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Empirical factor abundance with many factors and countries

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Abstract

Factor abundance is a two-dimensional concept that is awkward for data with numerous factors of production and many countries. The present paper introduces and utilizes a high-dimensional measure of factor abundance, the Euclidean distance to the intersection of an endowment ray with the unit hyperplane. Standard factor abundance is a special case of this distance abundance measure. Using a familiar data set, distance abundance outperforms share and world abundance in predicting factor content.

JEL classification: F1
Keywords: Factor abundance; Factor content; Euclidean distance

1. Introduction

Relative factor endowments explain trade in factor proportions trade theory with countries exporting products that use their abundant factors intensively. A recurring difficulty for empirical application is to define factor abundance when there are more than two factors of production and two countries. The classic studies of Baldwin (1971), Horiba (1974), and Leontief (1953) do not include a measure of factor abundance, and empirical tests generally examine implications of theory as pointed out by Deardorff (1984), Leamer and Levinsohn (1995), and Stern (1975). Independent measures of

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factor abundance would be ideal as suggested by Bowen, Leamer, and Sveikauskas (1987) and Leamer (1994).

The measures in the empirical literature are share abundance of Vanek (1968) and world abundance of Leamer (1980). Share abundance assumes static factor price equalization, which should limit its application. World abundance is the share of a country's factor in the world, not a relative endowment.

The present paper proposes and applies a new measure of factor abundance for any number of factors and countries, the Euclidean distance to the intersection of an endowment ray with the unit factor hyperplane. The paper compares its performance with share and world abundance using Trefler's (1995) data set that accounts for 79% of world output and 76% of world export revenue in 1983.

2. Factor abundance in the literature

Let v_{ij} represent the endowment of factor i in country j. With two countries and two factors, country 1 is abundant in factor 1 if the endowment ratio of factors 1 to 2 is higher,

$$v_{11}/v_{21} > v_{12}/v_{22}. \tag{1}$$

Assume free trade and equal product prices across countries. Identical linearly homogeneous neoclassical production functions and competitive factor markets imply factor price equalization, and each country produces more of the product using its abundant factor intensively. With homothetic utility functions, each country would consume products in the same ratio and effectively export its abundant factor.

Abundance readily extends to any number of countries. Country m is more abundant than country n in factor 1 if

$$\ldots > v_{1m}/v_{2m} > \ldots > v_{1n}/v_{2n} > \ldots \tag{2}$$

Abundance has a similar unambiguous definition with many factors but only two countries.

Moving to a model with three or more factors and countries, ratios fall short. The share abundance of Vanek (1968) requires a special set of assumptions including factor price equalization. Let s_n be the share of country n in world income, $s_n = y_n/y_w$. Given balanced trade and identical homothetic preferences, country n would consume the share of world output x_j^w of each product j equal to its income share, $c_{jn} = s_n x_j^w$. Casas and Choi (1985) adjust national income by the trade balance.

Country n is share abundant in factor i if its relative endowment of factor i is greater than its share of world income, $v_{in}/v_{iw} > s_n$. In units of the factor, share abundance is

$$S_{in} \equiv v_{in} - s_n v_{iw}. \tag{3}$$

There is upward bias for large countries in (3) and the present paper uses a share abundance index

$$\sigma_{in} \equiv (v_{in}/s_n v_{iw}) - 1, \tag{4}$$

similar to Bowen et al. (1987).

The 33 countries of the Trefler (1995) data include less developed countries with very small income shares. Static factor price equalization does not hold and from (4) the LDCs would tend to be share abundant. Developed countries have high consumption shares and would tend to be share scarce.

Leamer (1980) proposes an alternative definition, with country n "world abundant" in factor h relative to factor k if

$$W_{nhk} \equiv v_{hn}/v_{kn} - v_{hw}/v_{kw} > 0, \tag{5}$$

where v_{iw} is the world endowment of factor i. World abundance yields an unambiguous ranking of world endowment shares for each country n,

$$\omega_{hn} \equiv v_{hn}/v_{hw} > v_{kn}/v_{kw} \equiv \omega_{kn}. \tag{6}$$

Thompson (1999) shows that world abundance is a weak condition that might hold between pairs of countries and factors when the underlying factor abundance in (1) does not. Share abundance is weaker yet, perhaps holding between pairs of countries and factors when world abundance does not. Tests of factor content theory would have different outcomes according to the measure of factor abundance. Share and world abundance may not have provided fair tests of the concepts of factor content theory.

