integrated equilibrium yields a certain allocation pattern of resources across sectors, described by F-dimensional vectors

$$V_z = [a_{1z}(\omega), a_{2z}(\omega), ..., a_{Fz}(\omega)]x_z,$$

for all $z \in Z$, where ω is the F-dimensional vector of factor prices, $a_{fz}(\omega)$ is sector z's use of factor f per unit of output, and x_z denotes the output of good z in the integrated equilibrium.

Assume that the world is divided into $J \geq 2$ countries, with every country j receiving an endowment $V^j = (V_1^j, V_2^j, ..., V_F^j)$ of production factors, and the integrated equilibrium's preferences and technologies. With a slight abuse of notation we also use J to denote the set of countries. Let us suppose that the set of goods Z can be partitioned into a subset of nontraded goods Z_n and a subset of traded goods Z_t. Assume balanced trade, so that the share of a country in world spending is equal to its share in income. Let us consider the following situation: there is no international factor mobility, but countries can trade freely in $z \in Z_t$. As is well known, under these assumptions the factor price equalization set for these J countries can be characterized as follows:

$$\begin{aligned} FPE(J) \;=\; & \Bigg\{(V^1, V^2, ..., V^J) \mid \exists \lambda_z^j \geq 0, \sum_{j \in J} \lambda_z^j = 1, \forall z \in Z, \\ & \lambda_z^j = \frac{\omega V^j}{\omega V}, \forall z \in Z_n, \; s.t. \, V^j = \sum_{z \in Z} \lambda_z^j V_z, \forall j \in J \Bigg\}. \quad (1) \end{aligned}$$

Equation (1) implies that the FPE set is the set of country endowments that can reproduce the sectoral allocation of resources of the integrated equilibrium while granting full employment of resources in each country and self-sufficiency in the production of the nontraded goods they consume. These conditions are both necessary and sufficient[5]. For future reference, notice that we index the FPE set with the number of countries J.

Figure 1 depicts the FPE set for the case of three traded goods[6], two factors (capital and labor), and two countries. The whole length of each axis represents the diversification cone's endowment of each factor. O^1 is country 1's origin and O^2 is country 2's origin. The FPE set is delimited by the thick line, which is constructed by alligning the integrated equilibrium's sectoral allocation vectors V_z from more to less capital-intensive. The slope of each vector reflects the capital-labor intensity of the corresponding sector. Any vector $(V^1, V^2) \in FPE(2)$ generates a trading equilibrium in which factor prices are equal to those of the integrated equilibrium in both countries. On the other hand, for $(V^1, V^2) \notin FPE(2)$ the integrated equilibrium cannot be reproduced and factor prices are different across countries, which specialize in different ranges of goods.

Notice that the argument for worldwide FPE can also be applied to a group of countries for which FPE holds, but which are completely specialized vis-à-vis the rest of the world, that is, a diversification cone in our terminology. A diversification cone can be characterized by a vector of factor prices, a vector of goods production, and a vector of goods consumption, all determined by the world equilibrium. Let us divide the diversificaton cone in a set of countries that can trade among themselves. If these countries reproduce the diversification cone's resource allocation, they will face the same factor prices of the latter. The condition for this to happen is that the countries' factor endowments are such that the conditions in Equation (1) hold, where V_z refers now to the allocation of resources in the diversification cone[7].

Concerning the extensions of the Heckscher-Ohlin model to account for intraindustry trade, the Chamberlin-Heckscher-Ohlin model yields an iden-

[5] See Dixit and Norman (1980).

[6] Throughout the paper we neglet nontraded goods in the figures for simplicity.

[7] See Debaere and Demiroglu (1999) for a formal proof.

tical definition of the FPE set, provided that the problem of obtaining an integer number of varieties can be ignored[8]. In the Heckscher-Ohlin-Ricardo model the FPE set is characterized as a subset of the set defined above[9].

2.2 The Many-Country Case

In what follows we discuss how to reduce the many-country case of FPE to the more tractable two-country case[10]. We start with an almost trivial result: if FPE holds for J countries, it must also hold for any two groups of countries constructed by partitioning the set J into two subsets and aggregating the factor endowments of all countries within each subset.

Lemma 1 *Let us partition the set J into two subsets, J_1 and J_2, and aggregate the factor endowments of countries $(V^1, V^2, ..., V^J)$ correspondingly, obtaining a vector (V^{J_1}, V^{J_2}), where $V^{J_i} = \sum_{j \in J_i} V^j$, $i = 1, 2$. Then*

$$(V^1, V^2, ..., V^J) \in FPE(J) \Longrightarrow (V^{J_1}, V^{J_2}) \in FPE(2)$$

for any partition (J_1, J_2) of J.

The importance of this result lies in the fact that if FPE(2) is not satisfied for some partition (J_1, J_2), then FPE(J) does not hold either. The intuition behind is rather simple: the FPE condition is based on the relative factor endowments of countries exhibiting less variation than the technologies used in the integrated equilibrium. By aggregating countries into two groups we are smoothing the variation of relative factor endowments and making FPE more likely. If the FPE condition does not hold in this case, it cannot hold in the many-country case. As we will see below, the condition for FPE(2) turns

[8]See Helpman (1981) or Helpman and Krugman (1985). The Chamberlin-Heckscher-Ohlin model assumes some monopolistically competitive sectors are subject to increasing returns to scale on the production side and a preference for variety on the demand side, leading to countries specializing in the production of different varieties within the same sector.

[9]See Davis (1995). The Heckscher-Ohlin-Ricardo model assumes that countries have Ricardian comparative advantage in certain varieties. This implies an additional constraint on the FPE conditions, since the production of these varieties needs to be located in the countries with the corresponding total factor productivity advantage for the integrated equilibrium to be reproduced.

[10]The proofs of the two lemmas discussed in this section can be found in Appendix I.

out to be easy to construct and measure. However, we first need to discuss whether we should check for FPE(2) for any partition (J_1, J_2), or whether we can just focus on a subset of these groupings.

Figure 1 depicts the factor endowment distribution of four countries alligned from more to less capital-labor abundant. Let us group them into two subsets, as discussed above, and check whether the distribution of factor endowments across countries satisfies the requirements for FPE(2). Now O^1 is group J_1's origin and O^2 is group J_2's origin. Country 1 versus the aggregation of countries 2 through 4, and the aggregation of countries 1 and 2 versus the aggregation of coutries 3 and 4 satisfy the requirements for FPE(2), since the factor-endowment vectors resulting from the corresponding aggregations lie within the FPE set. On the other hand, the aggregation of countries 1 through 3 versus country 4 does not satisfy FPE(2)[11]. This implies that the distribution of factors (V^1, V^2, V^3, V^4) cannot achieve FPE(J).

Notice that we have proceeded in a very well defined manner in forming the partitions of the set J, constructing the most capital-abundant and labor-abundant groups we could. These groupings are actually the only ones we need to focus on: any other grouping of countries would result in factor-endowment vectors with slopes closer to that of the diagonal of the box. We formalize this idea in the following lemma, that applies to the two-factor case[12] in the absence of nontraded goods:

Lemma 2 *Consider the vector of factor endowments (capital and labor) of countries* $(V^1, V^2, ..., V^J)$, *where countries are ranked from most to least capital-abundant. Consider the corresponding* $J-1$ *partitions yielding the most capital-abundant and labor-abundant groups of countries, with endowments* $(V^{J_{1j}}, V^{J_{2j}})$, $V^{J_{1j}} = \sum_{h=1}^{j} V^h$, $V^{J_{2j}} = \sum_{h=j+1}^{J} V^h$, $j \in \{1, ..., J-1\}$. *Then*

$$(V^{J_{1j}}, V^{J_{2j}}) \in FPE(2)\, \forall j \in \{1, ..., J-1\} \Longrightarrow (V^1, V^2, ..., V^J) \in FPE(J).$$

[11] The factor endowment corresponding to the aggregation of countries 1 through 3 is represented in the figure by the dashed line.

[12] Appendix III, based on Deardorff (1994), shows how our quantitative criterion can be applied to the many-factor case.

2.3 The Two-Country Case

In this section we establish a measurable criterion to assess whether the condition for FPE holds in the two-country case. The criterion applies both to the standard Heckscher-Ohlin model and its Chamberlin-Heckscher-Ohlin extension[13].

Consider a diversification cone with competitive markets that produces a set of final goods $z \in Z$. Assume $Z_t = \{1, ..., t\}$ and $Z_n = \emptyset$. The cone has a given endowment of capital and labor $V = (k, l)$. Each good is produced with both production factors under constant returns to scale[14]. Define aggregate and sectoral factor income shares $\alpha \equiv \frac{rk}{y}$, $\beta \equiv \frac{wl}{y}$, $\alpha_z \equiv \frac{rk_z}{p_z x_z}$, $\beta_z \equiv \frac{wl_z}{p_z x_z}$, and sectoral shares in GDP $s_z \equiv \frac{p_z x_z}{y}$, where $y \equiv \sum_{z \in Z} p_z x_z$. Traded goods are ranked according to their capital-labor intensities: the lower z, the higher k_z/l_z. Given these definitions, the diversification cone's resource allocation vectors $V_z = (k_z, l_z)$ can be expressed as follows:

$$k_z = \frac{s_z \alpha_z}{\alpha} k, \tag{2}$$

$$l_z = \frac{s_z \beta_z}{\beta} l. \tag{3}$$

The integrated equilibrium's sectoral capital-labor ratios can be easily obtained from the equations above:

$$\frac{k_z}{l_z} = \frac{\alpha_z}{\beta_z} \frac{\beta}{\alpha} \frac{k}{l}. \tag{4}$$

Let us split the diversification cone into two countries and assume away factor mobility between them. The FPE set is the set of country-specific

[13]With the appropriate modifications the criterion also applies to the Heckscher-Ohlin-Ricardo model.

[14]This implies that the shares of labor and capital in the sector's value added add up to one. In the Chamberlin-Heckscher-Ohlin model, production functions in the monopolistically competitive sectors are subject to increasing returns to scale. With free entry, however, pure profits are driven down to zero, so that sectoral factor income shares also add up to one.

factor endowments $V^i = (k^i, l^i)$, $i = 1,2$, $V^1 + V^2 = V$, such that the conditions in Equation (1) hold. The FPE condition can be thought of in terms of capital-labor ratios: in Figure 2, if country 1 has labor endowment l^1, its factor endowment vector will be a straight line with slope k^1/l^1 from O^1 to some point on the l^1-vertical line. Figure 2 displays two such vectors: they are actually the upper and lower bounds for k^1/l^1 to satisfy the FPE condition. In Appendix II we show that these bounds can be expressed as follows:

$$\frac{\sum_{z\in Z_{t_l}} s_z\alpha_z}{\sum_{z\in Z_{t_l}} s_z\beta_z}\frac{\beta}{\alpha}\frac{k}{l} \leq \left(\frac{k^1}{l^1}\right)_{FPE} \leq \frac{\sum_{z\in Z_{t_k}} s_z\alpha_z}{\sum_{z\in Z_{t_k}} s_z\beta_z}\frac{\beta}{\alpha}\frac{k}{l}, \tag{5}$$

where $Z_{t_l} = \{t_l, ..., t\} \subseteq Z_t$, $t_l \geq 1$, is the subset of most labor-intensive traded goods; $Z_{t_k} = \{1, ..., t_k\} \subseteq Z_t$, $t_k \leq t$, is the subset of most capital-intensive traded goods; and the limits t_l and t_k are defined by

$$\frac{l^1}{l} = \frac{1}{\beta}\sum_{z\in Z_{t_l}} s_z\beta_z = \frac{1}{\beta}\sum_{z\in Z_{t_k}} s_z\beta_z. \tag{6}$$

Comparing Equations (4) and (5), the upper bound in Equation (5) can be interpreted as the capital-labor intensity of an artificial sector that produces all of the diversification cone's most capital-intensive goods up to the point in which it fully employs country 1's labor endowment[15] l^1. The lower bound can be interpreted symmetrically. Notice that if all sectors had very similar α_z/β_z, FPE would only hold in the neighborhood of the diagonal of the box, where $k^1/l^1 = k^2/l^2 = k/l$. Notice also that as l^1/l increases, the bounds

[15] For presentation purposes we ignore the more likely case that

$$\frac{l^1}{l} = \frac{1}{\beta}\left(\sum_{z\in Z_{t_k-1}} s_z\beta_z + \pi_{t_k} s_{t_k}\beta_{t_k}\right),$$

where $0 < \pi_{t_k} < 1$. In this case the corresponding constraint on $(k^1/l^1)_{FPE}$ is

$$\left(\frac{k^1}{l^1}\right)_{FPE} \leq \frac{\sum_{z\in Z_{t_k-1}} s_z\alpha_z + \pi_{t_k} s_{t_k}\alpha_{t_k}}{\sum_{z\in Z_{t_k-1}} s_z\beta_z + \pi_{t_k} s_{t_k}\beta_{t_k}}\frac{\beta}{\alpha}\frac{k}{l}.$$

become closer to k/l: the larger the size of a country, the less different from the diversification cone it can afford to be if FPE is to hold.

