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Abstract

This paper reports the results of a new test of the Leontiev-Trefler hypothesis that factor-augmenting international productivity differences explain most of the cross-country variation in factor prices. Our sample consists of four cross-sections of 16, 31, 51 and 50 countries for 1970, 1975, 1980 and 1985, respectively. Our test rejects the Leontiev-Trefler hypothesis, unless we restrict the sample to the European Union. While factor-augmenting productivity differences might be real and important, there is more in a cross-section of factor prices than them.

The failure of the Leontiev-Trefler hypothesis does not mean however that factor prices are related to domestic factor endowments. As a by-product of the test, we are able to estimate productivity-adjusted wage-rental ratios for a panel of countries. We find that, in closed economies, the cross-country variation in these wage-rental ratios can be explained in part by factor endowment variables. In open economies these factor endowment variables have no explanatory power however.

These findings suggest that we should develop models that: (1) feature the factor-price-insensitivity property emphasized by Leamer and Levinsohn (1995); but (2) allow for determinants of the cross-section of factor prices other than the productivity differences emphasized by Trefler (1993).

This paper reports the results of a new test of the Leontiev-Trefler hypothesis that factor-augmenting international productivity differences explain most of the cross-country variation in factor prices. Our sample consists of four cross-sections of 16, 31, 51 and 50 countries for 1970, 1975, 1980 and 1985, respectively. The test rejects the Leontiev-Trefler hypothesis, unless we restrict the sample to the European Union. While factor-augmenting productivity differences might be real and important, there is more in a cross-section of factor prices than them. The failure of the Leontiev-Trefler hypothesis does not mean however that factor prices are related to domestic factor endowments. As a by-product of the test, we are able to estimate productivity-adjusted wage-rental ratios for a panel of countries. We find that, in closed economies, the cross-country variation in these wage-rental ratios can be explained in part by factor endowment variables. In open economies these factor endowment variables have no explanatory power however. These findings suggest that we should develop models that: (1) Feature the factor-price-insensitivity property emphasized by Leamer and Levinsohn (1995); and (2) Allow for determinants of the cross-section of factor prices other than the productivity differences emphasized by Trefler (1993).

Existing evidence suggests that factor movements across countries are not large. Labor movements are notoriously restricted by existing immigration laws and net capital flows do not seem of large magnitude by any reasonable standard.[1] One might conclude from these facts that in a cross-section of countries, there should be a close relationship between factor prices and factor endowments. Yet this need not be the case. It was Paul Samuelson's (1948, 1949) brilliant insight that factor movements are not necessary for the equalization of factor prices across countries.[2] By specializing in labor (capital) intensive products, labor (capital) abundant countries are actually exporting labor (capital) embodied in their products. Samuelson noted and proved that an implication of this observation is that commodity trade should be sufficient to equalize factor prices across countries. Although initially developed within the factor proportions theory of trade, this insight has proven to hold also in many of the models of imperfect competition and increasing

[1]In a cross-section of countries there is an almost perfect correlation between GDP (what is produced with factors located within a country) and GNP (what is produced with factors that are owned by residents of a country).

[2]In his 1949 paper, Samuelson credits A.P. Lerner with an independent derivation of this result.

returns developed in the early 1980s (See Helpman and Krugman (1985)). Parallel to the discovery of how robust Samuelson's insight was in the theory, an overwhelming amount of evidence against factor price equalization was compiled. Fancy econometrics aside, wages in the U.S. are not the same as those in Mexico.

But then came the infuential paper of Trefler (1993). Following an earlier suggestion by Leontiev (1953), Daniel Trefler explored the hypothesis that the cross-section of factor prices can be explained by factor-augmenting international productivity differences. We refer to this possibility as the Leontiev-Trefler hypothesis. Its bottom line is: "Samuelson's insight is right, but existing studies are measuring factors incorrectly." If, for a given capital-labor ratio, the productivity of a US worker is twice that of a Mexican worker, we should multiply the US labor force by two when we compare US and Mexican labor forces. Also, we should expect US wages to be twice of Mexican wages. More generally, if we want to give a fair test to Samuelson's factor price equalization theorem, we have to correct measured factor prices by factor-augmenting productivity differences. This however seemed a daunting task. The sources of cross-country variation in productivities are potentially many, ranging from variation in educational achievements, laws and regulations, governmental provision of infrastructure, and so on. It was Trefler's important contribution to devise a method to compute productivity-adjusted factor prices and use them to provide very suggestive evidence in support of his hypothesis.

In this paper, we revisit the Leontiev-Trefler hypothesis and subject it to a formal econometric test that is carefully derived from the theory. Our testing strategy is based on the (evident) observation that this hypothesis imposes strong structure on the data. We show that this structure can be framed in terms of restrictions on the parameters of an econometric model. We test the validity of these restrictions in our sample and reject the Leontiev-Trefler hypothesis. This is true even if we restrict our test to the subset of open economies (as classified by Sachs and Warner (1985)). Only if we restrict our sample to the members of the European Union, the Leontiev-Trefler hypothesis is not rejected. An important feature of our test is that it does not require the use of productivity-adjusted factor prices, but only information on product prices and labor shares in costs. Measures of these variables are available for a relatively large panel of countries.

The failure of the Leontiev-Trefler hypothesis does not mean that factor prices are related to domestic factor endowments. As a by-product of our test we are able to estimate productivity-adjusted wage-rental ratios for a panel of countries. We examine the extent to which cross-country variation in these wage-rental ratios can be explained by factor abundance variables. The answer is surprisingly clear: In closed economies, factor endowment variables explain a fraction of the cross-country variation in factor prices. In open economies, factor endowment variables explain none of this variation. This evidence for open economies (which amounts to say that there are no diminishing returns at the country level) is consistent with the notion of factor-price-insensitivity that has been emphasized by Leamer and Levinsohn (1995). Yet the only formal models we have that exhibit this property are Samuelson's factor-price-equalization theorem and the Leontiev-Trefler modification of it, both of which are shown here to be inconsistent with existing data. This leads us to the main conclusion of the paper: We should develop models that feature the factor-price-insensitivity property, yet allow for determinants of the cross-section of factor prices other than factor-augmenting international productivity differences à la Leontiev-Trefler.

The paper is organized as follows: Section one reviews some related papers to put in perspective our contribution. Section two develops the theory. Section three explains the design of our tests, describes the data we use to implement them and finally presents the results. As a by-product of this test, we obtain some estimates of productivity-adjusted wage-rental ratios. Section four examines the extent to which these estimates are related to factor abundance variables.

1 Review of Related Research

This paper is related to the large literature that testing the implications of the factor proportions theory of trade for the international cross-sections of factor prices and commodity trade flows. The two main predictions of this theory are the Factor Price Equalization (FPE) and Heckscher-Ohlin-Vanek (HOV) theorems. To understand the structure of these theorems, we need some notation. Consider a set of countries that trade freely among themselves, $j = 1, ..., J$. There are I goods and F factors of production. Let A_j be the be the $F \times I$ matrix of factor input requirements of country j. We assume that $F \leq I$ and that all goods are traded. This matrix shows the total (direct plus indirect) amount of each of the F factors needed to produce one unit of output in each of I industries. We define T_j , Q_j and C_j as the $I \times 1$ vectors of net exports, production and consumption, respectively. Also, let V_j and w_j be the $F \times 1$ vectors of factor endowments and factor rentals. Since full-employment requires that $A_j \cdot Q_j = V_j$, it follows that $A_j \cdot T_j = V_j - A_j \cdot C_j$. Finally, define s_j as the income of country j as a share of the total income of the group of economies, i.e $s_j = \dfrac{w_j^T \cdot V_j}{\sum_{j'} w_{j'}^T \cdot V_{j'}}$.