3. A distance measure of factor abundance

The proposed distance factor abundance is the Euclidean distance to the intersection of an endowment ray with the unit hyperplane, a generalization of the 2×2 measure. Fig. 1 illustrates distance abundance in the two-factor model with country endowment rays m and n. The line from $v_{1j} = 1$ intersects the two abundance rays. Country m is abundant in factor 1 since the distance $d_{1m} = v_{2m}/v_{1m}$ from the unit input

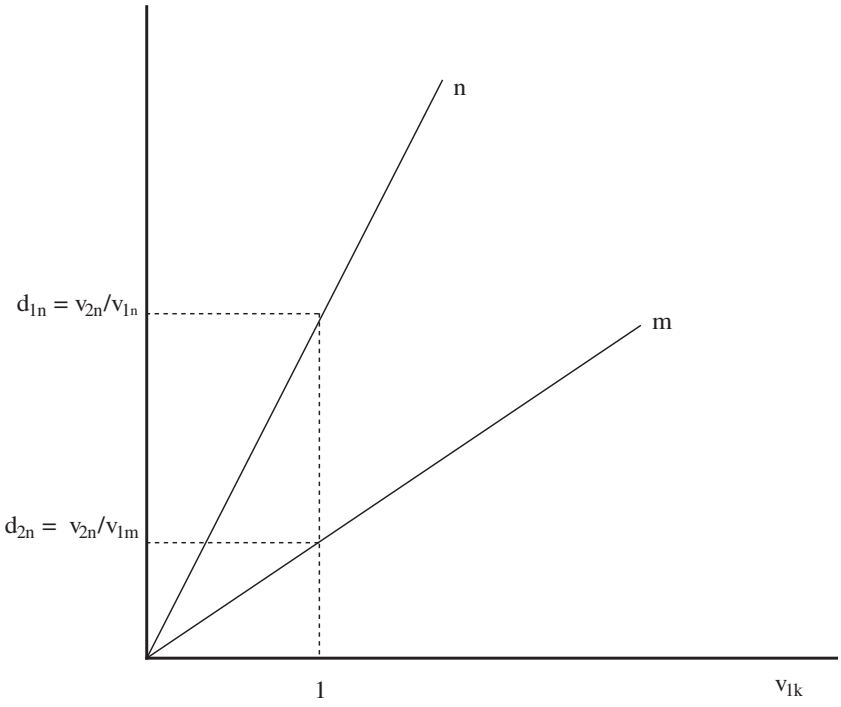

Fig. 1. Abundance distance with two factors.

of factor 1 to ray m is less than the distance $d_{1n}=v_{2n}/v_{1n}$ to ray n. The diagram is familiar but it is unusual to consider the ratios as distances. This two-factor abundance ranking applies to any number of countries.

The three-factor model in Fig. 2 illustrates the distance abundance of factor 1 in country m. The plane $v_{1m}=1$ intersects endowment ray m at point M and the Euclidean distance from its origin to point M is

$$d_{1m} = \left((v_{2m}/v_{1m})^2 + (v_{3m}/v_{1m})^2 \right)^{1/2}, \tag{7}$$

a summary measure of the abundance of factor 1 relative to the other two factors. Thompson (2003) introduces Euclidean factor intensity distance. Comparing countries m and n, if $d_{1m}<d_{1n}$ country m has more of factor 1 relative to 2 and 3, an abundance of factor 1.

Across any number of factors, the distance abundance for factor 1 in country k is

$$d_{1k} = \left((v_{2k}/v_{1k})^2 + \ldots + (v_{rk}/v_{1k})^2 \right)^{1/2}, \tag{8}$$

and the distance abundance for factor h is

$$d_{hk} = \left(\sum_{i \neq h} (v_{ik}/v_{hk})^2 \right)^{1/2}. \tag{9}$$

Distance abundance generates a ranking of countries for each factor, collapsing to the traditional definition (1) in two dimensions, and ranks factor abundance for each country.