Rescaling Equation (5) by k/l, the bounds tell us how many times larger or smaller than k/l can k^1/l^1 be under FPE:

$$\frac{\sum_{z\in Z_{t_l}} s_z\alpha_z}{\sum_{z\in Z_{t_l}} s_z\beta_z}\frac{\beta}{\alpha} \leq \frac{(k^1/l^1)_{FPE}}{k/l} \leq \frac{\sum_{z\in Z_{t_k}} s_z\alpha_z}{\sum_{z\in Z_{t_k}} s_z\beta_z}\frac{\beta}{\alpha}. \tag{7}$$

Finally, notice that the upper bound defined in Equation (7) is the solution to the following linear program:

$$\max_{\{k_z^1\}_{z\in Z}} \frac{k^1/l^1}{k/l} = \frac{1/l^1}{k/l}\sum_{z\in Z} k_z^1 \tag{8}$$

subject to

$$\sum_{z\in Z}\left(\frac{\alpha_z}{\beta_z}\frac{\beta}{\alpha}\frac{k}{l}\right)^{-1} k_z^1 = l^1, \tag{9}$$

$$0 \leqslant k_z^1 \leqslant \frac{s_z\alpha_z}{\alpha}k \quad \forall z \in Z_t. \tag{10}$$

The first constraint guarantees full employment of labor in country 1 when using the integrated equilibrium's sectoral capital-labor intensities. The second set of constraints is imposed by the integrated equilibrium's resource allocation: under FPE country 1 cannot allocate more capital to a sector than the integrated equilibrium does. The lower bound is the solution to the linear program that minimizes $\frac{k^1/l^1}{k/l} = \frac{1/l^1}{k/l}\sum_{z\in Z} k_z^1$ subject to the same constraints.

2.4 The Factor Price Equalization Condition

Sections 2.2 and 2.3 suggest the following iterative procedure to implement the FPE criterion:

1. Consider a group of J countries assumed to form a diversification cone. Compute the corresponding aggregates: k^j/l^j, k/l, s_z, α_z, β_z, α, and β.

2. Rank countries according to their relative capital-labor abundance. Aggregate the factor endowments of countries into two groups: the most capital-abundant country versus the rest. Compute the bounds with the linear program discussed in Section 2.3, and check whether FPE(2) holds.

3. Iterate by transferring the most capital-abundant country of the previous iteration's labor-abundant group to the capital-abundant group and checking for FPE(2), and so forth until comparing the group of $J-1$ most capital-abundant countries versus the most labor-abundant country.

If FPE(2) holds in every iteration, then by Lemma 2 countries' endowments are such that FPE(J) holds. If in any iteration FPE(2) does not hold, then by Lemma 1 FPE(J) cannot hold either.

3 Data and Variables

This section discusses the variables and data used in the implementation of the FPE criterion discussed above. We perform our exercise for the year 1988. Due to data availability, we constrain ourselves to a two-factor analysis: we consider that economies, indexed by j, have capital k^j and labor l^j. We disaggregate the economy into 35 sectors: 8 one-digit sectors and 27 three-digit manufacturing sectors, indexed by z, $z \in Z$. Table 1 lists the sectors into which we disaggregate the economy.

We have information on factor endowments and value added by sector at the one-digit level for roughly 114 countries. Out of them, for 66 countries we can disaggregate the manufacturing sector at the three-digit level. Table 2 displays our sample of countries, and indicates data availability at the one-digit and three-digit levels. As discussed below, given that in both cases we have the entire OECD, which accounts for the most important part of world GDP, and largely populated countries such as China and India, this enables us to construct a reasonable approximation to a hypothetical unique diversification cone.

The variables used in the exercise are computed as follows[16]:

[16] We use asterisks to distinguish the variables we construct from their theoretical counterparts. However, we avoid this additional piece of notation in the variables indexed in

i. We take information on aggregate investment from the Penn-World Tables[17] to construct capital stocks with the perpetual inventory method:

$$k^j(\tau) = (1-\delta)k^j(\tau-1) + \Delta k^j(\tau-1),$$

where τ denotes time, and the depreciation rate δ is assumed to be 0.06, as in Hall and Jones (1998). Following Young (1995), the series for capital are initialized with $k^j(0) = \frac{\Delta k^j(0)}{g^j(\Delta k)+\delta}$, where $\Delta k^j(0)$ is the first observation of the investment series, and $g^j(\Delta k) = \frac{1}{10}\frac{\Delta k^j(9)-\Delta k^j(0)}{\Delta k^j(0)}$ is the growth rate of the investment series in its very beginning (here the first ten years). With enough periods ahead of our particular year of interest, 1988, the assumption about the initial capital stock should not be crucial, since it depreciates away over time. In this respect almost all countries in our sample report aggregate investment series starting in or prior to 1970.

ii. We initially take each country's employment level e^j, also from the Summers-Heston database, as their labor endowment l^j: $l^j = e^j$. Table 3 ranks countries according to their capital-labor ratios and reports the countries' capital and labor endowments normalized by those of the U.S. Below we correct labor endowments with an efficiency-augmenting factor based on each country's human capital endowment.

iii. The diversification cone's aggregate capital-labor ratio is computed with the capital stocks and labor endowments of the corresponding countries:

$$\left(\frac{k^*}{l^*}\right) = \frac{\sum_{j\in S} k^j}{\sum_{j\in S} l^j},$$

where $S \subseteq J$ is the set of countries included in our database that are assumed to be part of a diversification cone with J countries.

iv. We compute country-specific sector shares in value added s_z^j by dividing sectoral nominal value added at market prices by the sum of sectoral value added across sectors:

j.

[17] See Summers and Heston (1991).

$$s_z^j = \frac{p_z^j x_z^j}{y^j} = \frac{p_z^j x_z^j}{\sum_{z \in Z} p_z^j x_z^j},$$

where $p_z x_z$ is sector z's value added. Information on sectoral value added disaggregated at the ISIC one-digit level is taken from the OECD and the UN National Accounts. We disaggregate the manufacturing sector at the three-digit level with information from the UNIDO database[18].

The diversification cone's sector shares in value added s_z^* are constructed with the country-specific sector shares s_z^j:

$$s_z^* = \frac{(p_z x_z)^*}{y^*} = \sum_{j \in S} \frac{y^j}{y^*} \frac{p_z^j x_z^j}{y^j} = \sum_{j \in S} \frac{y^j}{y^*} s_z^j, \tag{11}$$

where y^j is country j's GDP and $y^* = \sum_{j \in S} y^j$ is the hypothetical diversification cone's GDP[19]. We use real GDP from the Summers-Heston database to measure y^j. Given that we weight each s_z^j with y^j, eventual disparities in the classification of industries for countries with poor information will have a

[18]The share of each three-digit subsector within the manufacturing sector $(s_z^j)^3$ is normalized by the share of the manufacturing sector s_m^j in the one-digit disaggregation. Define $M \subset Z$ as the set of manufacturing sectors disaggregated in the UNIDO database. For all $z \in M$

$$s_z^j = s_m^j (s_z^j)^3 = s_m^j \left[\frac{\left(p_z^j x_z^j\right)^3}{\sum_{z \in M} \left(p_z^j x_z^j\right)^3} \right].$$

[19]The set of countries U for which we can compute the three-digit disaggregation of the manufacturing sector is a subset of the set of countries S for which we can compute the one-digit disaggregation. Therefore for $z \in M$ we compute the sectoral shares in the integrated equilibrium as follows:

$$s_z^* = \frac{\sum_{j \in S} \left[\frac{y^j}{\sum_{j \in S} y^j} s_m^j \right]}{\sum_{j \in U} \left[\frac{y^j}{\sum_{j \in U} y^j} s_m^j \right]} \sum_{j \in U} \left[\frac{y^j}{\sum_{j \in U} y^j} s_z^j \right].$$

In this manner we approximate sectoral shares in the diversification cone with all information available and so that they add up to one.

minor effect. Table 4 reports s_z^* for the two diversification cones we consider below: the world and the OECD[20].

v. To compute the integrated equilibrium's sectoral factor income shares, α_z^* and β_z^*, we first compute country-specific sectoral labor shares β_z^j from the cost components of value added as reported by the National Accounts and the UNIDO database. More precisely, the labor shares are computed as follows:

$$\beta_z^j = \frac{w^j l_z^j}{\left[p_z^j x_z^j\right]_{fc}},$$

where wl_z is sector z's compensation of employees[21], and $[p_z x_z]_{fc}$ is sector z's value added at factor cost. We compute β_z^j for a subset $A \subseteq S$ of OECD countries (Australia, Finland, Germany, Japan, Norway, the United Kingdom, and the United States) for which we have information on sectoral value added, compensation of employees, capital consumption, and net indirect taxes. We take averages over the period 1986-1990. For sectors employing mainly capital and labor we can obtain the capital share as a residual[22]: $\alpha_z^j = 1 - \beta_z^j$.

[20]Our definition of OECD is pretty loose: we actually refer to the 30 most capital-abundant countries of Table 3, which constitute the first quartile of our sample.

[21]For the sectors in the three-digit disaggregation, before computing country-specific factor income shares we rescale both value added by sector $\left(p_z^j x_z^j\right)^3$ and compensation of employees by sector $\left(w^j l_z^j\right)^3$ with the one-digit manufacturing sector's value added $p_m^j x_m^j$ and compensation of employees $w^j l_m^j$, respectively. For all $z \in M$

$$p_z^j x_z^j = p_m^j x_m^j \frac{\left(p_z^j x_z^j\right)^3}{\sum_{z \in M}\left(p_z^j x_z^j\right)^3},$$

$$w^j l_z^j = w^j l_m^j \frac{\left(w^j l_z^j\right)^3}{\sum_{z \in M}\left(w^j l_z^j\right)^3}.$$

[22]Computing capital shares as a residual for sectors that make use of land or natural resources is likely to be inaccurate. Therefore for agriculture, mining, and utilities we use an alternative procedure. From Equation (5) we know that for any pair of sectors the following holds: $\alpha_z = \beta_z \frac{\alpha_{z'}}{\beta_{z'}} \frac{k_z/l_z}{k_{z'}/l_{z'}}$. We take information on k_z/l_z for the year 1990 from Debaere and Demiroglu (1999), who use data from the Michigan Model (see Deardorff

We compute the integrated equilibrium's sectoral factor income shares as follows:

$$\alpha_z^* = \frac{(rk_z)^*}{(p_z x_z)^*} = \sum_{j \in A} \frac{p_z^j x_z^j}{(p_z x_z)^*} \frac{rk_z^j}{p_z^j x_z^j} = \sum_{j \in A} \frac{y^j}{y^A} \frac{s_z^j}{s_z^A} \alpha_z^j, \tag{12}$$

$$\beta_z^* = \frac{(wl_z)^*}{(p_z x_z)^*} = \sum_{j \in A} \frac{p_z^j x_z^j}{(p_z x_z)^*} \frac{wl_z^j}{p_z^j x_z^j} = \sum_{j \in A} \frac{y^j}{y^A} \frac{s_z^j}{s_z^A} \beta_z^j, \tag{13}$$

where $s_z^A = \sum_{j \in A} \frac{y^j}{y^A} s_z^j$; and $y^A = \sum_{j \in A} y^j$. The last two columns in Table 4 report α_z^* and β_z^*.