Section 2 provides precise conditions under which the FPE theorem applies. It suffices here to say that the key requirements are that countries have identical technologies and factor endowments that are not too dissimilar. Under these assumptions, one can prove that factor rentals are equalized across the group of countries:

$$w_j = w \qquad j = 1, ..., J. \tag{FPE}$$

Since all countries have the same technology and the same factor rentals, it follows that, $A_j = A$ for all j. If we further assume that preferences over the different products are homothetic, $C_j = s_j \cdot \sum_j Q_j$, and it follows that:

$$A \cdot T_j = V_j - s_j \cdot \sum_{j'} V_{j'} \qquad j = 1, ..., J. \tag{HOV}$$

This is the HOV theorem stating that the factors embodied in a country's vector of net exports equal the deviation of this country's endowment from the (scaled) average endowments of the group. The HOV theorem requires a more restrictive set of assumptions than the FPE theorem. In particular, the FPE theorem requires no assumptions on preferences while the HOV theorem requires the assumption of homothetic demands.

Since the assumptions required to stablish both FPE and HOV are utterly unrealistic, it should be nobody's surprise that the notion that they provide a good description of existing data has been repeatedly rejected in formal tests.[3] Starting from the important study by Bowen, Leamer and Sveikauskas (1987) there has been a collective effort to isolate the individual assumptions that are most responsible for the empirical rejection of FPE and HOV. This research strategy consists of relaxing one or more of the basic assumptions, deriving "modified" versions of the theorems and then testing them. We review here four papers that fall into this tradition and direct the reader to Leamer and Levinsohn (1995) for a comprehensive survey of the literature.

Bowen, Leamer and Sveikauskas (1987) and Trefler (1995) provide a variety of tests of "modified" versions of the HOV theorem. These authors consider the possibility of both cross-country differences in technology and non-homothetic preferences. They postulate the existence of measurement errors and transform the HOV equations into a regression model that can be estimated using standard methods. After reviewing the performance of these alternative hypotheses, Bowen et al. conclude that although the HOV model "does poorly, (...) we do not have anything that does better." In part, this conclusion reflects an error of implementation that was later corrected by Trefler (1995). In his paper, Trefler concludes that a model combining the Armington home bias assumption with factor-neutral international productivity differences improves over the basic HOV theorem. Both of these papers keep as a maintained assumption that the FPE theorem or a modified version of it is a good description of the data.

In a very influential paper, Trefler (1993) argued that a modified model that allows for factor-augmenting international productivity differences provides a good description of the existing cross-section of factor prices and the factor content of commodity trade flows. This is the Leontiev-Trefler hypothesis. Trefler noted that, if we do not impose any structure to cross-country differences in factor-augmenting productivity differences, it is possible to exactly fit the HOV or the FPE equations but not *both* sets of equations simultaneously. He then used the HOV equations to calibrate these productivity differences and showed that the calibrated values were roughly consistent

[3]An important exception is Davis et al. (1997) who use Japanese regional data.

with the FPE equations. This methodology can be understood as a test of overidentifying restrictions.

Gabaix (1997) has forcefully challenged Trefler's results. He repeats Trefler's procedure using the FPE equations to calibrate the productivity-differences and examines whether the calibrated values are roughly consistent with the HOV equations. In some sense, this is what Bowen et al. (1987) and Trefler (1995) did using a much more restricted model of technological differences. Surprisingly, Gabaix finds that the productivity-adjustments that he calibrates grossly violate the HOV equations. This finding is, to say the least, puzzling and could eventually lead to a revision of this whole testing methodology.

In this paper, we present a new methodology to test the Leontiev-Trefler version of the FPE theorem. In our test the HOV equations play no role, unlike the previous papers. Moreover, the dataset required to perform the test is new. We find that that the modified FPE theorem is rejected by the data. As a by-product of the test we obtain estimates of the productivity-adjusted wage-rental ratios that are valid even under the alternative hypothesis that the Leontiev-Trefler hypothesis fail. We then use these estimates to determine what further modifications of the theory are required.

2 Theory

In this section, we derive a pricing equation that links product prices and productivity-adjusted factor prices. These two sets of variables are interpreted as equilibrium values from a general equilibrium model. Yet the derivation of the pricing equation does not require us to specify the whole general equilibrium. An immediate implication is that this equation is valid under alternative sets of assumptions. In particular, we show that the assumptions underlying the pricing equation neither preclude nor imply the Samuelson and/or the Leontiev-Trefler factor-price-equalization theorems.

2.1 The Pricing Equation

There are J countries, $j = 1, ..., J$; I industries, $i = 1, ..., I$; and two production factors, labor and capital. Each industry contains one or many firms producing a homogeneous product. We study the problem of the representative firm of industry i located in country j at date t. We assume that this firm maximizes profits subject to existing cost and demand conditions.

First, we make one assumption regarding factor markets:

Assumption 1: Within a country and date, all firms face the same wage and rental rate to capital, i.e. W_{jt} and R_{jt}.

The existence of a unique pair of wage and rental rate within a country and date is fundamental in the analysis that follows. Without this assumption, existing factor-price-equalization theorems are meaningless. Naturally, assumption 1 is satisfied in models that assume away costs of reallocating factors across industries within a country. But the assumption of zero reallocation costs is stronger than assumption 1. Even if reallocation costs are positive, factor prices should be identical across industries that exhibit positive gross investment and engage in hirings of new workers. This follows from the fact that new pieces of capital and new workers have not yet paid the cost that makes them specific to the industry. As a result, they should command the same price in all industries.

Let C^i_{jt} be the total cost of producing Q^i_{jt}. We assume the following regarding the cost function of the representative firm:

Assumption 2: $C^i_{jt} = F^i_{jt} + V^i_{jt}$; where F^i_{jt} is independent of Q^i_{jt} and $V^i_{jt} = B^i_{jt}\left(\frac{W_{jt}}{\pi^L_{jt}}, \frac{R_{jt}}{\pi^K_{jt}}\right) \cdot Q^i_{jt}$. The function $B^i_{jt}(.)$ is continuous, twice differentiable, homogeneous of degree one and exhibits no factor-intensity reversals.

By setting $F^i_{jt} \neq 0$, we allow for variable returns to scale. In industries where $F^i_{jt} > 0$ ($F^i_{jt} < 0$), the representative firm exhibits increasing (decreasing) returns to scale. The important part of this assumption is that variable costs exhibit constant returns to scale. As it shall become clear later, our testing procedure relies heavily on this property of the cost function. Note also that our specification allows for cross-country differences in technology of two forms: (1) The industry production functions are allowed to vary over time and across countries in an unspecified manner; and (2) There might exist factor-augmenting productivity differences across countries. These productivity differences are allowed to vary over time and are captured by π^L_{jt} and π^K_{jt}. We define $\hat{W}_{jt}$ and $\hat{R}_{jt}$ as the productivity-adjusted wage and rental rate, i.e. $\hat{W}_{jt} = \frac{W_{jt}}{\pi^L_{jt}}$ and $\hat{R}_{jt} = \frac{R_{jt}}{\pi^K_{jt}}$. Finally, the assumption that the variable costs function exhibits no factor-intensity reversals is made for convenience only and could be easily dispensed of. It simply allows us to unambiguously rank industries by their factor-intensity.[4] Without loss of generality, we assume that this ranking is strict.

Next, we make one assumption regarding the demand conditions of the firm:

Assumption 3: The demand elasticity perceived by firms is independent of the price charged, $\sigma^i_t \in (1, \infty)$.

This assumption imposes restrictions on the demand elasticities that firms perceive, but it does not necessarily restrict the elasticity of market demands. For instance, if industry i is competitive, each firm perceives an infinite demand elasticity, $\sigma^i_t \to \infty$, even though the market demand elasticity is finite.

[4]Without this assumption, to order products by labor intensity we have to specify a productivity-adjusted wage and rental rate. Industry i is more labor-intensive than industry k if, *at the proposed* $\hat{W}_{jt}$ *and* $\hat{R}_{jt}$, industry i chooses a smaller productivity-adjusted capital-labor ratio than industry k.