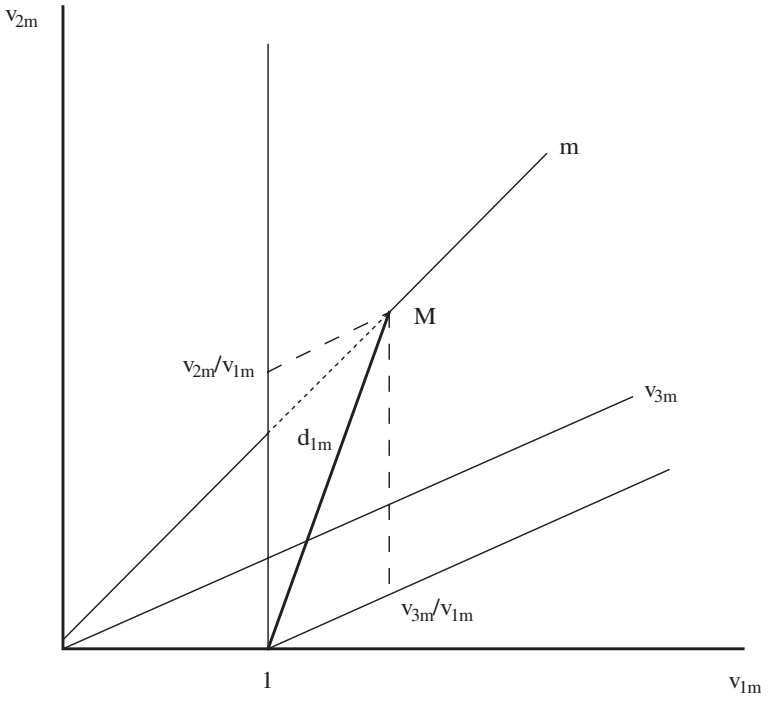

Fig. 2. Abundance distance with three factors.

The present data set includes capital, labor, and land variables that do not all have the same units of measure, leading to the "units" adding problem in (9). Rescaling each endowment relative to its mean across countries eliminates this problem.

Aggregation of high dimensional data generates simpler models but at the cost of bias. The share and world abundance measures of a factor not involved in the aggregation are unaffected, but its distance abundance is larger. In the three-factor model, aggregating factors 2 and 3 in (8) results in a d_{11} larger by $2v_{21}v_{31}/v_{11}$. Share and distance abundances of an aggregated factor are larger than the sum of the individual abundances. The world abundance of an aggregated factor, however, is less than the sum of the individual abundances.

Aggregation has other distorting effects, altering factor intensity. Net exports of an aggregate hide the disaggregated trade, generating intraindustry trade. Estimates of factor substitution involving an aggregated factor are not necessarily weighted averages of the disaggregated factors and there are distorted estimates of substitution for factors not involved in the aggregation. Technical separability tests such as Clark, Hofler, and Thompson (1988) indicate that it is improper to aggregate skilled labor groups, and there are similar conclusions throughout the applied production literature. As a rule of thumb, the most disaggregated data available will yield the truest test of theory.

Given high dimensional data, it is impossible to link endowments with levels of production or trade as developed by Chipman (1965–1966) and Ethier (1984). Thompson (1985) shows there are seven possible Rybczynski sign patterns of endowment-output changes in the model with only three factors and two goods. Factor endowments do not uniquely determine production, or by implication exports or the factor content of trade. Without stringent assumptions, distance abundance cannot be linked to production or trade.

Trade theorists may nevertheless want to apply the concepts of factor proportions theory and examine the extent to which factor abundance, at least under some metric, explains factor content. The recent theme in the empirical trade literature that factor proportions theory explains little trade must be due in part to the measure of abundance.

4. A comparison of factor abundance measures

This section compares the three measures of factor abundance in the Trefler (1995) data. Table 1 reports share abundance index σ_{ik} in (4) using the sum of sample national incomes as world GDP. For each factor, the scale of σ_{ik} is rescaled to [0,1].

The less developed countries in Table 1 have high share abundances due to low income shares. Sri Lanka, Singapore, Indonesia, and Panama have the highest capital share abundance, and the US, Sweden, and the UK the lowest. The result of any test of factor content theory with this rankings should be suspect. The story for professional labor is similar, with Sri Lanka, Bangladesh, and Thailand the most share abundant countries, and West Germany, Japan, and Hong Kong the scarcest. This share abundance paradox arises because static factor price equalization does not hold.