Finally, the diversification cone's aggregate factor income shares are computed as

$$\alpha^* = \frac{(rk)^*}{y^*} = \sum_{z \in Z} \frac{(p_z x_z)^*}{y^*} \frac{(rk_z)^*}{(p_z x_z)^*} = \sum_{z \in Z} s_z^* \alpha_z^*, \tag{14}$$

$$\beta^* = \frac{(wl)^*}{y^*} = \sum_{z \in Z} \frac{(p_z x_z)^*}{y^*} \frac{(wl_z)^*}{(p_z x_z)^*} = \sum_{z \in Z} s_z^* \beta_z^*. \tag{15}$$

4 Can International Trade Equalize Factor Prices Worldwide?

Our first hypothetical diversification cone is the whole world. We implement the algorithm sketched in Section 2 for the 114 countries in our sample, assuming all sectors are traded. Figure 5 plots the three terms of Equation (7) against the labor endowment ratio l^1/l for each iteration[23]. Recall that

and Stern (1990)). For agriculture we use footwear (which is reported to have the same k_z/l_z) as its reference sector; for mining and utilities we use non-ferrous metals as the reference sector. Other reference sectors yield nonsensical values for α_z: we therefore take our "estimates" as a first approximation, and discuss measurement error below.

[23]To preserve a manageable scale we censor the figures on the left of $l^1/l = 0.01$. The omitted observations do not affect the interpretation of our results.

as we iterate in our algorithm l^1/l increases from zero to one, and the bounds narrow down towards unity. The variation in relative factor endowments is remarkably high for the world, with $\frac{k^1/l^1}{k/l}$ ranging form 1 to 4.

It is apparent that the FPE condition is violated systematically: the ratio $\frac{k^1/l^1}{k/l}$ is above the upper bound for almost all observations. At $l^1/l = 0.25$ we are grouping the OECD vis-à-vis the rest of the world. The former turns out to be too capital-abundant relative to the latter for the existence of a unique diversification cone: the upper bound implies that k^1/l^1 can be at most twice as large as the world's capital-labor ratio k/l. k^1/l^1, however, turns out to be three times larger than k/l. To check the robustness of our results we construct 95% confidence intervals for $\frac{k^1/l^1}{k/l}$ with a bootstrapping routine (with one thousand repetitions): the 2.5th percentile of $\frac{k^1/l^1}{k/l}$ lies below the upper bound of the FPE condition. Thus, although suggestive, these results do not enable us to "reject" the possibility of worldwide FPE. Actually, if we also simulate the bounds with measurement error in α_z^* and β_z^*, the 97.5th percentile of the FPE condition's upper bound is likely to lie above $\frac{k^1/l^1}{k/l}$.

4.1 Production Factors

An important aspect of the empirical work on FPE consists in the proper measurement of production factors. Trefler (1993) revived the interest on the FPE model by arguing that it might not be such an unrealistic idea if one thinks about it in terms of equivalent efficiency units of factors and corrects for the efficiency of countries' factor endowments: differences in countries' relative factor endowments may be much smaller if factors are measured in efficiency units. However, Trefler's efficiency adjustments were made so that the FPE model delivered the right predictions about the net factor content of trade. That is, his adjustments make the FPE model work by construction[24].

To adjust for the efficiency of factors we use a variable h^j constructed by Hall and Jones (1998) to measure the amount of human capital per worker[25].

[24]See Gabaix (1997) for a criticism of Trefler's results.

[25]This idea goes back to Leontief (1953). In this respect, Repetto and Ventura (1997) suggest that education-related variables are good proxies for the labor-bias in productivity. We cannot adjust for total factor productivity (TFP) differences due to lack of data. Hicks-neutral TFP, however, has no effect on relative capital-labor endowments.

This variable, computed for 1988, is based on data on educational attainment from Barro and Lee (1993), and on returns to schooling from Psacharopoulos (1994), based on international Mincerian wage regressions. We correct each country's labor endowment with this variable, so that effective employment is $l^j = h^j e^j$. Table 3 reports h^j and $k^j/(h^j e^j)$.

Figures 5 also displays the ratio $\frac{k^1/l^1}{k/l}$ computed with labor endowments corrected by the Hall-Jones coefficients. Due to the positive correlation between physical and human capital across countries, relative capital-labor endowments are somewhat smoothed for the world: $\frac{k^1/l^1}{k/l}$ now ranges from 1 to 3.40. The FPE condition for a unique diversification cone, however, is still violated systematically. As above, though, the 2.5th percentile of $\frac{k^1/l^1}{k/l}$ lies below the FPE condition's upper bound.

4.2 Aggregation and Omitted Countries

The sectors in our dataset are the aggregation of finer subsectors. This poses a problem if the latter have some heterogeneity in their factor intensities: according to the Rybczynski Theorem, capital-abundant countries tend to produce more capital-intensive goods than labor-abundant countries[26]. Therefore α_z^j or its average over a subset of countries α_z^* may be "biased estimators" of α_z (a symmetric discussion applies to the sectoral labor shares): assume the integrated equilibrium generates α_{zi} and s_{zi}^j, where the parameter i denotes the subsectors that constitute observable sector z. Thus, $\alpha_z^j = \sum_i \frac{s_{zi}^j}{s_z^j}\alpha_{zi}$ and $\alpha_z = \sum_i \frac{s_{zi}}{s_z}\alpha_{zi}$. Given that we are likely to have $s_{zi}^j \neq s_{zi}$, $\alpha_z^j \neq \alpha_z$ even if FPE holds.

Can we say anything about the size of this "bias"? Recall Equation (12) approximates $\alpha_z = \sum_{j\in J} \frac{y^j}{y}\frac{s_z^j}{s_z}\alpha_z^j$ with $\alpha_z^* = \sum_{j\in A} \frac{y^j}{y^A}\frac{s_z^j}{s_z^A}\alpha_z^j$. The difference between the two terms can be written as

$$\alpha_z^* - \alpha_z = \sum_{j\in J\setminus A} \frac{y^j}{y^A}\frac{s_z^j}{s_z^A}\left(\alpha_z - \alpha_z^j\right).$$

[26] As Davis and Weinstein (1998) point out, this implies that differences in sectoral factor intensities (or in α_z^j/β_z^j) across countries are not strong evidence to reject the FPE hypothesis.

Under the assumption of worldwide FPE α_z^* is likely to have a positive "bias", given that most of the countries left out in its construction are those with low α_z^j, i.e. labor-abundant countries, and y^A is less than half of y^*. To assess the importance of this problem we implement the following simulation exercise:

We add an error term ε_z to each sectoral capital share α_z^*, where the ε_z are i.i.d. and follow a uniform distribution: $\varepsilon_z \sim U[-x(1+q), x(1-q)]$. We compute the bounds for the world diversification cone with these randomized sectoral factor shares one hundred times[27] to obtain 95% confidence intervals. Any choice of variance in the errors is arbitrary here; therefore we simulate the bounds for a grid of values: $x = 0.10$, 0.15, 0.20, 0.25, and 0.30. As for the parameter q, we try $q = 0$, and 0.25. Notice that $q = 0$ implies $E(\varepsilon_z) = 0$, whereas $q > 0$ implies $E(\varepsilon_z) < 0$. The latter case corrects for potential positive biases in α_z^*. Even in the most optimistic case, with $x = 0.10$ and $q = 0$, it is hard to "reject" the FPE condition in the presence of measurement error. The differences between the bounds obtained with $q = 0$ and $q = 0.25$ are minor.

A similar problem occurs with the sectoral shares in value added s_z. Our sample of countries S is a subset of the set of countries J in the corresponding hypothetical diversification cone. The latter has sectoral shares $s_z = \sum_{j \in J} \frac{y^j}{y} s_z^j$. Equation (11) instead computes the integrated equilibrium's sectoral shares as $s_z^* = \sum_{j \in S} \frac{y^j}{y^*} s_z^j$. It is easy to show that the "bias" of s_z^* is

$$s_z^* - s_z = \sum_{j \in J \setminus S} \frac{y^j}{y^*} \left(s_z - s_z^j\right).$$

Thus, if the size in terms of GDP of the omitted countries is small, s_z^* will be a good approximation to s_z. Finally, if the factor endowments of the omitted countries are small relative to those of the countries in our sample, k^*/l^* will also be a relatively accurate approximation to k/l. Given the size in terms of GDP, capital, and labor of the countries included in our sample,

[27] We set up our algorithm so that $\alpha_z^* + \beta_z^*$ is fixed: a positive shock ε_z to α_z^* implies therefore a negative shock to β_z^* of the same magnitude. In case the randomized capital shares reach values below zero or above $\alpha_z^* + \beta_z^*$, we give them values 0.001 and $\alpha_z^* + \beta_z^* - 0.001$, respectively.

we are confident about the minor influence of omitted countries in s_z^*, k^* and l^*.

A second problem related with aggregation is the following: even if α_z/β_z is a good indicator of sector z's average factor-intensity, the lack of a finer disaggregation reduces the variation of the sectoral factor intensities in the data artificially, and may lead us to "reject" the possibility of FPE mistakenly. One way to assess the importance of this problem is to check how our results change when we make matters worse for FPE: we aggregate the three-digit manufacturing subsectors into their one-digit aggregate, and compute the FPE bounds with just the nine one-digit sectors.

Figure 6 compares the initial 35-sector bounds for the world diversification cone with their 9-sector counterparts. Although the latter are a bit more restrictive, they are pretty close to the former, implying that not so much is gained in practice with finer levels of disaggregation. Obviously, this is not a proof that aggregation is not an issue, but at least it questions its quantitative relevance. At the same time, this result implies that combining information from the National Accounts and the UNIDO database does not bias our results significantly.

4.3 Nontraded Goods

So far we have worked under the assumption that all goods are traded. Let us relax this assumption by considering that there is a nontraded good: $Z_n = \{n\}$. Given the additional constraint on the factor endowments of countries (self-sufficiency in the production of the nontraded goods consumed in each country), the FPE set with nontraded goods is a subset of the FPE set with only traded goods, making FPE less likely. Therefore a "rejection" of the FPE condition is not affected by our ignoring the importance of nontraded goods. A "non-rejection" of the FPE condition instead may be subject to some qualifications in the presence of nontradables.

In terms of our quantitative criterion, to obtain the FPE bounds for $\frac{k^1/l^1}{k/l}$ we need to introduce an additional constraint into the linear program discussed in Section 2.3:

$$k_n^1 = \frac{y^1}{y} k_n = \frac{y^1}{y} \frac{s_n \alpha_n}{\alpha} k. \tag{16}$$

The larger the share of nontraded goods in GDP, the smaller the difference between the FPE bounds, which are modified as follows:

$$\frac{\frac{y^1}{y}s_n\alpha_n + \sum_{z\in Z_{t_l}} s_z\alpha_z}{\frac{y^1}{y}s_n\beta_n + \sum_{z\in Z_{t_l}} s_z\beta_z}\frac{\beta}{\alpha} \leq \frac{(k^1/l^1)_{FPE}}{k/l} \leq \frac{\frac{y^1}{y}s_n\alpha_n + \sum_{z\in Z_{t_k}} s_z\alpha_z}{\frac{y^1}{y}s_n\beta_n + \sum_{z\in Z_{t_k}} s_z\beta_z}\frac{\beta}{\alpha}. \quad (17)$$

One problem we encounter when executing our FPE algorithm with nontradables is that in the first iterations the linear program may have no solution. To understand this problem let us combine the two equality constraints of the linear program, i.e., Equations (9) and (16):

$$\sum_{z\in Z_t}\left(\frac{\alpha_z}{\beta_z}\frac{\beta}{\alpha}\frac{k}{l}\right)^{-1}\frac{k_z^1}{l^1} + \frac{s_n\beta_n}{\beta}\frac{y^1/l^1}{y/l} = 1. \quad (18)$$

If $\frac{s_n\beta_n}{\beta}\frac{y^1/l^1}{y/l} > 1$, Equation (18) has no solution, since income shares and factor endowments are nonnegative. To grasp the intuition underlying this issue, notice that $\frac{s_n\beta_n}{\beta}\frac{y^1/l^1}{y/l} > 1$ implies $l_n^1 = \frac{y^1}{y}\frac{s_n\beta_n}{\beta}l > l^1$; that is, the linear program will not deliver a solution if the hypothetical integrated equilibrium requires that country 1 allocate more labor than it has to the nontraded sector.