The same is true if firms engage in Bertrand competition. Therefore, both perfect competition and Bertrand pricing are special cases of our assumptions, regardless of the nature of market demand elasticities. If firms engage in Cournot competition or act as monopolists à la Spence-Dixit-Stiglitz, assumption 3 implies that the market demand elasticity of industry i is independent of sales. In Cournot competition, the perceived demand elasticity of the firm is $\sigma_t^i = n \cdot \sigma_{M,t}^i$, where n is the number of firms in the market and $\sigma_{M,t}^i$ is the market demand elasticity. In monopolistic competition models, the perceived demand elasticity is the market one, $\sigma_t^i = \sigma_{M,t}^i$.

Let P_{jt}^i be the price of the product of industry i in country j at date t. If the representative firm of this industry decides to produce, its optimal pricing rule is given by:

$$P_{jt}^i = \frac{\sigma_t^i}{\sigma_t^i - 1} \cdot B_{jt}^i \left(\hat{W}_{jt} \, , \, \hat{R}_{jt} \right) \tag{1}$$

Equation (1) states that firms will charge a markup, $\frac{\sigma_t^i}{\sigma_t^i - 1}$, over marginal cost, $B_{jt}^i \left(\hat{W}_{jt} \, , \, \hat{R}_{jt} \right)$. The markup is a decreasing function of the demand elasticity that the firm perceives. The representative firm will produce if and only if the quantity that can sell at the optimal price is large enough to cover the fixed cost, i.e. $P_{jt}^i \cdot Q_{jt}^i \geq C_{jt}^i$. Otherwise, $Q_{jt}^i = 0$ and equation (1) need not hold.

Let $N \, (\leq I)$ be the number of industries in which there is positive production. Equation (1) provides a set of N equations linking product prices, P_{jt}^i, to productivity-adjusted factor prices, $\hat{W}_{jt}$ and $\hat{R}_{jt}$. To derive these equations we have not made assumptions regarding international trade and factor mobility. Our notation allows for (but does not require that) product and factor prices vary across countries and dates. Also note that our assumptions are shared by basically all existing models of trade and growth. Neoclassical growth models and factor proportions trade models assume that the economy is competitive. This corresponds to our model as $\sigma_t^i \to \infty$ and $F_{jt}^i = 0$. Models of technological progress typically assume that there are no fixed costs of production, i.e. $F_{jt}^i = 0$.[5] Models of intraindustry trade permit $F_{jt}^i > 0$ but then assume free-entry in each industry and, as a result, imply

[5]In this class of models there are positive costs of developing new products but, once these products have been developed, production exhibits constant returns to scale.

that $P^i_{jt} \cdot Q^i_{jt} = C^i_{jt}$. Both models of technological progress and intraindustry trade typically feature constant market demand elasticities.

2.2 Factor-Price-Equalization Theorems

Next we show how adding three assumptions to the theory, we obtain Samuelson's original version of the factor-price-equalization theorem and the Leontiev-Trefler modification of it. Let J be the set of all countries. Let $C_t \subset J$ be a subset of countries. We index this subset of countries by t to indicate that the composition of this subset can vary over time. To prove Samuelson's factor-price-equalization theorem, we require the following assumptions:

Assumption 4: (Identical technologies) Firms in all countries have the same technology: $B^i_{jt}(.) = B^i_t(.)$, $\pi^L_{jt} = \pi^L_t$ and $\pi^K_{jt} = \pi^K_t$ if $j \in C_t$;

Assumption 5: (Commodity-price-equalization) There is free and costless trade in $K\,(\geq 2)$ industries among all $j \in C_t$. We assign low indexes to these industries, $i = 1, ..., K$.

Assumption 6: (Diversification) There exist at least two industries with index $i \leq K$ for which $Q^i_{jt} > 0$ for all $j \in C_t$.

The role of assumption 4 in the theorem is to ensure that the relationship between product and factor prices is the same across countries, i.e. equation (1) is identical for all $j \in C_t$. Without this assumption, it is not possible that *both* product and factor prices be equalized across countries simultaneously. Assumption 5 implies that the prices for $K\,(\geq 2)$ products are equalized across all $j \in C_t$. Finally, assumption 6 implies that at least two of the pricing equations in (1) hold for all $j \in C_t$.[6] Since assumptions 4 and 5 require technology and product prices to be equal across this group of countries, these two (or more) pricing equations can hold if and only if wages and rental rates are equalized across them, i.e. $W_{jt} = W_{Ct}$ and $R_{jt} = R_{Ct}$ if $j \in C_t$. This proves Samuelson's original version of the factor-price-equalization theorem.

[6] In general equilibrium formulations of the theory, assumption 6 is replaced by the requirement that cross-country differences in capital-labor ratios are not too large. In usual trade-theoretic parlance, the requirement consists of capital-labor ratios for all $j \in C_t$ belonging to the same diversification cone. This condition ensures that full employment of factors is consistent with positive production of these two commodities.

Inspired by a suggestion in Leontiev (1953), Trefler (1993) relaxed assumption 4 as follows:

Assumption 4': (Almost identical technologies) Firms in all countries have technologies that differ, at most, by factor-augmenting differences in productivity: $B^i_{jt}(.) = B^i_t(.)$ if $j \in C_t$.

Using parallel arguments, it is straightforward to show that, if assumptions 4', 5 and 6 hold, productivity-adjusted factor prices are equalized across this group of countries, i.e. $\hat{W}_{jt} = \hat{W}_{Ct}$ and $\hat{R}_{jt} = \hat{R}_{Ct}$ if $j \in C_t$. This is the Leontiev-Trefler version of the factor-price-equalization theorem.

The reader might have noticed already that the assumptions we have used are stronger than is required to obtain the two theorems. For instance, assumption 4 (or 4') could be relaxed to say that technologies be identical (or almost identical) only for those products that are subject to assumption 6. Also, assumption 6 could be weakened.[7] We do not pursue these extensions here.

[7]To see this, consider the example in which $C_t = 1, 2, 3$ and the set of traded goods is $i = 1, 2, 3$. Assume then that country 1 produces only commodities 1 and 2; country 2 produces only commosities 2 and 3; and country 3 produces only commodities 1 and 3. This pattern of production violates assumption 6. Yet it is straightforward to show that, if assumptions 4' and 5 hold, the Leontiev-Trefler theorem goes through in this example.

3 Tests of the Leontiev-Trefler Hypothesis

In this section, we provide a formal econometric test of the Leontiev-Trefler hypothesis. Our testing strategy is based on the (evident) observation that this hypothesis imposes strong structure on the data. We proceed in three steps. First, we derive a log-linear approximation to the pricing equation and formulate it as an econometric model. Second, we show how the Leontiev-Trefler hypoythesis can be naturally framed as a set of restrictions on the estimated parameters of this econometric model. Third, we use data on product prices and labor shares to estimate this regression model and test the validity of the Leontiev-Trefler restrictions. The test rejects the notion that the Leontiev-Trefler hypothesis provides a good description of the data, unless we restrict the sample to the European Union.

3.1 Testing Strategy

Let lowercase letters indicate logarithms, i.e. $p_{jt}^i = \ln P_{jt}^i$, $\hat{w}_{jt} = \ln \hat{W}_{jt}$ and $\hat{r}_{jt} = \ln \hat{R}_{jt}$. A Taylor expansion around $\hat{w}_{jt} = \hat{r}_{jt} = 0$ yields the following log-linear approximation to equation (1):[8]

$$p_{jt}^i = \alpha_{jt}^i + (\hat{w}_{jt} - \hat{r}_{jt}) \cdot s_{jt}^i \tag{2}$$

where $\alpha_{jt}^i = \ln\left(\sigma_t^i \cdot (\sigma_t^i - 1)^{-1} \cdot B_{jt}^i(1,1) \cdot \hat{R}_{jt}\right)$ and $s_{jt}^i = \left.\dfrac{\partial \ln B_j^i(.)}{\partial \hat{w}_{jt}}\right|_{\hat{w}_{jt}=\hat{r}_{jt}=0}$.
Note that s_{jt}^i is the share of wages in variable costs in industry i, evaluated at $\hat{w}_{jt} = \hat{r}_{jt} = 0$.