There is a high degree of variation in σ_{ik} with standard deviations greater and in some cases twice as large as means. Labor is more highly dispersed than capital or land. All share abundances have a right skew with a long tail above the mean and are highly leptokurtic with many countries close to the mean. The positive outliers for share capital abundance are the poorest countries. Table 2 reports world abundance ω_{ik} from (6), each country's share of the world endowment rescaled to the interval

Table 1
Share abundance

	Capital	Labor						Land	
		Professional	Clerical	Sales	Service	Agriculture	Manufacturing	Cropland	Pasture
Austria	0.133	0.040	0.099	0.012	0.023	0.003	0.031	0.034	0.017
Bangladesh	0.026	0.834	0.772	1.000	1.000	1.000	1.000	1.000	0.026
Belgium	0.080	0.059	0.080	0.004	0.001	0.001	0.015	0.012	0.004
Canada	0.064	0.042	0.068	0.005	0.008	0.001	0.004	0.198	0.041
Columbia	0.153	0.092	0.144	0.057	0.114	0.044	0.097	0.210	0.442
Denmark	0.053	0.060	0.072	0.003	0.025	0.002	0.011	0.064	0.002
Finland	0.088	0.066	0.034	0.003	0.011	0.004	0.017	0.062	0.002
France	0.094	0.042	0.071	0.004	0.008	0.002	0.012	0.045	0.012
Greece	0.212	0.114	0.119	0.031	0.035	0.025	0.077	0.161	0.086
Hong Kong	0.095	0.023	0.122	0.030	0.070	0.001	0.108	0.000	0.000
Indonesia	0.386	0.256	0.307	0.357	0.160	0.289	0.335	0.297	0.072
Ireland	0.161	0.099	0.088	0.025	0.015	0.009	0.057	0.078	0.155
Israel	0.199	0.185	0.136	0.009	0.022	0.002	0.025	0.026	0.020
Italy	0.139	0.046	0.080	0.007	0.010	0.004	0.032	0.040	0.007
Japan	0.073	0.004	0.076	0.020	0.002	0.004	0.023	0.005	0.000
Netherlands	0.050	0.057	0.058	0.005	0.003	0.001	0.002	0.008	0.004
New Zealand	0.089	0.067	0.094	0.012	0.006	0.004	0.028	0.025	0.321
Norway	0.066	0.042	0.000	0.002	0.003	0.001	0.003	0.018	0.001
Pakistan	0.164	0.493	0.378	0.303	0.215	0.353	0.621	0.963	0.094
Panama	0.386	0.281	0.285	0.046	0.176	0.042	0.112	0.268	0.212
Portugal	0.383	0.206	0.418	0.068	0.130	0.034	0.219	0.262	0.016
Singapore	0.436	0.097	0.219	0.048	0.051	0.001	0.101	0.000	0.000
Spain	0.147	0.054	0.097	0.020	0.027	0.009	0.064	0.168	0.035
Sri Lanka	1.000	1.000	1.000	0.345	0.374	0.378	0.797	0.695	0.056
Sweden	0.010	0.115	0.039	0.003	0.010	0.001	0.006	0.039	0.004
Switzerland	0.092	0.017	0.053	0.000	0.000	0.001	0.004	0.005	0.009
Thailand	0.245	0.308	0.147	0.213	0.117	0.424	0.220	0.729	0.005
Trinidad	0.138	0.028	0.069	0.007	0.017	0.003	0.040	0.030	0.001
UK	0.022	0.081	0.079	0.001	0.018	0.000	0.020	0.019	0.012
Uruguay	0.212	0.186	0.267	0.062	0.141	0.018	0.110	0.267	1.000
US	0.000	0.018	0.036	0.003	0.003	0.000	0.000	0.079	0.039
W. Germany	0.068	0.000	0.059	0.004	0.001	0.002	0.013	0.014	0.004
Yugoslavia	0.338	0.229	0.217	0.028	0.042	0.038	0.136	0.188	0.061
Mean	0.176	0.159	0.175	0.083	0.086	0.082	0.131	0.182	0.084
S.D.	0.189	0.224	0.211	0.192	0.183	0.203	0.234	0.271	0.191
Skewness	2.846	2.713	2.729	3.833	4.218	3.413	2.716	2.089	3.902
Kurtosis	10.71	7.61	8.07	16.78	20.23	13.16	7.09	3.62	17.11

[0,1] for comparison. In contrast to share abundance, the large US economy has the highest world abundance of every factor except agricultural labor. The US has the largest portion of world capital, other countries with an average of 10% of the US level and Japan the closest at 56%. The LDCs in the sample generally have low world abundances except for agricultural labor and land variables. World abundance measures also have high degrees of variation with right skews and high peaks around the means.