Some back-of-the-envelope calculations show why $\frac{s_n\beta_n}{\beta}\frac{y^1/l^1}{y/l}$ may be larger than one in the data. Recall that in the initial iterations of our algorithm we aggregate the richest countries of the world into our so-called "country 1". In this case $\frac{y^1/l^1}{y/l}$ tends to be rather large. For example, when country 1 comprises the first 30 countries in the sample, $\frac{y^1/l^1}{y^*/l^*} = 2.66$ if labor is measured simply as employment, and $\frac{y^1/l^1}{y^*/l^*} = 2.03$ if employment is adjusted with the Hall-Jones coefficients. Furthermore, in the very first iterations $\frac{y^1/l^1}{y^*/l^*}$ reaches values close to or above three.

Concerning nontradables, let us start by assuming that utilities, construction and the entire service sector are nontraded. This might appear too ambitious a classification, but all these sectors produce an important share of goods or services that tend to be nontraded due to transport costs. Obviously, one can find important tradable subsectors in each of these sectors; however, as we argue below, what matters for our argument is the share of nontraded value added in GDP. Under the null hypothesis of FPE, $s_n^* = 0.64$, $\beta_n^* = 0.67$, $\beta^* = 0.62$, and $\frac{s_n^* \beta_n^*}{\beta^*} = 0.7$. In this case, given the initial values of $\frac{y^1/l^1}{y^*/l^*}$, Equation (19) has no solution and worldwide FPE is impossible.

Since we started with a relatively ambitious classification of nontradables, let us perform the following thought experiment: given s_n^*, β_n^*, and β^*, what is the fraction g of s_n^* that should be at most nontradable for Equation (18) to have a solution? Solving for g,

$$g \leq \left(\frac{s_n^* \beta_n^*}{\beta^*} \frac{y^1/l^1}{y^*/l^*} \right)^{-1}.$$

For $\frac{y^1/l^1}{y^*/l^*} = 3$, we get $g \leq 0.5$: the existence of a solution to the linear program requires that at most 50% of value added of the sectors mentioned above (equivalent to 30% of world GDP) be actually nontraded. Notice that the existence of a solution does not imply that the FPE condition will hold: for $\frac{y^1/l^1}{y^*/l^*} = 3$ and $g = 0.5$, country 1 needs to employ all its factors in the production of the nontraded goods it consumes, implying $\frac{k_z^1/l^1}{k/l} = 0 \; \forall z \in Z_t$. This implies the following values for the FPE bounds:

$$\frac{\alpha_n}{\beta_n} \frac{\beta}{\alpha} \leq \frac{(k^1/l^1)_{FPE}}{k/l} \leq \frac{\alpha_n}{\beta_n} \frac{\beta}{\alpha}. \tag{19}$$

That is, the FPE condition will only hold in the unlikely case that country 1 has a capital-labor ratio equal to the capital-labor intensity of the nontraded sector in the integrated equilibrium: $\left(\frac{k^1}{l^1}\right)_{FPE} = \frac{\alpha_n}{\beta_n} \frac{\beta}{\alpha} \frac{k}{l}$. Thus, for the FPE condition to hold we need to assume that the share of sector n's value added that is nontraded is far below one half (or below 30% of world GDP). This looks too strong a requirement from reality[28].

[28] One virtue of this argument is that it does not rely on the two variables subject to measurement error most importantly, k^j and α_z^*. In fact, the argument holds as long as (i) GDP per worker of rich countries is large relative to the diversification cone's average, (ii) s_n is large enough, and (iii) $\beta_n > \beta$. The latter two conditions do not seem so unrealistic, given the size and the labor-intensive character of the service sector.

Our argument has been made so far under the assumption of identical homothetic preferences across countries. If we depart from it, matters get even worse for the FPE condition. With actual value added of the nontraded sector for each country, Equation (16) and the second term in Equation (18) become, respectively, $\frac{k_n^1/l^1}{k/l} = \frac{y^1}{y}\frac{s_n^1}{s_n}\frac{s_n\alpha_n}{\alpha}\left(\frac{l^1}{l}\right)^{-1}$ and $\frac{s_n^1}{s_n}\frac{s_n\beta_n}{\beta}\frac{y^1/l^1}{y/l}$. For rich countries we have an average $s_n^1 = 0.7 > s_n^*$ (the average size of the service sector in the OECD is 60% of GDP), which implies an even lower g to grant the existence of a solution to the linear program.

Figure 7 presents the FPE bounds for the world diversification cone, considering factors in efficiency units and assuming $g = 0.5$. Notice that for l^1/l small the FPE condition's upper and lower bounds have very similar values. This signals that the problem discussed in Equation (19) is occurring. The ratio $\frac{k^1/l^1}{k/l}$ is above the FPE condition's upper bound for the whole range of l^1/l. What's more, even the 2.5th percentile of $\frac{k^1/l^1}{k/l}$ is above the upper bound for small values of l^1/l. Without efficiency adjustments the violation of the FPE condition is even more pronounced.

5 Can International Trade Equalize Factor Prices in the OECD?

Our second hypothetical cone comprises the group of 30 most capital-abundant countries in Table 3, which is roughly the OECD. Figure 8 plots the three terms of Equation (7) against the ratio l^1/l. Notice that disparities in relative capital-labor endowments are much smaller for this group than for the world: $\frac{k^1/l^1}{k/l}$ is almost horizontal and ranges from 1 to 1.50. The FPE condition is not violated a single time in this case.

5.1 Production Factors

Efficiency adjustments play no major role for the OECD: Figure 8 also displays the ratio $\frac{k^1/l^1}{k/l}$ computed in efficiency units, which also abides to the FPE condition.

5.2 Aggregation and Omitted Countries

Aggregation seems to be a minor problem in the case of the OECD cone. Going back to Equation (12), notice that the countries in A constitute 70% of the OECD cone's GDP. Therefore we are relatively confident that $\alpha_z^* - \alpha_z$ is very small here. As for s_z^*, k^*, and l^*, we cannot think of any major rich country omitted in our sample.

5.3 Nontraded Goods

Figure 9 presents the FPE bounds for the OECD diversification cone, considering factors in efficiency units and assuming $g = 0.85$. This is equivalent to assuming that 60% of the OECD cone's GDP is nontradable. Even with such extreme values most of the 2.5th percentile of $\frac{k^1/l^1}{k/l}$ is under the FPE condition's upper bound. In fact, more moderate classifications of nontraded goods lead us to not reject the FPE condition. Hence, it is difficult to reject the FPE condition for the OECD. The results do not change if we consider capital-labor ratios without efficiency adjustments.

6 Concluding Remarks

The whole world is unlikely to constitute a unique diversification cone: once we take into account the presence of nontraded goods in the economy, the relative factor endowments of 114 countries, with which we approximate a hypothetical world integrated equilibrium, violate the condition for factor price equalization. This result suggests that the complete specialization case of the Heckscher-Ohlin model deserves more attention than is usually paid. Factor price equalization seems neither the right hypothesis to test nor the appropriate analytical workhorse with which to understand international-trade related issues for large cross-sections of countries.

The FPE condition does hold for the OECD. This stands in contrast with recent work by Davis and Weinstein (1998), who argue that the pattern of the nect factor content of trade can be best understood by assuming that rich countries are each completely specialized. Our results suggest that it is worth exploring whether departures from other assumptions of the Heckscher-Ohlin model (e.g., technical differences) can reconcile theory and data.

The implementation of our empirical criterion can be extended in several directions, and therefore invites future work on this subject. First, relating our work to part of the empirical literature on the FPE hypothesis requires checking the FPE condition in the many-factor case. Second, it might be the case that OECD countries are indeed not in the same diversification cone: the Heckscher-Ohlin-Ricardo model, which we do not consider in our empirical exercise, imposes further constraints on the FPE set, making FPE less likely. (This case, however, brings us back to the use of different technologies across countries.)

Third and perhaps most importantly, given the lack of an alternative hypothesis, in this paper we have simply assessed whether the FPE condition holds for some groups of countries. This is a first approximation to a more important question, namely finding out how many cones the world has and which countries belong together in the same cone.

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8 Appendix I: Proofs of Lemmas 1 and 2

This appendix presents the proofs of the lemmas discussed in the paper[29].

8.1 Lemma 1

Let us characterize the set $FPE(2)$:

$$FPE(2) = \left\{ (V^{J_1}, V^{J_2}) \mid \exists \delta_z^{J_i} \geq 0, \sum_{i=1,2} \delta_z^{J_i} = 1, \forall z \in Z, \delta_z^{J_i} = \right.$$
$$\left. = \frac{\omega V^{J_i}}{\omega V}, \forall z \in Z_n, \ s.t. \, V^{J_i} = \sum_{z \in Z} \delta_z^{J_i} V_z, \forall i = 1,2 \right\}. \quad (20)$$

Let us construct $\delta_z^{J_i}$ as $\delta_z^{J_i} = \sum_{j \in J_i} \lambda_z^j$, $i = 1,2$, where the parameters λ_z^j are such that $(V^1, V^2, ..., V^J) \in FPE(J)$. We are left with checking whether the parameters $\delta_z^{J_i}$ so defined satisfy the constraints of the set characterized in Equation (20):

i.

$\delta_z^{J_i} \geq 0 \ \forall z \in Z$, since $\lambda_z^j \geq 0 \ \forall z \in Z$.

ii.

$\sum_{i=1,2} \delta_z^{J_i} = \sum_{j \in J_1} \lambda_z^j + \sum_{j \in J_2} \lambda_z^j = \sum_{j \in J} \lambda_z^j = 1 \ \forall z \in Z$.

iii.

$\delta_z^{J_i} = \sum_{j \in J_i} \frac{\omega V^j}{\omega V} = \frac{\omega V^{J_i}}{\omega V} \ \forall z \in Z_n$.

iv.

$\sum_{z \in Z} \delta_z^{J_i} V_z = \sum_{z \in Z} \sum_{j \in J_i} \lambda_z^j V_z = \sum_{j \in J_i} \sum_{z \in Z} \lambda_z^j V_z =$
$= \sum_{j \in J_i} V^j = V^{J_i} \ \forall i = 1,2$.

Therefore $(V^{J_1}; V^{J_2}) \in FPE(2)$.

[29] Although we constrain ourselves to the Heckscher-Ohlin model and its Chamberlin-Heckscher-Ohlin generalization, the proofs can be extended to the Heckscher-Ohlin-Ricardo model.

8.2 Lemma 2

Let us rank countries from most to least capital-labor abundant. That is, country 1 has the largest capital-labor ratio, then country 2, and so forth. Let us consider the partition of the set J with factor endowments $(V^{J_{1j}}, V^{J_{2j}})$, where $V^{J_{1j}} = \sum_{h=1}^{j} V^h$, $V^{J_{2j}} = \sum_{h=j+1}^{J} V^h$, $j = 1, ..., J-1$. For future reference, notice that $V^{J_{1j}} - V^{J_{1j-1}} = V^j \ \forall j \in \{2, ..., J\}$. Assume $Z_n = \emptyset$.

As j increases $V^{J_{1j}}$ becomes larger in terms of both capital and labor. Also, while remaining the capital-abundant group of countries, the aggregate capital-labor ratio of J_{1j} decreases with j. Meanwhile, $V^{J_{2j}}$ becomes smaller in terms of both factors, and J_{2j} becomes more labor-abundant with j. This implies that if $(V^{J_{1j}}, V^{J_{2j}}) \in FPE(2) \ \forall j \in \{1, ..., J-1\}$, we can always find a sequence $\{\delta^{J_{ij}}\}_{j=1}^{J-1}$, $i = 1, 2$, for which $(V^{J_{1j}}, V^{J_{2j}}) \in FPE(2) \ \forall j \in \{1, ..., J-1\}$, such that $\delta_z^{J_{1j}} \geq \delta_z^{J_{1j-1}} \ \forall z \in Z$ and $\forall j \in \{2, ..., J-1\}$.