Let I be the set of all industries for which we have data. Let $M \subset I$ be a subset of industries or economic sector. In the data, we will identify M as a three-digit ISIC, i.e. manufacturing. Let θ_{jt}^i be the production weight of industry i in sector M of country j at time t, i.e. $\theta_{jt}^i = \dfrac{P_{jt}^i \cdot Q_{jt}^i}{\sum_{i' \in M} P_{jt}^{i'} \cdot Q_{jt}^{i'}}$.
Also, define $p_{jt}^M = \sum_{i \in M} \theta_{jt}^i \cdot p_{jt}^i$ and $s_{jt}^M = \sum_{i \in M} \theta_{jt}^i \cdot s_{jt}^i$. Then, it follows immediately from (2) that:

$$p_{jt}^M = \sum_{i \in M} \theta_{jt}^i \cdot \alpha_{jt}^i + (\hat{w}_{jt} - \hat{r}_{jt}) \cdot s_{jt}^M \tag{3}$$

[8]In the special case in which $B_{jt}^i(.)$ is of the Cobb-Douglas form, this approximation would be exact.

Equation (3) relates a geometric average of product prices to a simple average of labor shares in variable costs. Based on this equation, we postulate the following regression model:

$$p_{jt}^M = \beta_1^M \cdot d^M + \beta_{2,j} \cdot d_j + \beta_{3,t} \cdot d_t + \beta_{4,jt} \cdot s_{jt}^M + u_{jt}^M \tag{4}$$

where d^M, d_j and d_t are dummies for each sector, country and year. We treat $\beta_1^M \cdot d^M + \beta_{2,j} \cdot d_j + \beta_{3,t} \cdot d_t$ as the linear predictor of the quantity $\sum_{i \in M} \theta_{jt}^i \cdot \alpha_{jt}^i$. This allows us to interpret $\beta_{4,jt}$ as an estimate of the (log) productivity-adjusted wage-rental ratio, i.e. $\hat{w}_{jt} - \hat{r}_{jt}$. The error term u_{jt}^M contains at least two pieces: (i) The deviation of $\sum_{i \in M} \theta_{jt}^i \cdot \alpha_{jt}^i$ from its linear predictor $\beta_1^M \cdot d^M + \beta_{2,j} \cdot d_j + \beta_{3,t} \cdot d_t$; and (ii) Approximation errors that result from the log-linearization in (2).

Under the null hypothesis that the Leontiev-Trefler theorem is valid for a subset of countries C_t, $\hat{w}_{jt} = \hat{w}_{Ct}$ and $\hat{r}_{jt} = \hat{r}_{Ct}$ if $j \in C_t$, or alternatively, $\beta_{4,jt} = \beta_{4,Ct}$ if $j \in C_t$. The following regression model imposes these restrictions:

$$p_{jt}^M = \beta_1^M \cdot d^i + \beta_{2,j} \cdot d_j + \beta_{3,t} \cdot d_t + \beta_{4,Ct} \cdot s_{jt}^M \cdot d_{jt}^C + \beta_{4,jt} \cdot s_{jt}^M \cdot (1 - d_{jt}^C) + u_{jt}^M \tag{5}$$

where the dummy variables d_{jt}^C takes the value one if $j \in C_t$, and zero otherwise. Since model (5) is nested in model (4), we test the Leontiev-Trefler theorem by performing a F test of the validity of the restrictions. If we reject (do not reject) the restricted model, we conclude that the data is inconsistent (consistent) with the Leontiev-Trefler theorem.[9]

The data required to perform the test consists of product prices and labor shares, that is, p_{jt}^M and s_{jt}^M. In particular, we do not need productivity-

[9] One could argue that assuming the existence of two aggregates such as "capital" and "labor" might be too strong an assumption. Perhaps a richer classification that separates unskilled and skilled labor or that takes into account the existence of intermediate inputs would be more appropriate. We are sympathetic to this view, but cannot explore its implications at this time. While it is straightforward to show that our test can be generalized to account for the possibility of many production factors, the required data to implement this generalized test is not available. To see this, assume that there is an additional factor. Then, we would generalize assumption 1 to state that all firms within a country and date face the same price for this factor, say X_{jt}. Also, we would rewrite the function $B_{jt}^i(.)$ in assumption 2 as $B_{jt}^i\left(\frac{W_{jt}}{\pi_{jt}^L}, \frac{R_{jt}}{\pi_{jt}^K}, \frac{X_{jt}}{\pi_{jt}^X}\right)$. Under these revised assumptions, equations (1) and (2) still hold, provided we use the new definition of $B_{jt}^i(.)$. If we log-linearize the

adjusted factor prices. In fact, the latter can be obtained as a by-product of the test since we can use the estimated values for $\beta_{4,jt}$ as estimates of the (log) productivity-adjusted wage-rental ratio, i.e. $\hat{w}_{jt} - \hat{r}_{jt}$. Furthermore, since we have only used the pricing equation (1) to derive the regression model (4), our estimates of the productivity-adjusted (log) wage-rental ratio are valid under assumptions 1, 2 and 3. These estimates can therefore be used even if the Leontiev-Trefler hypothesis fails, provided we are willing to keep as maintained assumptions 1, 2 and 3. We will do this in section 4.

3.2 Data and Estimation

Product prices were kindly provided by Alan Heston. They consist of unpublished raw data collected by the benchmark studies of the United Nations International Comparison Program (ICP) that form the basis of the widely used Penn World Table. These prices were collected following detailed specifications to ensure comparability across countries.[10] The ICP studies divide GDP into 150 detailed categories (approximately 110 consumption, 35 investment and 5 government). For each category, prices are expressed as ratios of the corresponding item in the US. The ICP studies provide four cross-sections of prices for the years 1970, 1975, 1980 and 1985 for a variety of countries.

To construct labor shares, we used data from the United Nations Industrial Development Organization (UNIDO) Industrial Statistics Yearbook, which contains information on value added, employment and wages for 28 three-digit manufacturing subsectors. This source allows us to construct the share of wages in value added for these 28 industries for all countries and

revised version of equation (1) around $\hat{w}_{jt} = \hat{r}_{jt} = \hat{x}_{jt} = 0$ we would obtain:

$$p^i_{jt} = \alpha^i_{jt} + (\hat{w}_{jt} - \hat{r}_{jt}) \cdot s^{i,L}_{jt} + (\hat{x}_{jt} - \hat{r}_{jt}) \cdot s^{i,X}_{jt}$$

where $s^{i,L}_{jt}$ and $s^{i,X}_{jt}$ are the shares of labor and the additional factor in variable costs. It should be apparent to the reader that implementing this revised version of our test requires us to have data on both the shares of labor and those of the additional factor. We do not have however data on the share in costs of skilled and unskilled workers or the share of intermediate inputs. If the share of this additional factor is "large", the tests presented here suffer from an omitted-variable bias that, unfortunately, we cannot sign.

[10]See Kravis, Heston and Summers (1982) and Summers and Heston (1991) for detailed descriptions of how these prices were collected and processed.

years in the ICP studies, except for Congo, Botswana, Luxembourg, Mali and Swaziland. We were forced to eliminate these countries from our sample. In addition, we also dropped observations from Madagascar, Malawi and Senegal because we suspect that the labor share data contains errors. In the end, we were left with four cross-sections of prices and labor shares for the years 1970, 1975, 1980 and 1985; with 16, 31, 51 and 50 countries, respectively. Table 1 lists the countries and years for which data is available.

To relate our data to the appropriate theoretical concepts, we need to deal with two problems. First, our data consists on observations on labor shares in *total* instead of *variable* cost. We interpret this as an error in measuring s_{jt}^M. To see this, let $\tilde{s}_{jt}^i$ be the labor share in total cost in industry i, i.e. $\tilde{s}_{jt}^i = \dfrac{V_{jt}^i}{F_{jt}^i + V_{jt}^i} \cdot s_{jt}^i$. We interpret an ISIC code as a subset of industries. Therefore, we can define our data as $\tilde{s}_{jt}^M = \sum_{i \in M} \theta_{jt}^i \cdot \tilde{s}_{jt}^i$ and relate it to s_{jt}^M as follows:

$$\tilde{s}_{jt}^M = s_{jt}^M + \eta_{jt}^M \tag{6}$$

where $\eta_{jt}^M = \sum_{i \in M} \theta_{jt}^i \cdot (\tilde{s}_{jt}^i - s_{jt}^i)$ is the error in measurement.