Table 2
World abundance

	Capital	Labor						Land	
		Professional	Clerical	Sales	Service	Agriculture	Manufacturing	Cropland	Pasture
Austria	0.034	0.023	0.031	0.030	0.031	0.009	0.036	0.009	0.009
Bangladesh	0.001	0.038	0.032	0.265	0.137	0.478	0.126	0.048	0.003
Belgium	0.038	0.038	0.038	0.028	0.022	0.003	0.037	0.004	0.003
Canada	0.136	0.123	0.129	0.114	0.113	0.020	0.105	0.242	0.101
Columbia	0.020	0.019	0.022	0.051	0.053	0.063	0.043	0.030	0.126
Denmark	0.020	0.023	0.021	0.016	0.027	0.005	0.019	0.014	0.001
Finland	0.022	0.022	0.013	0.014	0.017	0.009	0.021	0.012	0.001
France	0.274	0.217	0.233	0.185	0.194	0.059	0.233	0.098	0.054
Greece	0.021	0.019	0.017	0.028	0.018	0.031	0.032	0.021	0.022
Hong Kong	0.012	0.007	0.015	0.023	0.028	0.001	0.037	0.000	0.000
Indonesia	0.096	0.102	0.107	0.701	0.178	1.000	0.330	0.103	0.050
Ireland	0.008	0.008	0.005	0.011	0.004	0.006	0.011	0.005	0.020
Israel	0.012	0.017	0.011	0.007	0.008	0.001	0.008	0.002	0.003
Italy	0.243	0.167	0.186	0.166	0.157	0.070	0.257	0.065	0.022
Japan	0.556	0.315	0.538	0.825	0.362	0.201	0.660	0.025	0.003
Netherlands	0.056	0.063	0.052	0.050	0.041	0.008	0.044	0.004	0.005
New Zealand	0.009	0.010	0.010	0.010	0.005	0.004	0.011	0.002	0.063
Norway	0.024	0.022	0.008	0.016	0.016	0.004	0.017	0.004	0.000
Pakistan	0.015	0.056	0.039	0.190	0.072	0.390	0.186	0.106	0.021
Panama	0.000	0.001	0.000	0.001	0.003	0.004	0.000	0.003	0.005
Portugal	0.017	0.016	0.027	0.029	0.028	0.023	0.042	0.019	0.002
Singapore	0.010	0.004	0.007	0.011	0.006	0.000	0.010	0.000	0.000
Spain	0.098	0.070	0.082	0.110	0.091	0.060	0.153	0.107	0.045
Sri Lanka	0.007	0.014	0.012	0.030	0.015	0.061	0.032	0.011	0.002
Sweden	0.031	0.066	0.030	0.030	0.036	0.007	0.034	0.016	0.003
Switzerland	0.046	0.028	0.033	0.022	0.024	0.006	0.030	0.002	0.007
Thailand	0.025	0.046	0.021	0.167	0.052	0.579	0.086	0.100	0.001
Trinidad	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000
UK	0.174	0.266	0.225	0.137	0.233	0.011	0.252	0.037	0.048
Uruguay	0.002	0.004	0.005	0.009	0.010	0.005	0.006	0.008	0.057
US	1.000	1.000	1.000	1.000	1.000	0.094	1.000	1.000	1.000
W. Germany	0.311	0.169	0.268	0.235	0.194	0.069	0.304	0.039	0.020
Yugoslavia	0.053	0.058	0.049	0.045	0.038	0.083	0.091	0.041	0.027
Mean	0.102	0.092	0.099	0.138	0.097	0.102	0.129	0.066	0.052
S.D.	0.200	0.181	0.196	0.241	0.182	0.213	0.208	0.175	0.173
Skewness	3.414	4.251	3.600	2.655	4.104	3.063	2.963	5.051	5.470
Kurtosis	13.14	20.68	14.58	6.591	19.53	10.01	9.946	27.20	30.77

Table 3 reports the distance measure d_{ik} in (9) inverted and rescaled to the interval [0,1] so 1 is the most abundant country. The most capital abundant countries are Sweden, Norway, and West Germany, and scarcest are Bangladesh, Pakistan, and Thailand. The countries most abundant in professional labor are Sweden, the Netherlands, and Israel, and the scarcest Uruguay, Bangladesh, and Thailand. For cropland, the most abundant countries are Canada, Spain, and the US. The distributions of distance abundance measures are much closer to normal than the other measures. Their standard deviations are