Let us have a look at Figure 3 to understand the previous paragraph. Vector $V^{J_{1j-1}}$ corresponds to the factor endowment of the capital-abundant group of countries resulting in iteration $j-1$. If FPE(2) holds, vector $V^{J_{1j-1}}$ can be obtained as a linear combination of the factor-use vectors V_1, V_2 and V_3 : $V^{J_{1j-1}} = \delta_1^{J_{1j-1}} V_1 + \delta_2^{J_{1j-1}} V_2 + \delta_3^{J_{1j-1}} V_3$, where $0 \leq \delta_z^{J_{1j-1}} \leq 1$. Linear combinations are represented in Figure 3 by the dashed thick lines. Given that FPE(2) holds by assumption and given the way we have defined the subsequent partitions, we know that vector $V^{J_{1j}}$ is within the FPE set, and that its extreme is in the area delimited by the dashed thin lines: it is apparent that $V^{J_{1j}}$ can be obtained as a linear combination of the factor-use vectors V_1, V_2 and V_3, with $\delta_z^{J_{1j}} \geq \delta_z^{J_{1j-1}} \ \forall z$.

We make use of the sequence $\{\delta^{J_{1j}}\}_{j=1}^{J-1}$ to construct the following parameters λ_z^j: $\lambda_z^1 = \delta_z^{J_{11}}$, $\lambda_z^j = \delta_z^{J_{1j}} - \delta_z^{J_{1j-1}} \ \forall j \in \{2, ..., J-1\}$, and $\lambda_z^J = 1 - \delta_z^{J_{1J-1}}$. We now check whether these λ_z^j are such that $(V^1, V^2, ..., V^J) \in FPE(J)$:

i.

$\lambda_z^1 \geq 0 \ \forall z \in Z$, since $\delta_z^{J_{11}} \geq 0 \ \forall z \in Z$.

$\lambda_z^j = \delta_z^{J_{1j}} - \delta_z^{J_{1j-1}} \geq 0 \ \forall z \in Z$, $\forall j \in \{2, ..., J-1\}$, since $\delta_z^{J_{1j}} \geq \delta_z^{J_{1j-1}}$ $\forall z \in Z$.

$\lambda_z^J = 1 - \delta_z^{J_{1J-1}} \geq 0 \ \forall z \in Z$, since $0 \leq \delta_z^{J_{1J-1}} \leq 1 \ \forall z \in Z$.

ii.
$\sum_{j=1}^{J} \lambda_z^j = \delta_z^{J_{11}} + \left(\delta_z^{J_{12}} - \delta_z^{J_{11}}\right) + \left(\delta_z^{J_{13}} - \delta_z^{J_{12}}\right) + \ldots + \left(\delta_z^{J_{1J-1}} - \delta_z^{J_{1J-2}}\right) +$
$+ \left(1 - \delta_z^{J_{1J-1}}\right) = 1 \; \forall z \in Z.$

iii.
$\sum_{z \in Z} \lambda_z^1 V_z = \sum_{z \in Z} \delta_z^{J_{11}} V_z = V^1.$
$\sum_{z \in Z} \lambda_z^j V_z = \sum_{z \in Z} \left(\delta_z^{J_{1j}} - \delta_z^{J_{1j-1}}\right) V_z = V^{J_{1j}} - V^{J_{1j-1}} = V^j$
$\forall j \in \{2, \ldots, J-1\}.$
$\sum_{z \in Z} \lambda_z^J V_z = \sum_{z \in Z} \left(1 - \delta_z^{J_{1J-1}}\right) V_z = V - V^{J_{1J-1}} = V^J.$
Therefore $(V^1, V^2, \ldots, V^J) \in FPE(J)$.

9 Appendix II: The FPE Condition in the Two-Country Case

How can we characterize the FPE condition in the two-country case? The strategy we pursue consists in fixing country 1's labor endowment l^1 and finding what range of values of k^1 is compatible with the pair (k^1, l^1) being in the FPE set, given k and l. Figure 2 displays the upper and lower bounds for k^1, given l^1. Recall that the upper bound for k^1 is the amount of capital that the diversification cone allocates to the most capital-intensive sectors employing labor up to l^1. The lower bound can be interpreted symmetrically.

Let us start with country 1's market-clearing condition for capital:

$$k^1 = \sum_{z \in Z} k_z^1 = \sum_{z \in Z} \frac{k_z^1}{l_z^1} l_z^1. \tag{21}$$

An economy in the FPE set uses the same capital-labor intensities of the diversification cone, given that both face the same factor prices. Thus, plugging Equation (4) into Equation (21),

$$k_{FPE}^1 = \frac{\beta}{\alpha} \frac{k}{l} \sum_{z \in Z} \frac{\alpha_z}{\beta_z} l_z^1.$$

Assume, as we do in Section 4, that Z can be partitioned into two sets, $Z_t = \{1, ..., t\}$ and $Z_n = \{n\}$, where Z_n is the nontraded sector. To find the upper bound of k^1_{FPE}, let us define good t_k as follows:

$$l^1 = \frac{1}{\beta}\left(\frac{y^1}{y}s_n\beta_n + \sum_{z\in Z_{t_k}} s_z\beta_z\right)l,$$

where $Z_{t_k} \subseteq Z_t$ is the subset of most capital-intensive goods: $Z_{t_k} = \{1, ..., t_k\}$, $t_k \leq t$. Notice from Equation (3) that $l^1 \leq l$ equals the amount of labor needed to produce all of the diversification cone's most capital-intensive traded goods and the nontraded goods demanded by country 1 (under the assumption of homothetic preferences and balanced trade). Given l^1, the largest k^1 such that FPE holds is the one that enables country 1 to produce precisely those goods. Let country 1 assign its labor endowment accordingly: for n, $l^1_n = \frac{y^1}{y}l_n$; for $z \in Z_{t_k}$, $l^1_z = l_z$; and for $z \notin Z_{t_k}$, $l^1_z = 0$. Then

$$k^1_{FPE} \leq \frac{1}{\alpha}\frac{k}{l}\frac{l^1}{\mu^1}\left(\frac{y^1}{y}s_n\alpha_n + \sum_{z\in Z_{t_k}} s_z\alpha_z\right),$$

where $\mu^1 = l^1/l$. Full employment of labor is achieved[30], given the way we fixed t_k.

A symmetric argument can be made to find the lower bound of k^1_{FPE}, yielding

[30] For presentation purposes we ignore the more likely case that

$$l^1 = \frac{\frac{y^1}{y}s_n\beta_n + \sum_{z\in Z_{t_k-1}} s_z\beta_z + \pi_{t_k}s_{t_k}\beta_{t_k}}{\beta}l,$$

where $0 < \pi_{t_k} < 1$. In this case the corresponding constraint on k^1_{FPE} is

$$k^1_{FPE} \leq \frac{1}{\alpha}\frac{k}{l}\frac{l^1}{\mu^1}\left[\frac{y^1}{y}s_n\alpha_n + \sum_{z\in Z_{t_k-1}} s_z\alpha_z + \pi_{t_k}s_{t_k}\alpha_{t_k}\right].$$

$$k_{FPE}^1 \geq \frac{1}{\alpha}\frac{k}{l}\frac{l^1}{\mu^1}\left(\frac{y^1}{y}s_n\alpha_n + \sum_{z\in Z_{t_l}} s_z\alpha_z\right),$$

where $Z_{t_l} \subseteq Z_t$ is the subset of most labor-intensive goods, $Z_{t_l} = \{t_l, ..., t\}$, $t_l \geq 1$, determined by

$$l^1 = \frac{1}{\beta}\left(\frac{y^1}{y}s_n\beta_n + \sum_{z\in Z_{t_l}} s_z\beta_z\right) l.$$

Putting the two constraints together and rearranging:

$$\frac{\frac{y^1}{y}s_n\alpha_n + \sum_{z\in Z_{t_l}} s_z\alpha_z}{\frac{y^1}{y}s_n\beta_n + \sum_{z\in Z_{t_l}} s_z\beta_z}\frac{\beta}{\alpha}\frac{k}{l} \leq \left(\frac{k^1}{l^1}\right)_{FPE} \leq \frac{\frac{y^1}{y}s_n\alpha_n + \sum_{z\in Z_{t_k}} s_z\alpha_z}{\frac{y^1}{y}s_n\beta_n + \sum_{z\in Z_{t_k}} s_z\beta_z}\frac{\beta}{\alpha}\frac{k}{l}.$$

10 Appendix III: Factor Price Equalization in the Many-Country, Many-Factor Case

Deardorff (1994) generalizes the FPE condition to the many-country, many-factor case. Let us start with the many-country, two-factor case. His argument is summarized in Figure 4, which shows two 'lenses' in Deardorff's terminology. The so-called country-endowment lens is constructed by ordering the vectors defined by the capital-labor endowments of countries from more to less capital-abundant. In Figure 4 we assume there are four countries in the world. The second lens, the factor-use lens, is constructed with the vectors reflecting the sectoral factor-use in the integrated equilibrium from more to less capital-intensive. Deardorff proves that a necessary and sufficient condition for FPE is that the first lens fall within the second one. The example in Figure 4 is a case in which FPE cannot take place.

F-dimensional lenses are obviously harder to depict in two dimensions. However, Deardorff (1994) proves that "...for one (F-dimensional) lens to be inside another it must also be true that the projections of the first lens (the country-endowment lens) onto any plane must also be inside the projection of the second (the factor-use lens) onto the same plane." In other words, pick any pair of factors: a necessary condition for FPE is that the corresponding country-endowment lens fall within the corresponding factor-use lens[31]. Notice that we can check this condition with the procedure discussed in Section 2.

The essence of the F-factor case is captured by a three-factor example. Consider the integrated economy of Section 2, but assume that x_z is produced with three production factors, capital k, unskilled workers l and skilled workers[32] h. Define $\alpha_z \equiv \frac{rk_z}{p_z x_z}$, $\beta_z \equiv \frac{w_l l_z}{p_z x_z}$, $\gamma_z \equiv \frac{w_h h_z}{p_z x_z}$ as the corresponding income shares of the factors allocated to sector z, where $\alpha_z + \beta_z + \gamma_z = 1$. Denote the corresponding shares in aggregate value added with α, β and γ.

Following the same steps as above, the integrated equilibrium's resource allocation can be shown to be $k_z = \frac{s_z \alpha_z}{\alpha} k$, $l_z = \frac{s_z \beta_z}{\beta} l$, and $h_z = \frac{s_z \gamma_z}{\gamma} h$. To obtain the two-factor lenses, we rank goods according to the sectoral relative intensities of the factors in the plane considered. Then we can apply the condition we obtained in the two-factor case to each pair of factors.

Let us consider the capital-unskilled labor plane, and rank goods according to their capital-unskilled labor intensities: the higher z, the lower k_z/l_z, where $\frac{k_z}{l_z} = \frac{\alpha_z}{\beta_z}\frac{\beta}{\alpha}\frac{k}{l}$. The condition for FPE in this plane is identical to Equations (5) and (6). Similar conditions are obtained for the two other planes.

[31]Demiroglu and Yun (1999) show that sufficiency does not hold generally in the many-factor case.

[32]Skills are no longer an efficiency-augmenting coefficient, but an entirely different factor.