A second problem is that we have very disaggregated price data, while the labor shares are only available at the three-digit ISIC code. To match the price and labor-share data, we were forced to group the price categories in the ICP studies according to the three-digit ISIC code. We considered only those categories that could be matched without uncertainty into the ISIC codes. At the end, we were left with 13 manufacturing subsectors. Table 2 lists the manufacturing subsectors for which we have data and provides details of how we matched data on product prices and labor shares. Since we do not have the production weights θ_{jt}^i, we constructed a simple geometric average of prices, i.e. $\tilde{p}_{jt}^M = \sum_{i \in M} p_{jt}^i$, for each of the 13 subsectors. Therefore, we can relate our data to the theoretical price variable as follows:

$$\tilde{p}_{jt}^M = p_{jt}^M + \varepsilon_{jt}^M \tag{7}$$

where $\varepsilon_{jt}^M = \sum_{i \in M} (1 - \theta_{jt}^i) \cdot p_{jt}^i$ is interpreted as an error in measuring p_{jt}^M.

Since $\tilde{s}_{jt}^M$ is highly correlated with the country dummies, estimates of $\beta_{4,jt}$ using equation (4) are imprecise due to multicollinearity problems.[11] To

[11] A regression of $\tilde{s}_{jt}^M$ on d_j produces an R^2 of 0.87.

increase the precision of the estimates, we estimated the following transformations of regression models (4) and (5):

$$\Delta\tilde{p}_{jt}^{M} = \gamma_0 + \gamma_1^M \cdot d^M + \gamma_{2,jt} \cdot \Delta\tilde{s}_{jt}^M + v_{jt}^M \quad (8)$$

$$\Delta\tilde{p}_{jt}^{M} = \gamma_1^M \cdot d^M + \gamma_{2,Ct} \cdot \Delta\tilde{s}_{jt}^M \cdot d_{jt}^C + \gamma_{2,jt} \cdot \Delta\tilde{s}_{jt}^M \cdot (1 - d_{jt}^C) + v_{jt}^M \quad (9)$$

where $\Delta\tilde{p}_{jt}^M = \tilde{p}_{jt}^M - 13^{-1} \cdot \sum_S \tilde{p}_{jt}^M$ and $\Delta\tilde{s}_{jt}^M = \tilde{s}_{jt}^M - 13^{-1} \cdot \sum_S \tilde{s}_{jt}^M$. Note that $\gamma_1^M = \beta_1^M - \sum_{M' \in I} \beta_1^{M'} \cdot \frac{d^{M'}}{d^M}$ and $\gamma_{2,jt} = \beta_{4,jt}$ is an estimate of the the (log) productivity-adjusted wage-rental ratio, i.e. $\hat{w}_{jt} - \hat{r}_{jt}$. The error terms contain, in addition of the two pieces mentioned above, the measurement errors in ε_{jt}^M and η_{jt}^M. By construction, η_{jt}^M is correlated with the regressor $\tilde{s}_{jt}^M$. Moreover, there are reasons to suspect that the pieces of the error term might also be correlated with $\tilde{s}_{jt}^M$. To obtain consistent estimates for $\gamma_{2,jt}$, we use $\tilde{s}_{jt-1}^M$ as an instrument for $\tilde{s}_{jt}^M$. This is appropriate under the assumption of no serial correlation in the measurement error.

3.3 Results

Estimation of the unrestricted regression model (5) generates our estimates of the productivity-adjusted (log) wage-rental ratio. Figures 1 to 4 show the results of this estimation for the four cross-sections in our sample. Each figure contains three cross-sections corresponding to the whole sample, the set of open economies and the members of the European Union as of 1985. Visual inspection of the numbers does not reveal any clear pattern or suggest any variable to explain the cross-sectional variation in our estimates. A feature of the data is that, in general, the ranking of wage-rental ratios does not vary much over time. That is, countries with low (high) wage-rental ratios in one year tend to have low (high) wage-rental ratios in other years.

Table 3 presents the results of the test. First, we ask whether the Leontiev-Trefler theorem applies to all countries in each of the cross-sections in our sample. That is, we implement $C_t = \begin{cases} J & t \in T \\ 0 & otherwise \end{cases}$ with $T = \{1970, 1975, 1980, 1985\}$. The restricted model is strongly rejected in each of the four cross-sections. The p-values never exceed 0.02. Consequently, we also reject the notion that productivity-adjusted factor prices are equalized across all countries in each of these years.

It was too optimistic to expect that the Leontiev-Trefler hypothesis to be a good description of the cross-section of factor prices in our sample. After all, one should expect factor prices to be equalized through commodity trade and/or factor movements and there are many countries in the sample that impose substantial restrictions to international transactions of all sorts. To give the hypothesis a fair chance, we test the validity of the hypothesis in the subset of countries that are relatively open to foreign trade and factor movements. To determine whether a country is open or not, we rely on the classification of Sachs and Warner (1995). These authors classify a country as closed if it exhibits at least one of these five characteristics: (1) Nontariff barriers covering 40 percent of trade or more; (2) Average tariff rates of 40 percent or more; (3) A black market exchange rate that is depreciated by 20% or more relative to the official exchange rate, on average, during the 1970s and 1980s; (4) A socialist economic system; and (5) A state monopoly on major exports. An open economy is defined as one in which none of the five conditions applies.[12] Let $OPEN_t$ be the subset of countries that Sachs and Warner classify as open in year t. We implement $C_t = \begin{cases} OPEN_t & t \in T \\ 0 & otherwise \end{cases}$ with, once again, $T = \{1970, 1975, 1980, 1985\}$. The results of these additional tests are presented in the second column of Table 3. The hypothesis is clearly rejected for 1970, 1980 and 1985. We cannot reject the Leontiev-Trefler hypothesis for 1975 at the 5% level, although we can reject it at the 10% confidence level. We interpret these results as a failure of the hypothesis.

Perhaps it was also too optimistic to even expect that the Leontiev-Trefler hypothesis hold for the set of economies that Sachs and Warner classify as open. After all, these countries exhibit substantial variation in policies and so on. To give even a better chance to the theory, we test the validity of the hypothesis in the susbset of countries that belong to the European Union. That is, let EU_t be the subset of countries that are members of the European Union. Then ,we implement $C_t = \begin{cases} EU_t & t \in T \\ 0 & otherwise \end{cases}$ with, once again, $T = \{1970, 1975, 1980, 1985\}$. The results are presented in the thrid

[12]See Sachs and Warner (1995) for further details regarding the construction of this classification. Table 1 denotes with an asterisk those country/year pairs in our sample that are classified as open by Sachs and Warner.

column of Table 3. We cannot reject the Leontiev-Trefler hypothesis at the 5% level in any of the years. Only in 1975 we can reject the hypothesis at the 10% level. It is difficult to interpret these results, since perhaps wage-rental ratios are equal because these countries are very similar and not because the theory is correct.

4 Evidence on Factor-Price-Insensitivity

The results of the test suggest that there is more in a cross-section of wage-rental ratios than factor-augmenting productivity differences. Many theories, such as the neoclassical growth model, assume that there are diminishing returns to capital and labor at the country level and therefore predict that a cross-section of wage-rental ratios should reflect variation in factor endowments. Leamer and Levinsohn (1995) have coined the term factor-price-insensitivity to refer to the possibility that factor prices be unrelated to factor endowments. In this section, we provide some evidence supporting the notion that wage-rental ratios are related to factor endowments only in closed economies. Consistent with Leamer and Levinsohn's notion of factor-price insensitivity, we find that wage-rental ratios are not related to measures of factor endowments in open economies. The results presented here are valid under the maintained assumption that the model of firm behavior developed in section 1 is a good one. That is, we adopt the view that violations to assumptions 4', 5 and 6 are the culprit of the rejection of the Leontiev-Trefler hypothesis, while assumptions 1, 2 and 3 are roughly correct. This allows us to use our estimated values for $\gamma_{2,jt}$ as estimates of the productivity-adjusted wage-rental ratio.