Table 3
Distance abundance

	Capital	Labor						Land	
		Professional	Clerical	Sales	Service	Agriculture	Manufacturing	Cropland	Pasture
Austria	0.703	0.329	0.860	0.479	0.647	0.039	0.534	0.154	0.048
Bangladesh	0.000	0.018	0.049	0.622	0.318	0.671	0.176	0.125	0.002
Belgium	0.733	0.585	1.000	0.401	0.389	0.009	0.494	0.072	0.015
Canada	0.372	0.235	0.461	0.193	0.269	0.008	0.147	1.000	0.094
Columbia	0.103	0.023	0.105	0.143	0.230	0.085	0.099	0.158	0.473
Denmark	0.541	0.490	0.778	0.299	0.814	0.031	0.359	0.342	0.007
Finland	0.695	0.564	0.524	0.311	0.547	0.059	0.472	0.350	0.005
France	0.757	0.449	0.863	0.362	0.504	0.033	0.420	0.260	0.043
Greece	0.401	0.251	0.403	0.402	0.322	0.152	0.427	0.378	0.134
Hong Kong	0.374	0.147	0.616	0.608	1.000	0.004	1.000	0.000	0.000
Indonesia	0.102	0.035	0.109	0.822	0.142	0.591	0.231	0.124	0.019
Ireland	0.303	0.191	0.273	0.274	0.144	0.046	0.273	0.155	0.344
Israel	0.662	0.795	0.818	0.277	0.444	0.011	0.321	0.091	0.044
Italy	0.805	0.396	0.799	0.399	0.473	0.051	0.611	0.202	0.020
Japan	0.680	0.254	0.916	1.000	0.398	0.057	0.596	0.029	0.001
Netherlands	0.696	0.661	0.889	0.490	0.490	0.019	0.356	0.050	0.016
New Zealand	0.122	0.046	0.125	0.002	0.000	0.007	0.032	0.027	0.973
Norway	0.884	0.635	0.405	0.431	0.580	0.030	0.429	0.130	0.004
Pakistan	0.041	0.075	0.099	0.469	0.149	0.529	0.381	0.338	0.019
Panama	0.282	0.230	0.382	0.209	0.653	0.122	0.228	0.300	0.178
Portugal	0.358	0.224	0.767	0.488	0.620	0.122	0.704	0.376	0.013
Singapore	0.816	0.254	0.820	0.746	0.525	0.003	0.665	0.001	0.000
Spain	0.465	0.226	0.510	0.420	0.419	0.072	0.560	0.607	0.068
Sri Lanka	0.161	0.182	0.313	0.476	0.279	0.466	0.454	0.209	0.010
Sweden	0.445	1.000	0.581	0.316	0.541	0.019	0.332	0.217	0.012
Switzerland	1.000	0.418	0.921	0.319	0.462	0.023	0.413	0.037	0.037
Thailand	0.052	0.023	0.000	0.265	0.038	1.000	0.065	0.238	0.001
Trinidad	0.808	0.316	0.722	0.391	0.603	0.039	0.737	0.150	0.003
UK	0.466	0.651	0.878	0.247	0.695	0.000	0.503	0.098	0.040
Uruguay	0.054	0.000	0.063	0.000	0.083	0.010	0.000	0.095	1.000
US	0.408	0.304	0.547	0.299	0.394	0.002	0.251	0.476	0.158
W. Germany	0.854	0.303	0.992	0.489	0.479	0.039	0.580	0.097	0.015
Yugoslavia	0.441	0.366	0.537	0.257	0.277	0.198	0.584	0.353	0.069
Mean	0.472	0.324	0.549	0.391	0.422	0.138	0.407	0.219	0.117
S.D.	0.290	0.244	0.317	0.208	0.225	0.237	0.222	0.202	0.246
Skewness	−0.060	0.836	−0.309	0.795	0.196	2.369	0.252	2.047	3.001
Kurtosis	−1.163	0.492	−1.235	1.645	0.196	5.266	0.312	6.014	8.649

generally less than the means, with positive skew with high peaks only for the agricultural inputs. Distance abundance generates sensible abundance rankings, and the effect of comparing each factor with all of the others creates a normalizing influence.