FIGURE 1: THE INTEGRATED ECONOMY

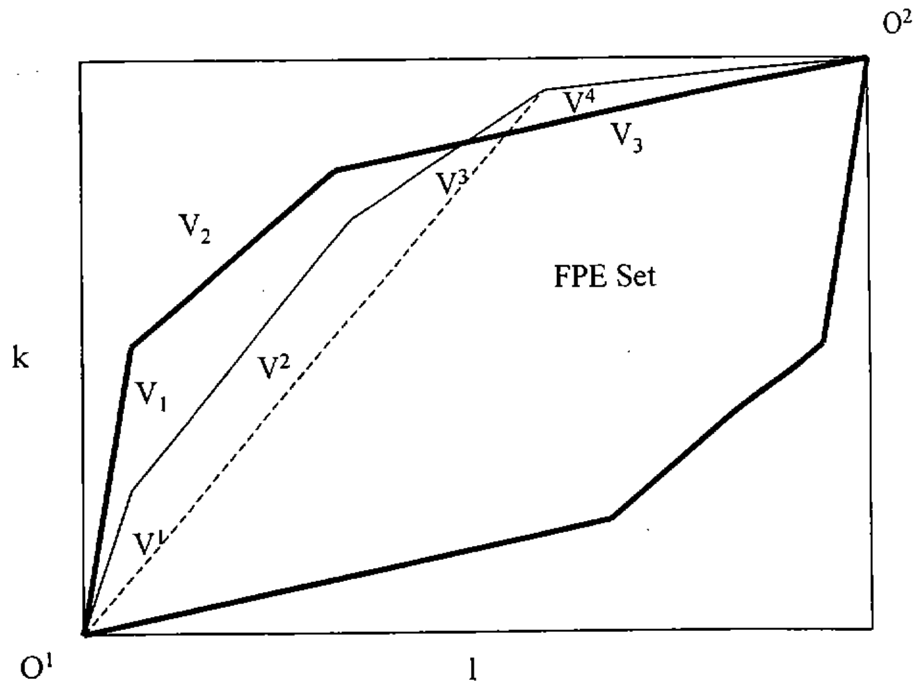

FIGURE 2: A QUANTITATIVE CRITERION FOR FPE

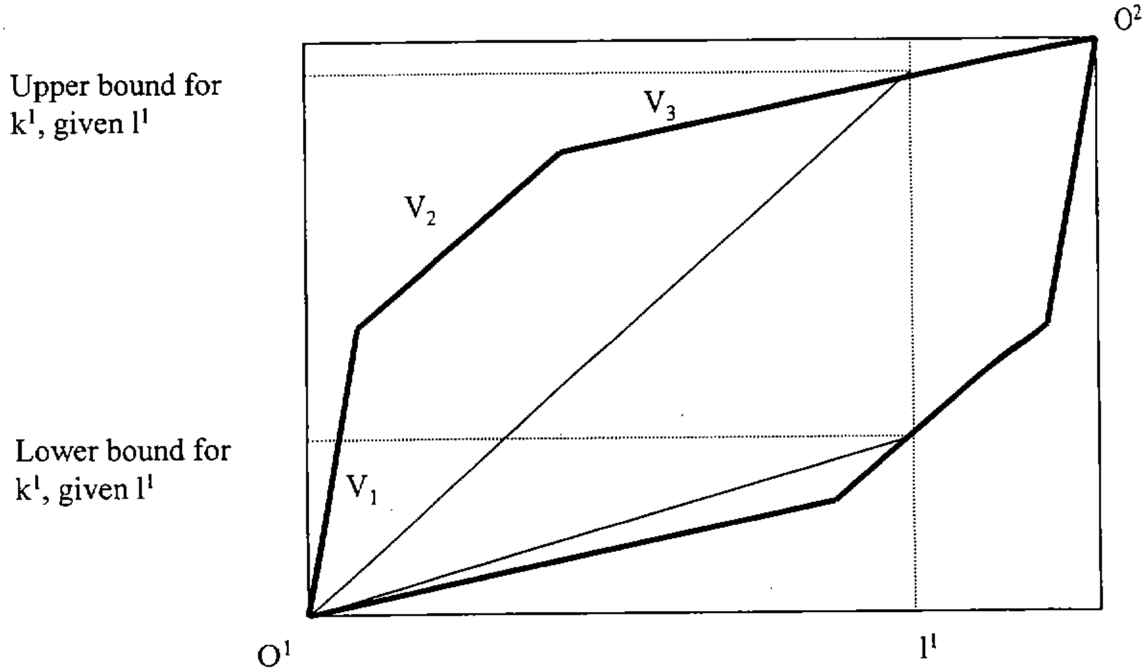

FIGURE 3: LEMMA 2

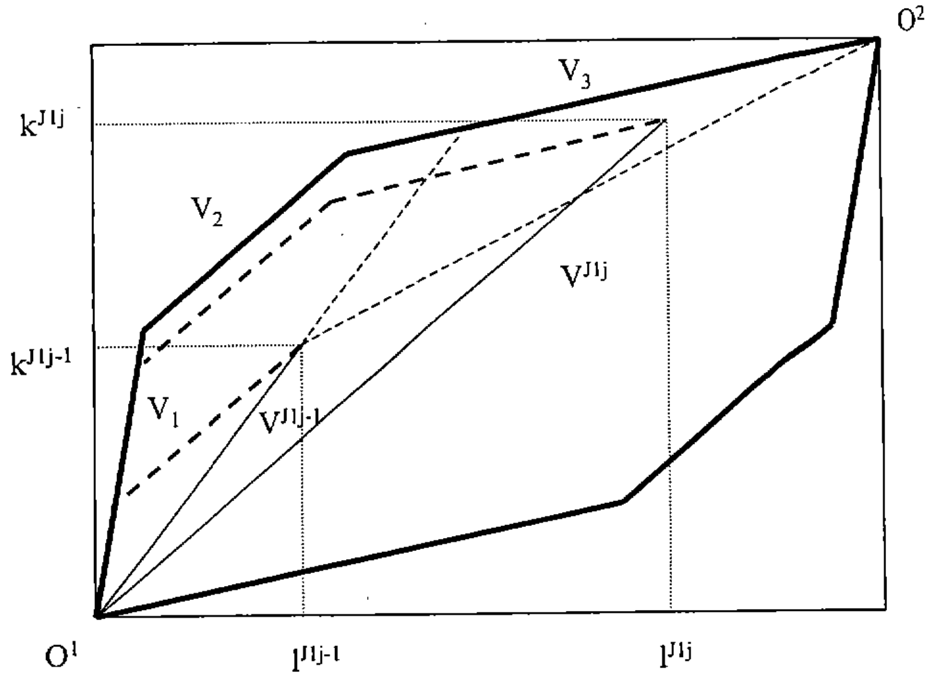

FIGURE 4: DEARDORFF'S LENSES

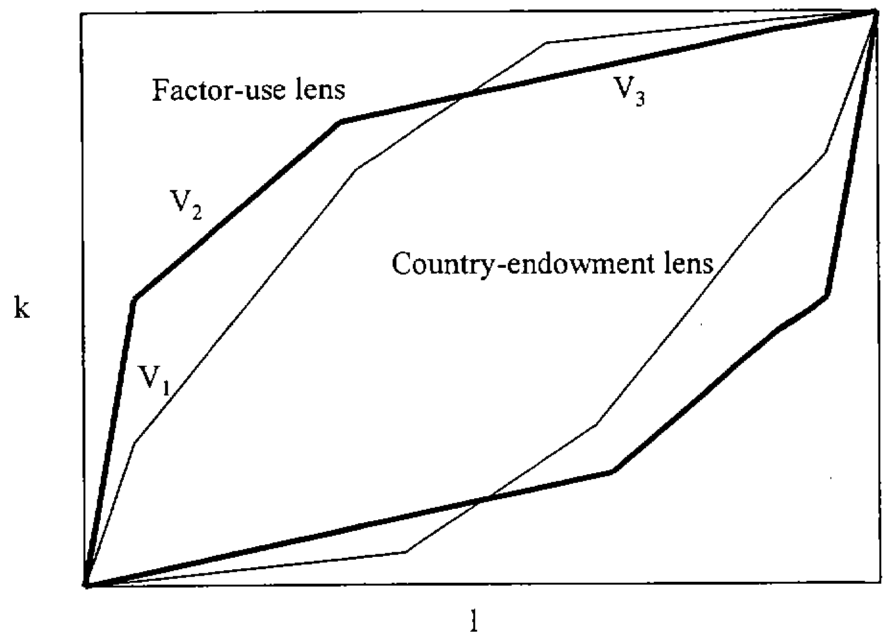

FIGURE 5: THE WORLD DIVERSIFICATION CONE

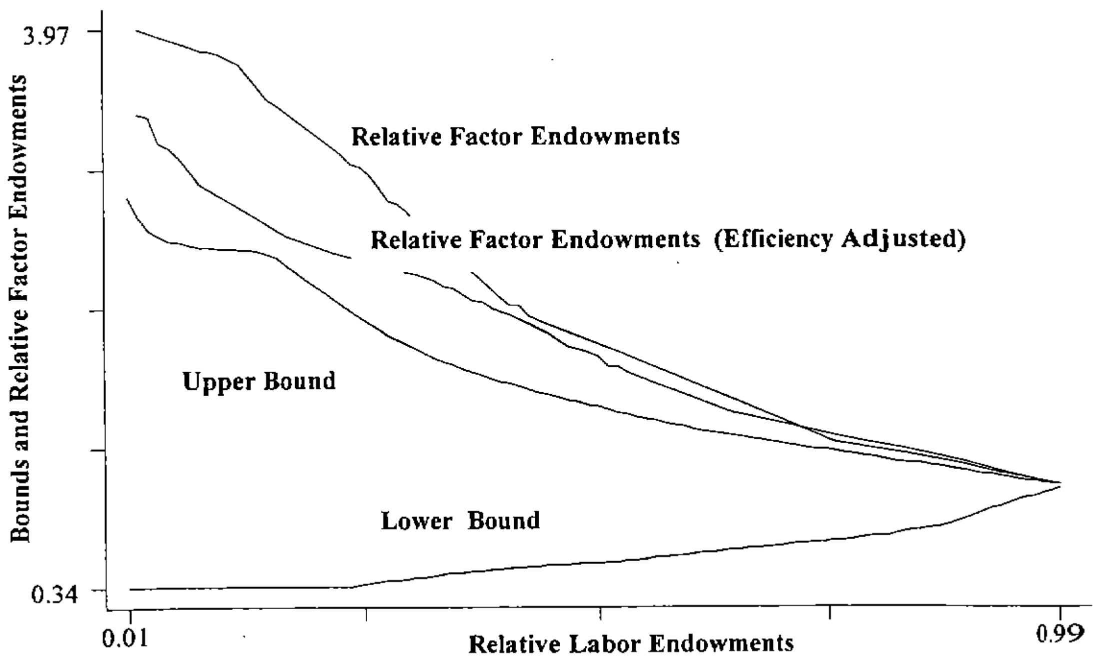

FIGURE 6: THE WORLD DIVERSIFICATION CONE
(BOUNDS WITH DIFFERENT LEVELS OF DISAGGREGATION)

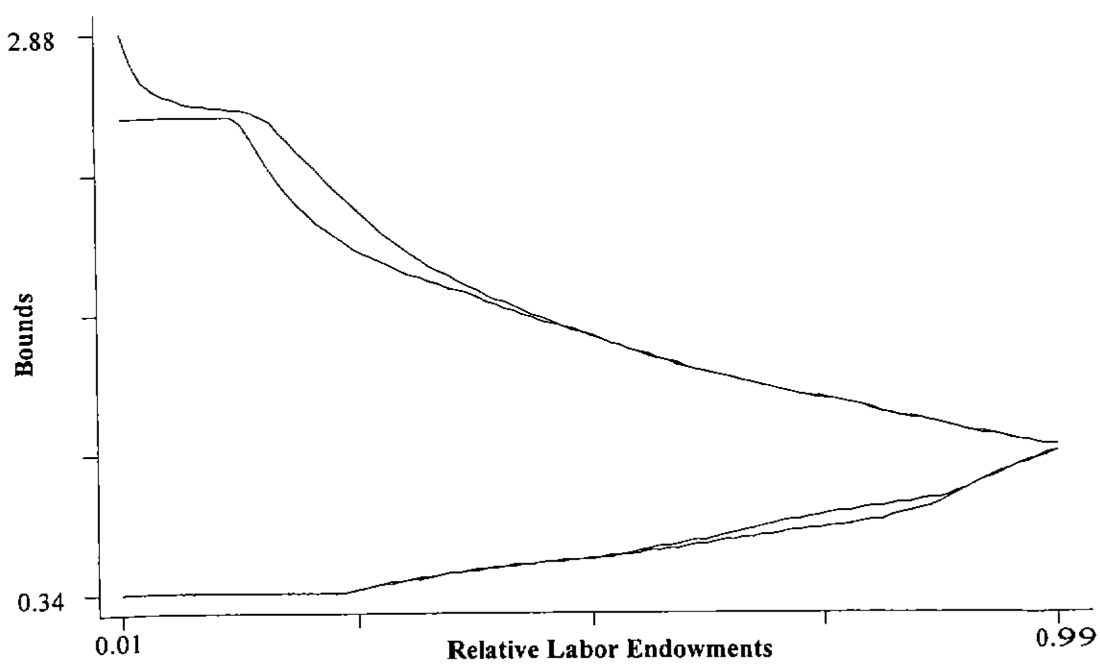

FIGURE 7: THE WORLD DIVERSIFICATION CONE
(NONTRADED GOODS; g = 0.5)