4.1 Panel Regressions

We estimate regressions of the following form:

$$\omega_{jt} = X_{jt} \cdot \beta' + \varepsilon_{jt} \tag{10}$$

where we use our estimates for $\gamma_{2,jt}$ as measures for ω_{jt} and X_{jt} is a vector that contains country-specific constants and a set of variables that measure factor abundance and policy distortions that will be motivated in what follows.

To test whether the wage rental ratio is sensitive to relative factor abundance we included the capital-labor ratio (in logs) as one of our explanatory variables. Since the estimated wage-rental ratio is already adjusted for productivity differentials, the proper factor abundance variable to control for should be the productivity-adjusted capital-labor ratio. Therefore, to correct for the initial level of human capital we used the average number of years of attained male secondary school education. As before, the capital-labor ratios were taken from Summers and Heston Penn World Tables Mark

5.6. The education variable is taken from the Barro-Lee data set. See Barro and Lee (1993) for details regarding the construction of this data set.

The violation of two of the Leontiev-Trefler assumptions can lead to factor-price sensitivity. On the one hand, assumption 6 states that the sets of products that countries produce have a nontrivial intersection. If countries specialize in disjoint sets of products, one would expect that those countries that produce a set of more labor-intensive products have both a lower wage-rental ratio and a lower capital-labor ratio. On the other hand, assumption 5 states that product prices need to be equalized. One would expect that in closed economies the wage-rental ratio reflects domestic scarcities and therefore be related to the capital-labor ratio. In contrast, one would expect that the wage-rental ratio not be related to the domestic capital-labor ratio in open economies. To distinguish between these two potential sources of factor price sensitivity, we interacted the factor abundance variables with a dummy indicating if the country is open or closed. The dummy is equal to one if the country is open and zero otherwise. As in section 3, we relied on the classification constructed by Sachs and Warner (1995) to classify the countries.

We added an additional set of variables to our specification that we suspect can partially account for violations in the models assumptions. First, the rejection of the Leontiev-Trefler hypothesis can also be due to the absence of commodity price equalization, even in the presence of international trade. Taxes, tariffs, and capital controls can account for differences in factor prices, such that in their absence factor prices would be equalized. However, these distortions need to be biased towards certain goods and/or factors to have an effect on the wage rental ratio. For example, a tariff on a sector that uses intensively one factor of production will increase the relative reward of that factor. Ideally, we should include variables that account for this bias. However, we were unable to find comparable cross country data on such variables for all our sample in all four years. To control for these potential distortions, we used two variables as proxies: the black market premium and the ratio of government consumption (net of defense and education spending) over GDP. We expect these variables to be correlated with the existence of such distortions. Unfortunately, they do not give us information on the sign of the distortion bias. Both variables are measured as an average over the preceding five years. Data was taken from the Barro-Lee data set.

We also added to our specification a measure of political instability. This variable is a simple average of the number of revolutions per year and the number of assassinations per million habitants per year. We used the average value over the preceding five years, and collected the data from the Barro-Lee data set. The motivation for the inclusion of this variable is the fact that sociopolitical conflict creates incentives to engage in activities outside the formal market. Informal markets might use essentially different technologies or can affect the relative productivity of factors.

Finally, we added country specific effects and time dummies. These are intended to capture cross-country differences in technology and common shocks, respectively.

Turning next to the estimation procedure, we note that there are two potential sources of inconsistency in estimating equation (10) using standard techniques. First, country-specific effects capture unobservable differences in technology that are not controlled for by the independent variables. However, if the country effects are correlated with any of the right hand side variables, the estimated coefficients would be inconsistent. Second, all our control variables can be understood as variables that are jointly determined with the wage-rental ratio in a more general model. Furthermore, most of the variables are proxies and hence measured with error. Not correcting for the endogeneity and error in variables problems would also lead us to inconsistent estimates of the parameters.

To avoid these problems we first took differences in order to eliminate the country effect. This methodology allows us to estimate an equation like (10) only for countries for which we have at least three observations. This reduced our set of countries to 23.[13] Then we estimated the differenced model using an instrumental variable approach. Following Hsiao (1986), we used $x_{i,t-2\tau} - x_{i,t-3\tau}$ as instrument for $x_{i,t} - x_{i,t-\tau}$. Implicitly, this assumes that there is no serial correlation in the error term and in the measurement error, and that the variables that are not predetermined as of the period between $t-\tau$ and t are predetermined as of the period between $t-3\tau$ and $t-2\tau$. The differenced model was estimated by two stage least squares with White robust standard errors.

[13] We repeated the tests performed in section 3 for this reduced sample and found the same set of results.

4.2 Results

Table 4 presents the regression results. In the first column we report our benchmark estimation in which we only included the factor abundance variables. In the next column we add the policy distortion variables and the political instability measure.

The results suggest that factor abundance is a determinant of the wage-rental ratio only in closed economies. The coefficient of the capital-labor ratio and the education variable are positive and statistically significant in both regressions. Interestingly, the estimated coefficients on the interactions between the factor abundance variables and the openness dummy are of the opposite sign and of roughly the same absolute value than the coefficient of the same variables when not interacted. In fact, in none of the cases we can reject the hypothesis that the sum of pairs of coefficients is statistically insignificant. These findings are consistent with the hypothesis of factor price insensitivity for open economies.

We showed in the previous section that the Leontiev-Trefler hypothesis is rejected even for open economies. The variables that intend to account for distortions and technological differences could reconcile these findings. The regression results in Table 4 indicate that countries with large governments and/or high distortions in the foreign exchange market have lower wage rental ratios. As we already noted, it is not straightforward to interpret the black market premium and the level of government consumption as measures of the bias in government market interventions. Nonetheless, the sign suggests that policy interventions tend to decrease the relative price of labor intensive commodities. Unfortunately, neither these two variables, nor the political instability measure turned out to be statistically significant in our regressions. This is likely a signal that these are very imperfect proxies of the variables we intend to measure.

To sum up, we find that the failure of the Leontiev-Trefler hypothesis does not mean that factor prices are related to domestic factor endowments in open economies. Combined with the results of the test in section 3. these findings suggest that we should develop models that: (1) Feature the factor-price-insensitivity property emphasized by Leamer and Levinsohn (1995); and (2) Allow for determinants of the cross-section of factor prices other than the productivity differences emphasized by Trefler (1993).

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Table 1. Country Coverage

1970	1975	1980	1985
Belgium*	Austria*	Argentina	Australia*
Colombia	Belgium*	Austria*	Austria*
France*	Brazil	Belgium*	Bahamas
Germany*	Colombia	Bolivia	Bangladesh
Hungary	Denmark*	Brazil	Barbados*
India	France*	Cameroon	Belgium*
Iran	Germany*	Canada*	Benin
Italy*	Hungary	Chile*	Cameroon
Japan*	India	Colombia	Canada*
Kenya	Iran	Costa Rica*	Denmark*
Korea*	Ireland*	Denmark*	Egypt
Malaysia*	Italy*	Dominican Rep.	Finland*
Netherlands*	Jamaica	Ecuador	France*
Philippines	Japan*	El Salvador	Germany*
United Kingdom*	Kenya	Finland*	Greece*
United States*	Korea*	France*	Hong Kong*
	Malaysia*	Germany*	Hungary
	Mexico	Greece*	India
	Netherlands*	Guatemala	Iran
	Pakistan	Honduras	Ireland*
	Philippines	Hong Kong*	Italy*
	Poland	Hungary	Ivory Coast
	Spain*	India	Jamaica
	Sri Lanka	Indonesia*	Japan*
	Syria	Ireland*	Kenya
	Thailand*	Israel	Korea*
	United Kingdom*	Italy*	Mauritius
	Uruguay	Ivory Coast	Morocco
	United States*	Japan*	Nepal
	Yugoslavia	Kenya	Netherlands*
	Zambia	Korea*	New Zealand*
		Mexico	Nigeria
		Morocco	Norway*
		Netherlands*	Pakistan
		Nigeria	Philippines
		Norway*	Poland
		Pakistan	Portugal*
		Panama	Spain*
		Peru	Sri Lanka
		Philippines	Sweden*
		Poland	Tanzania
		Portugal*	Thailand*
		Spain*	Trinidad Tobago*
		Tunisia	Tunisia
		United Kingdom*	Turkey
		Uruguay	United Kingdom*
		United States*	United States*
		Venezuela*	Yugoslavia
		Yugoslavia	Zambia
		Zambia	Zimbabwe
		Zimbabwe	

* Countries classified as open according to Sachs and Warner (1995).