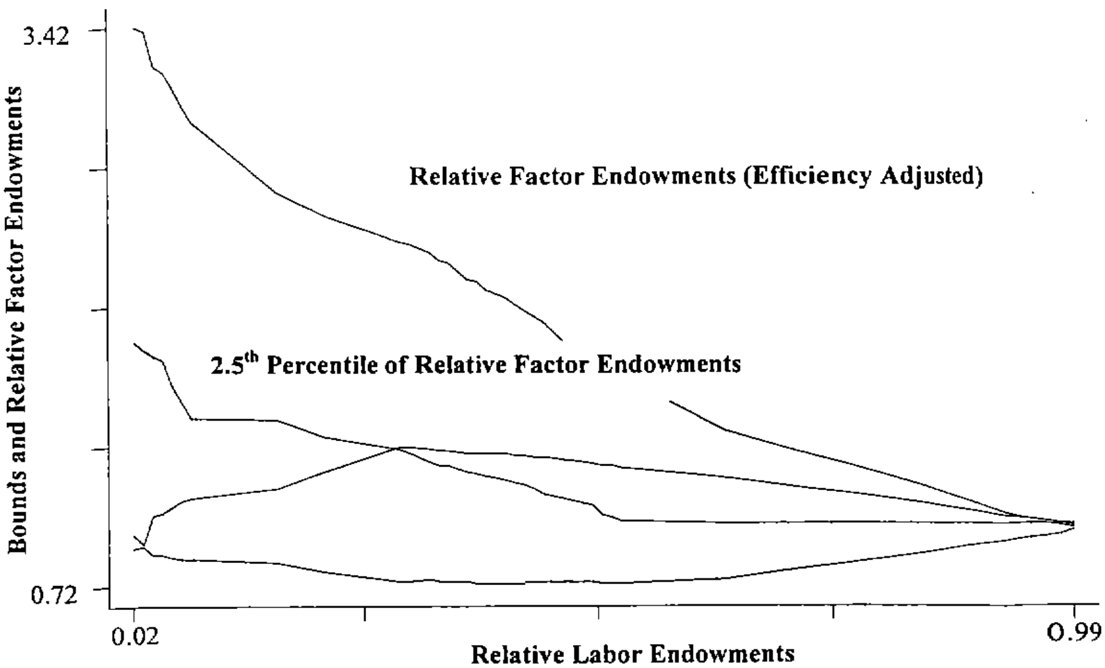

FIGURE 8: THE OECD DIVERSIFICATION CONE

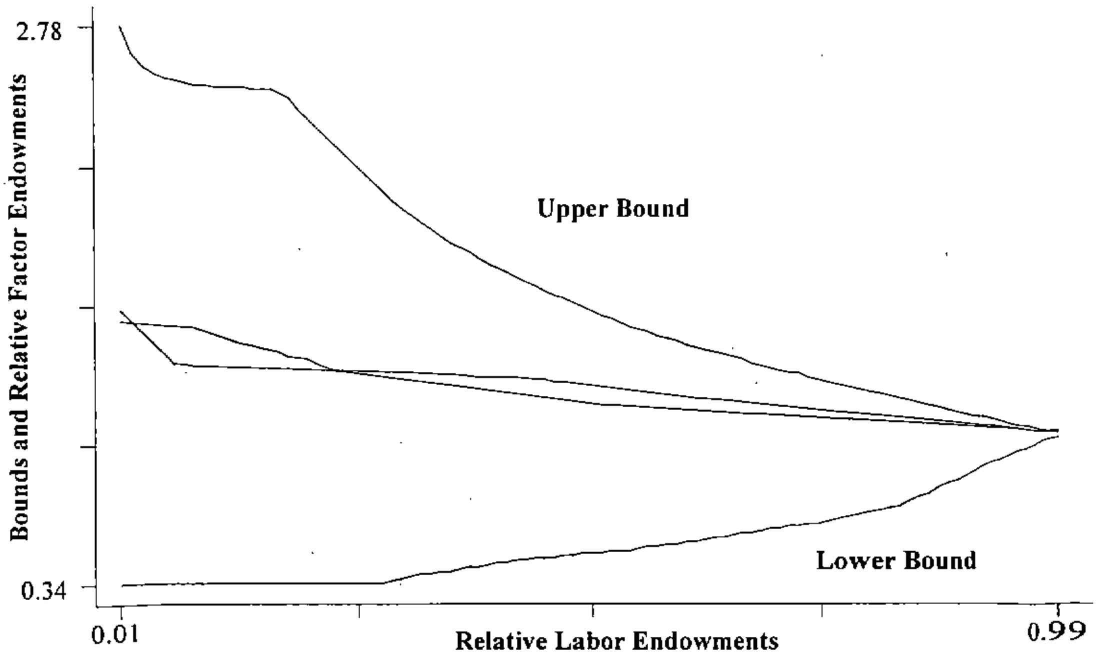

FIGURE 9: THE OECD DIVERSIFICATION CONE
(NONTRADED GOODS; g = 0.85)

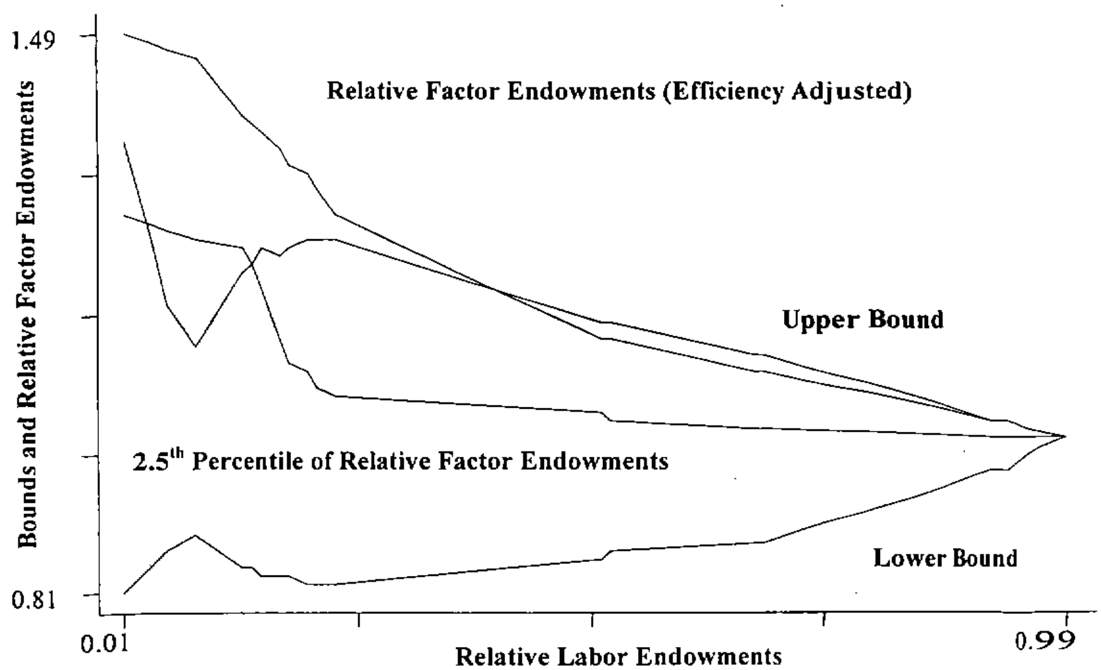

TABLE 1: DISAGGREGATION

Code*	Sector
100	Agriculture, fishing, hunting and forestry
200	Mining and quarrying
311	Food products
313	Beverages
314	Tobacco
321	Textiles
322	Wearing apparel, except footwear
323	Leather products
324	Footwear, except rubber or plastic
331	Wood products, except furniture
332	Furniture, except metal
341	Paper and products
342	Printing and publishing
351	Industrial chemicals
352	Other chemicals
353	Petroleum refineries
355	Rubber products
356	Plastic products
361	Pottery, china, earthenware
362	Glass and products
369	Other non-metallic mineral products
371	Iron and steel
372	Non-ferrous metals
381	Fabricated metal products
382	Machinery, except electrical
383	Machinery electric
384	Transport equipment
385	Professional and scientific equipment
390	Other manufactured products
400	Electricity, gas and water
500	Construction
600	Trade, restaurants and hotels
700	Transport, storage and communication
800	Financing, insurance, real state and business services
900	Community, social and personal services

* Sectors 353 and 900 include sectors 354 (Misc. petroleum and coal) and 1000 (Government services), respectively.

TABLE 2: SAMPLE OF COUNTRIES

Country		
Angola[1]	Guyana[1]	Peru[1,3]
Argentina[1,3]	Haiti[1]	Philippines[1,3]
Australia[1,3]	Honduras[1,3]	Poland[1,3]
Austria[1,3]	Hong-Kong[1,3]	Portugal[1,3]
Bangladesh[1,3]	Hungary[1,3]	Puerto Rico[1]
Barbados[1,3]	Iceland[1,3]	Reunion[1]
Belgium[1,3]	India[1,3]	Romania[1,3]
Benin[1]	Indonesia[1,3]	Rwanda[1]
Bolivia[1,3]	Iran[1,3]	Saudi Arabia[1]
Botswana[1]	Ireland[1,3]	Senegal[1]
Brazil[1]	Israel[1,3]	Seychelles[1]
Burundi[1,3]	Italy[1,3]	Sierra Leone[1]
Cameroon[1]	Jamaica[1]	Singapore[1,3]
Canada[1,3]	Japan[1,3]	Somalia[1]
Cape Verde[1]	Jordan[1,3]	South Africa[1,3]
Central African. Rep.[1,3]	Kenya[1,3]	Spain[1,3]
Chile[1,3]	Korea[1,3]	Sri Lanka[1,3]
China[1,3]	Lesotho[1]	Suriname[1]
Colombia[1,3]	Luxembourg[1]	Swaziland[1]
Congo[1]	Malawi[1]	Sweden[1,3]
Costa Rica[1,3]	Malaysia[1,3]	Switzerland[1]
Cote d'Ivoire[1]	Mali[1]	Syria[1]
Cyprus[1,3]	Malta[1,3]	Taiwan[1,3]
Denmark[1,3]	Mauritania[1]	Tanzania[1]
Dominican Rep.[1]	Mauritius[1,3]	Thailand[1,3]
Ecuador[1,3]	Mexico[1,3]	Trinidad-Tobago[1]
Egypt[1,3]	Morocco[1]	Tunisia[1]
El Salvador[1]	Myanmar[1]	Turkey[1,3]
Fiji[1,3]	Namibia[1]	Uganda[1]
Finland[1,3]	Netherlands[1,3]	U. Kingdom[1,3]
France[1,3]	New Zealand[1,3]	United States[1,3]
Gabon[1]	Niger[1]	U.S.S.R.
Gambia[1]	Nigeria[1]	Uruguay[1,3]
W. Germany[1,3]	Norway[1,3]	Venezuela[1,3]
Ghana[1]	Oman[1]	Zambia[1]
Greece[1,3]	Pakistan[1,3]	Zimbabwe[1,3]
Guatemala[1,3]	Panama[1,3]	
Guinea[1]	Papua New Guinea[1,3]	
Guinea-Bissau[1]	Paraguay[1]	

1 indicates availability of data on value added by sector at the one-digit level of disaggregation.
3 indicates availability of data on value added by sector in manufacturing at the three-digit level of disaggregation.

TABLE 3: FACTOR ENDOWMENTS

Rank(1)	Rank(2)	Country	Capital	Employment	Human Capital per Worker	Capital per Worker	Capital per Effective Worker
1	2	Switzerland	0.0337	0.0272	0.8320	1.2374	1.4872
2	1	Luxembourg	0.0016	0.0013	0.8050	1.2338	1.5327
3	8	Norway	0.0190	0.0175	0.9090	1.0871	1.1959
4	5	W. Germany	0.2402	0.2347	0.8020	1.0234	1.2761
5	7	Finland	0.0214	0.0210	0.8550	1.0228	1.1963
6	12	Australia	0.0654	0.0647	0.9000	1.0115	1.1239
7	15	U.S.A.	1.0000	1.0000	1.0000	1.0000	1.0000
8	3	France	0.2051	0.2104	0.6660	0.9747	1.4635
9	14	Canada	0.1012	0.1073	0.9080	0.9435	1.0391
10	4	Italy	0.1803	0.1912	0.6500	0.9431	1.4509
11	11	Netherlands	0.0458	0.0503	0.8030	0.9111	1.1346
12	21	N. Zealand	0.0110	0.0123	1.0170	0.8972	0.8822
13	13	Belgium	0.0299	0.0340	0.8360	0.8782	1.0505
14	17	Sweden	0.0300	0.0359	0.8530	0.8348	0.9787
15	6	Austria	0.0244	0.0297	0.6740	0.8236	1.2220
16	20	Denmark	0.0190	0.0234	0.9050	0.8104	0.8954
17	16	Iceland	0.0008	0.0011	0.7640	0.7627	0.9983
18	19	Japan	0.4704	0.6393	0.7970	0.7359	0.9233
19	10	Spain	0.0818	0.1157	0.6050	0.7068	1.1683
20	9	Singapore	0.0066	0.0103	0.5450	0.6441	1.1818
21	24	Ireland	0.0071	0.0112	0.7730	0.6378	0.8251
22	23	U.S.S.R.	0.7559	1.1963	0.7240	0.6319	0.8728
23	29	Israel	0.0084	0.0142	0.8510	0.5923	0.6960
24	28	U. Kingdom	0.1342	0.2322	0.8080	0.5780	0.7154
25	18	Oman	0.0018	0.0033	0.5650	0.5423	0.9598
26	27	Greece	0.0155	0.0316	0.6800	0.4908	0.7218
27	25	Venezuela	0.0254	0.0524	0.5930	0.4851	0.8180
28	22	Pto. Rico	0.0046	0.0095	0.5500	0.4846	0.8812
29	30	Trin.-Tob.	0.0018	0.0039	0.6640	0.4551	0.6854
30	26	S. Arabia	0.0146	0.0340	0.5600	0.4308	0.7693
31	37	Cyprus	0.0011	0.0026	0.7080	0.4236	0.5983
32	38	Argentina	0.0352	0.0921	0.6760	0.3818	0.5649
33	47	Hungary	0.0164	0.0431	0.9320	0.3794	0.4071
34	40	Malta	0.0004	0.0010	0.6920	0.3773	0.5452
35	45	Poland	0.0581	0.1609	0.7950	0.3611	0.4542
36	31	Portugal	0.0129	0.0382	0.5040	0.3380	0.6706
37	44	Hong-Kong	0.0101	0.0302	0.7350	0.3339	0.4543
38	35	Mexico	0.0719	0.2204	0.5380	0.3261	0.6061
39	33	Namibia	0.0010	0.0034	0.4770	0.3050	0.6394
40	46	Taiwan	0.0215	0.0715	0.6990	0.3008	0.4304
41	39	Syria	0.0066	0.0231	0.5150	0.2873	0.5579
42	36	Iran	0.0359	0.1265	0.4690	0.2840	0.6055

43	53	Korea	0.0407	0.1433	0.7610	0.2837	0.3728
44	43	Malaysia	0.0153	0.0566	0.5920	0.2698	0.4557
45	49	Uruguay	0.0026	0.0098	0.6610	0.2669	0.4038
46	32	Gabon	0.0011	0.0041	0.4080	0.2668	0.6538
47	52	Chile	0.0099	0.0381	0.6610	0.2603	0.3938
48	42	Jordan	0.0014	0.0056	0.5320	0.2550	0.4794
49	41	Brazil	0.1058	0.4354	0.4820	0.2430	0.5042
50	34	Suriname	0.0003	0.0012	0.4000	0.2430	0.6076
51	50	Ecuador	0.0061	0.0253	0.6050	0.2428	0.4014
52	56	Fiji	0.0005	0.0020	0.6820	0.2315	0.3394
53	48	S. Africa	0.0233	0.1009	0.5680	0.2310	0.4068
54	54	Panama	0.0015	0.0068	0.6510	0.2266	0.3481
55	61	Barbados	0.0002	0.0011	0.7330	0.2154	0.2938
56	57	Peru	0.0113	0.0543	0.6180	0.2081	0.3368
57	59	Costa Rica	0.0016	0.0082	0.5900	0.1912	0.3241
58	51	Turkey	0.0360	0.1929	0.4690	0.1866	0.3979
59	58	Colombia	0.0148	0.0836	0.5440	0.1776	0.3264
60	63	Guyana	0.0004	0.0024	0.5770	0.1645	0.2851
61	60	Reunion	0.0003	0.0019	0.5100	0.1628	0.3193
62	64	Jamaica	0.0014	0.0093	0.5240	0.1466	0.2798
63	55	Seychelles	0.0000	0.0002	0.4070	0.1404	0.3449
64	65	Domin. Rep.	0.0024	0.0174	0.5250	0.1400	0.2667
65	62	Tunisia	0.0026	0.0207	0.4210	0.1235	0.2934
66	69	Romania	0.0115	0.0946	0.6080	0.1214	0.1997
67	66	Botswana	0.0004	0.0033	0.4960	0.1133	0.2285
68	68	Paraguay	0.0012	0.0111	0.5540	0.1111	0.2005
69	70	Bolivia	0.0018	0.0176	0.5310	0.1049	0.1976
70	74	Mauritius	0.0005	0.0050	0.5480	0.0996	0.1818
71	71	Swaziland	0.0002	0.0025	0.5000	0.0934	0.1868
72	72	Indonesia	0.0512	0.5525	0.4990	0.0927	0.1859
73	78	Philippines	0.0164	0.1783	0.6630	0.0921	0.1389
74	67	Guatemala	0.0018	0.0205	0.4270	0.0889	0.2082
75	76	Thailand	0.0203	0.2370	0.5750	0.0857	0.1491
76	75	Cape Verde	0.0001	0.0011	0.4720	0.0753	0.1595
77	79	Zambia	0.0015	0.0208	0.5350	0.0737	0.1377
78	77	Honduras	0.0009	0.0121	0.4860	0.0709	0.1460
79	81	Morocco	0.0044	0.0619	0.5750	0.0707	0.1230
80	73	P.N.Guinea	0.0010	0.0145	0.3770	0.0696	0.1845
81	86	Sri Lanka	0.0034	0.0501	0.5930	0.0678	0.1144
82	80	El Salvador	0.0009	0.0136	0.4870	0.0649	0.1332
83	82	Congo	0.0004	0.0080	0.4600	0.0548	0.1190
84	83	C. d'Ivoire	0.0019	0.0365	0.4470	0.0530	0.1185
85	85	Zimbabwe	0.0017	0.0337	0.4290	0.0494	0.1152
86	87	Mauritania	0.0003	0.0063	0.4230	0.0477	0.1127
87	92	China	0.2587	5.4330	0.6320	0.0476	0.0753
88	88	Pakistan	0.0114	0.2613	0.3900	0.0435	0.1115
89	90	India	0.1137	2.6228	0.4540	0.0433	0.0955
90	84	Nigeria	0.0139	0.3268	0.3670	0.0424	0.1156
91	94	Egypt	0.0044	0.1142	0.5760	0.0387	0.0672
92	91	Cameroon	0.0014	0.0403	0.4070	0.0357	0.0878
93	93	Kenya	0.0027	0.0840	0.4570	0.0315	0.0690
94	89	G.-Bissau	0.0001	0.0037	0.3250	0.0312	0.0961
95	96	Lesotho	0.0002	0.0066	0.4830	0.0290	0.0601

96	97	Somalia	0.0006	0.0278	0.4100	0.0217	0.0530
97	95	Benin	0.0004	0.0175	0.3320	0.0216	0.0650
98	98	Haiti	0.0004	0.0217	0.3750	0.0192	0.0511
99	99	Bangladesh	0.0046	0.2470	0.3930	0.0185	0.0471
100	102	Senegal	0.0004	0.0265	0.4160	0.0163	0.0393
101	101	Gambia	0.0000	0.0032	0.3380	0.0139	0.0410
102	107	Ghana	0.0007	0.0498	0.4650	0.0138	0.0297
103	100	Niger	0.0004	0.0293	0.3250	0.0135	0.0417
104	106	Malawi	0.0004	0.0284	0.4270	0.0135	0.0317
105	103	Tanzania	0.0012	0.0903	0.4100	0.0134	0.0327
106	104	Myanmar	0.0019	0.1478	0.3960	0.0128	0.0324
107	109	Guinea	0.0002	0.0210	0.4140	0.0114	0.0274
108	105	C.A.R.	0.0001	0.0115	0.3570	0.0113	0.0317
109	108	Mali	0.0003	0.0274	0.3370	0.0095	0.0281
110	110	Rwanda	0.0002	0.0268	0.3380	0.0083	0.0246
111	112	Angola	0.0003	0.0355	0.4570	0.0080	0.0174
112	111	Burundi	0.0002	0.0225	0.3950	0.0073	0.0184
113	113	S. Leone	0.0001	0.0120	0.3800	0.0053	0.0139
114	114	Uganda	0.0002	0.0592	0.3900	0.0042	0.0107

Data are normalized with respect to the U.S. Rank(1) and Rank(2) rank countries according to the variable Capital per Worker and Capital per Effective Worker, respectively.

TABLE 4: SECTORAL SHARES

Sector	Sectoral Shares in GDP (World)	Sectoral Shares in GDP (OECD)	Sectoral Capital Shares	Sectoral Labor Shares
100	0.0932	0.0275	0.1595	0.2900
200	0.0218	0.0174	0.2694	0.6300
311	0.0203	0.0197	0.4562	0.5438
313	0.0067	0.0046	0.4660	0.5340
314	0.0055	0.0027	0.6064	0.3936
321	0.0140	0.0075	0.3303	0.6697
322	0.0053	0.0045	0.3177	0.6823
323	0.0011	0.0006	0.3988	0.6012
324	0.0010	0.0009	0.3582	0.6418
331	0.0040	0.0041	0.3298	0.6702
332	0.0027	0.0032	0.3037	0.6963
341	0.0077	0.0083	0.4532	0.5468
342	0.0099	0.0125	0.4042	0.5958
351	0.0150	0.0130	0.5575	0.4425
352	0.0122	0.0122	0.5854	0.4146
353	0.0078	0.0053	0.6051	0.3949
355	0.0036	0.0028	0.4252	0.5748
356	0.0059	0.0063	0.4370	0.5630
361	0.0013	0.0011	0.4499	0.5501
362	0.0023	0.0021	0.4514	0.5486
369	0.0079	0.0061	0.4214	0.5786
371	0.0123	0.0093	0.3445	0.6555
372	0.0044	0.0039	0.3082	0.6918
381	0.0129	0.0144	0.3095	0.6905
382	0.0240	0.0257	0.3388	0.6612
383	0.0224	0.0236	0.3845	0.6155
384	0.0213	0.0243	0.3064	0.6936
385	0.0051	0.0065	0.3070	0.6930
390	0.0034	0.0029	0.3312	0.6688
400	0.0240	0.0291	0.4551	0.4000
500	0.0592	0.0611	0.3389	0.6611
600	0.1531	0.1562	0.2554	0.7446
700	0.0640	0.0646	0.2421	0.7579
800	0.1672	0.2076	0.5676	0.4324
900	0.1775	0.2088	0.1523	0.8477