Table 2. Matching the ICP into the UNIDO ISIC codes

ISIC Code	ISIC Product	ICP Code	ICP Product
311	Food products	1	Rice, glazed or polished
		2	Flour and cereals
		3	Bread and rolls
		4	Other bakery products
		5	Cereal preparations
		6	Macaroni & similar prod.
		11	Other fresh and frozen meats
		12	Meat preparations
		14	Preserved fish and seafood
		16	Preserved milk
		18	Butter
		19 -20	Margarine, oils and other fat
		24	Dried fruit and nuts
		25	Dried, frozen and preserved fruits
		27	Coffees
		28	Teas
		29	Cocoa
		30	Raw and refined sugar
		31	Jam, jelly, honey, syrup
		32	Chocolate and ice cream
		33	Salt, spices and sauces
313	Beverages	34	Mineral water
		35	Spirits and liqueur
		36	Wine
		37	Beer
314	Tobacco	38	Cigarettes
		39	Other tobacco products
321	Textiles	40	Cloth. material
322	Wearing apparel (except footwear)	41	Men's outer clothing
		42	Women's outer clothing
		43	Children's outer clothing
		44	Men's under/nightwear clothing
		45	Women's under/night. clothing
		46	Other clothing
324	Footwear	48	Men's footwear
		49	Women's footwear
		50	Children's footwear
332	Wood furniture (except metal)	58	Furniture and fixtures

Table 2. Continuation

342	Printing and publishing	97	Books, newspapers,magazines
352	Other chemicals (than 351)	72	Drugs and medical preparations
382	Machinery, except electrical	133 - 134	Agricultural machinery and parts
		135	Office machines and equipment
		136	Metalworking machinery
		137	Constr., mining and oil field mach.
383	Machinery, electric	61	Refrigerator and freezers
		62	Washing appliances
		63	Cooking appliances
		64	Heat and air-conditioning
		65 - 66	Other major household appliances
		91	Telephone, and telegraph equip.
		92	Radio,TV and audio equipment
		141	Lamps and other electr.equipment
		142 - 143	Telecomm and elect., n.s.e.
384	Transport equipment	125 - 126	Railway vehicles and parts
		127 - 128	Motor vehicles and parts
		129	Aircraft and parts
		130	Ships and boats, and parts
		131	Other
390	Other manufactured products	106	Jewelry,watches

Table 3. Testing the Leontiev-Trefler FPE Theorem

	Universal FPE	Open Economies	European Union*
1970			
F value	1.98	2.06	1.70
D.F.	(15,1741)	(9,1741)	(5,1741)
P value	0.01	0.03	0.13
1975			
F value	1.99	1.53	1.82
D.F.	(29,1741)	(14,1741)	(7,1741)
P value	0.00	0.09	0.08
1980			
F value	2.13	2.36	1.72
D.F.	(49,1741)	(21,1741)	(7,1741)
P value	0.00	0.00	0.10
1985			
F value	1.50	1.71	1.22
D.F.	(48,1741)	(23,1741)	(7,1741)
P value	0.02	0.02	0.29

* Membership as of 1985.

Table 4. Wage-Rental Ratio Regression Results

	(1)	(2)
K/L	3.908	5.206
	(2.056)*	(2.436)**
K/L*open	-4.474	-5.807
	(2.158)**	(2.599)**
Secondary Education	-2.670	-2.830
	(1.410)*	(1.497)*
Sec Education * open	2.808	2.913
	(1.277)**	(1.376)**
BMP		0.399
		(0.306)
Gov.Consumption		-2.469
		(8.308)
Political Instability		1.266
		(0.871)

All regressions include a constant and time dummies.
Standard errors in parenthesis.
** Indicates significant at a 5% ; * indicates significant at a 10%.

Figure 1. Estimated Productivity Adjusted Wage-Rental Ratio, 1970

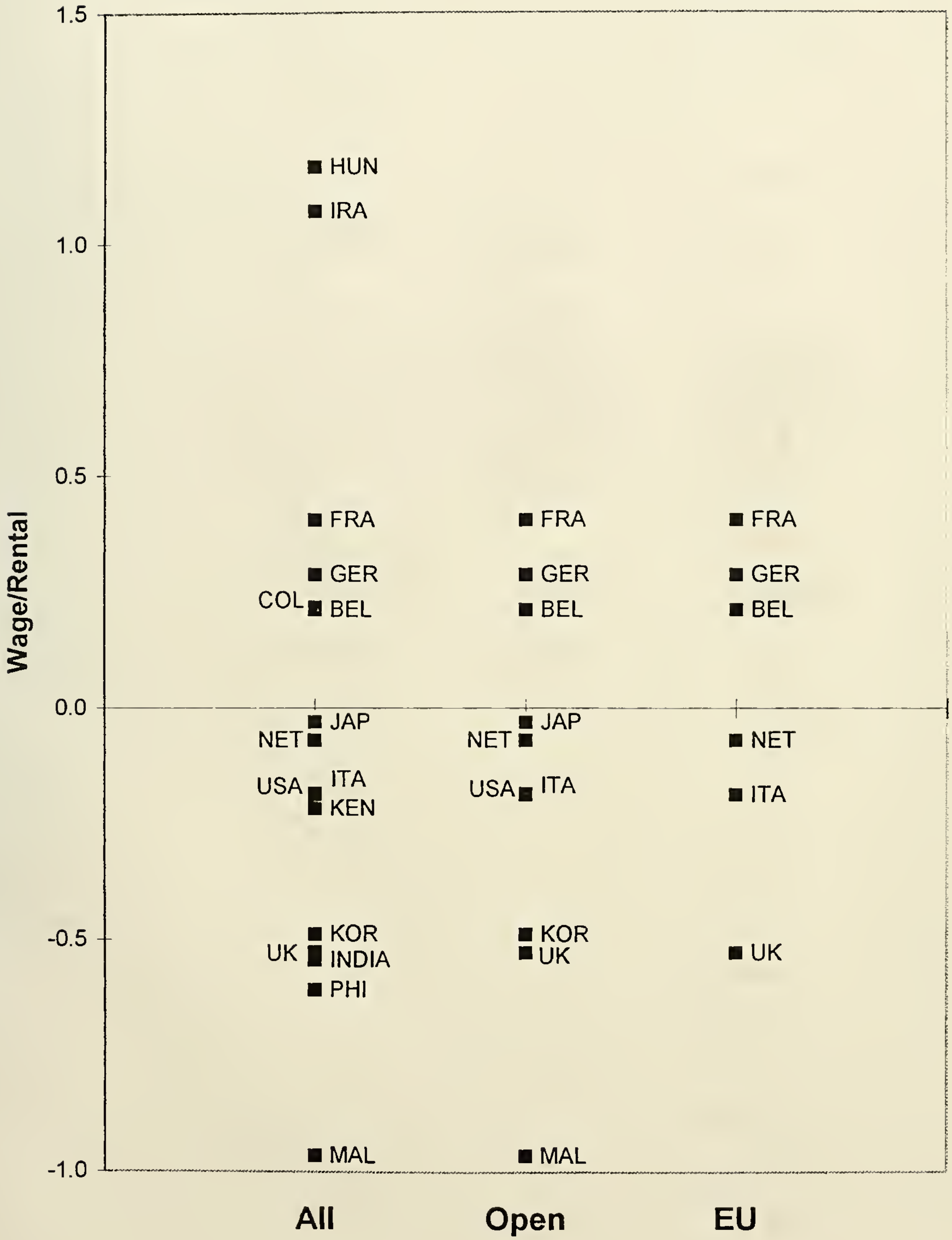

Figure 2. Estimated Productivity Adjusted Wage-Rental Ratio, 1975

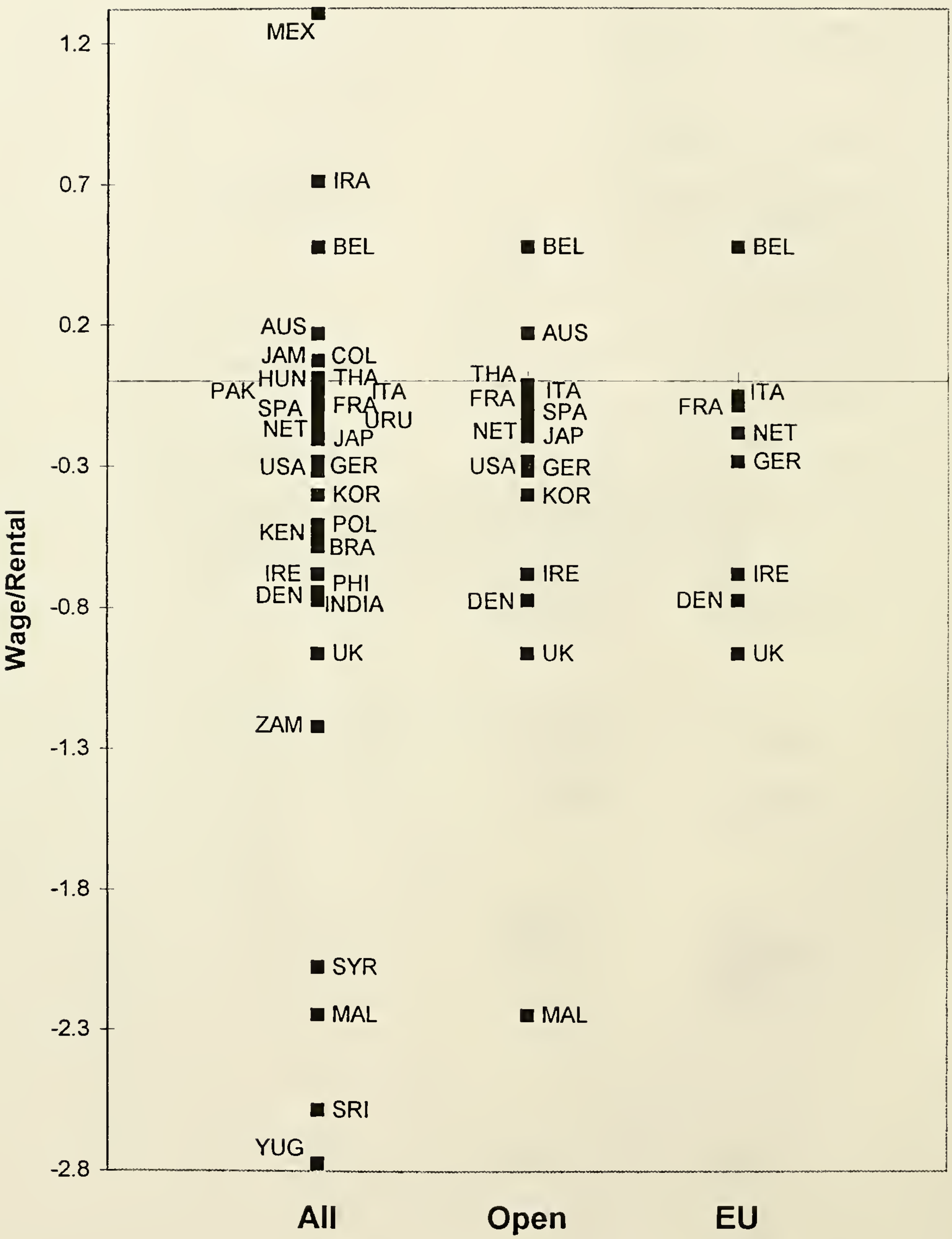

Figure 3. Estimated Productivity Adjusted Wage-Rental Ratio, 1980

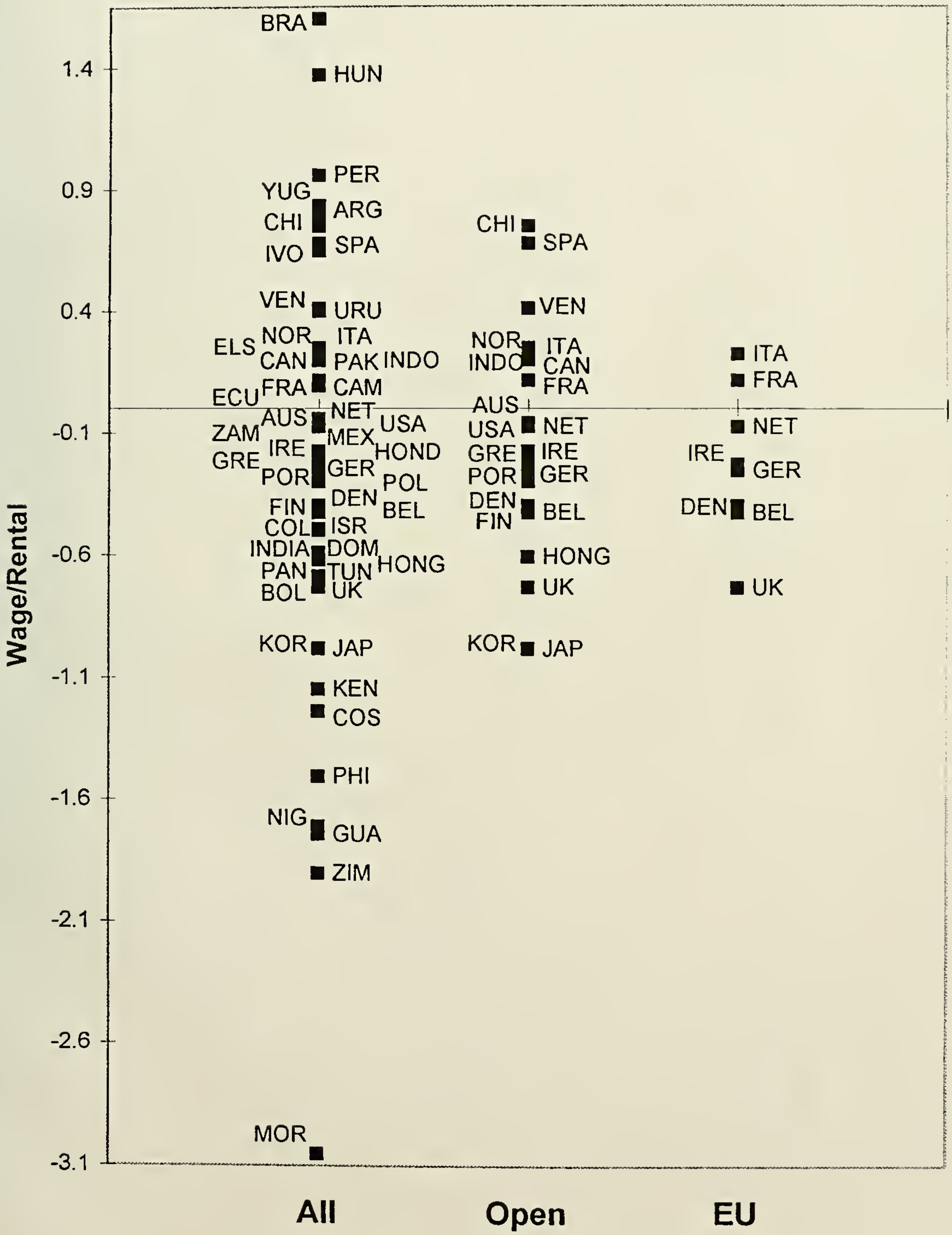

Figure 4. Estimated Productivity Adjusted Wage-Rental Ratio, 1985