Fig. 3 illustrates the difference in the three measures and isolates capital abundance outliers. The skewness of share and world abundances is apparent. The typical world abundance is close to zero. Share abundances of the developed countries are all close to zero. The more normal distribution of the

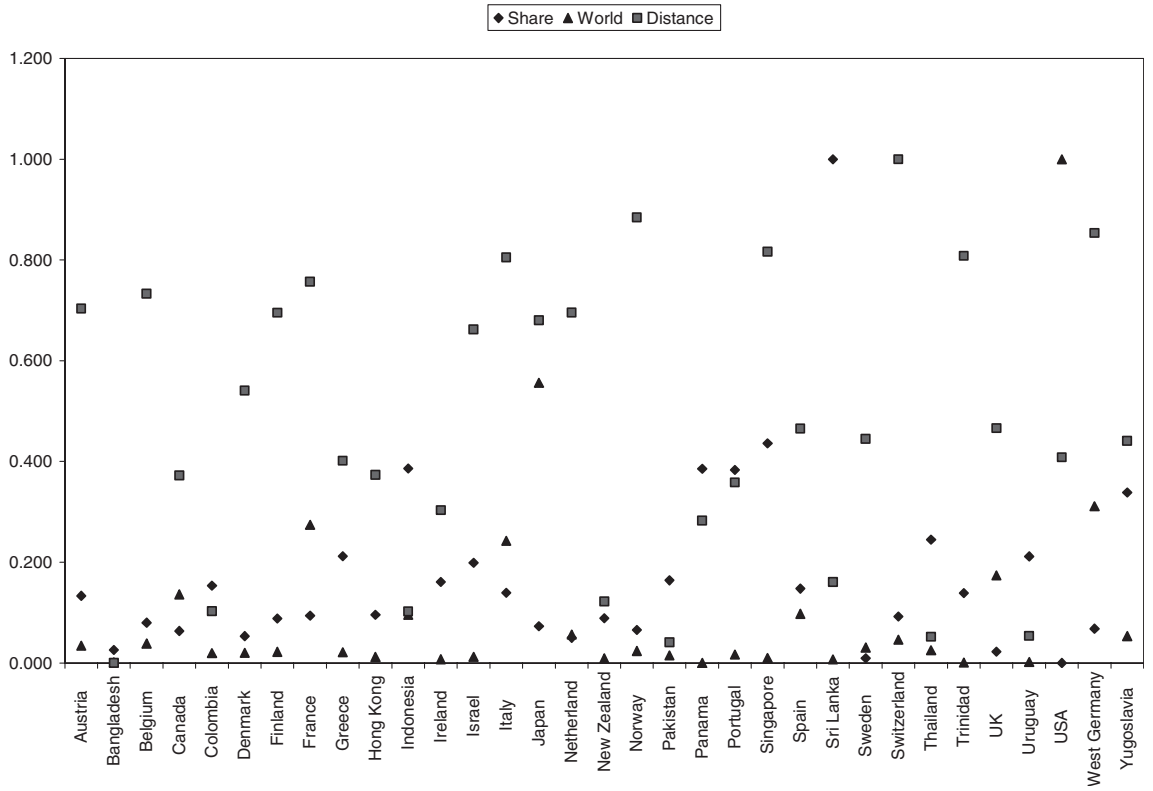

Fig. 3. Capital abundance.

distance abundance is apparent. The picture for manufacturing labor in Fig. 4 is similar with the poorest countries share abundant outliers, world abundance hovering close to zero, and a normal looking distribution for distance abundance.

Table 4 also illustrates the difference in the three measures by their correlations, typically small and more than a third negative. World and distance abundance are the most similar and the three measures are most consistent for agricultural labor. Given their differences, outcomes of tests of factor content theory are certain to vary across measures.

The first row in Table 5 reports the signs of US factor contents calculated by Trefler with positive signs indicating net factor exports. The US is a net importer of capital and all types of labor except agriculture, and is a net exporter of cropland and pastureland. Table 5 also reports the signs of the three US abundance measures relative to world means. Share and distance abundance correctly predict US factor content for every factor. World abundance predicts correctly only for agricultural inputs.

A similar analysis for all countries reported in Table 6 reveals that share abundance correctly predicts factor content for 54% of the sample, slightly better than a coin toss as pointed out by Trefler (1995). World abundance does considerably better, correctly predicting for 65% of the observations.

Distance abundance hardly misses, correctly predicting factor content for 97% of the sample. It misses only for pastureland, and 8 of the 9 misses are for scarce countries that export

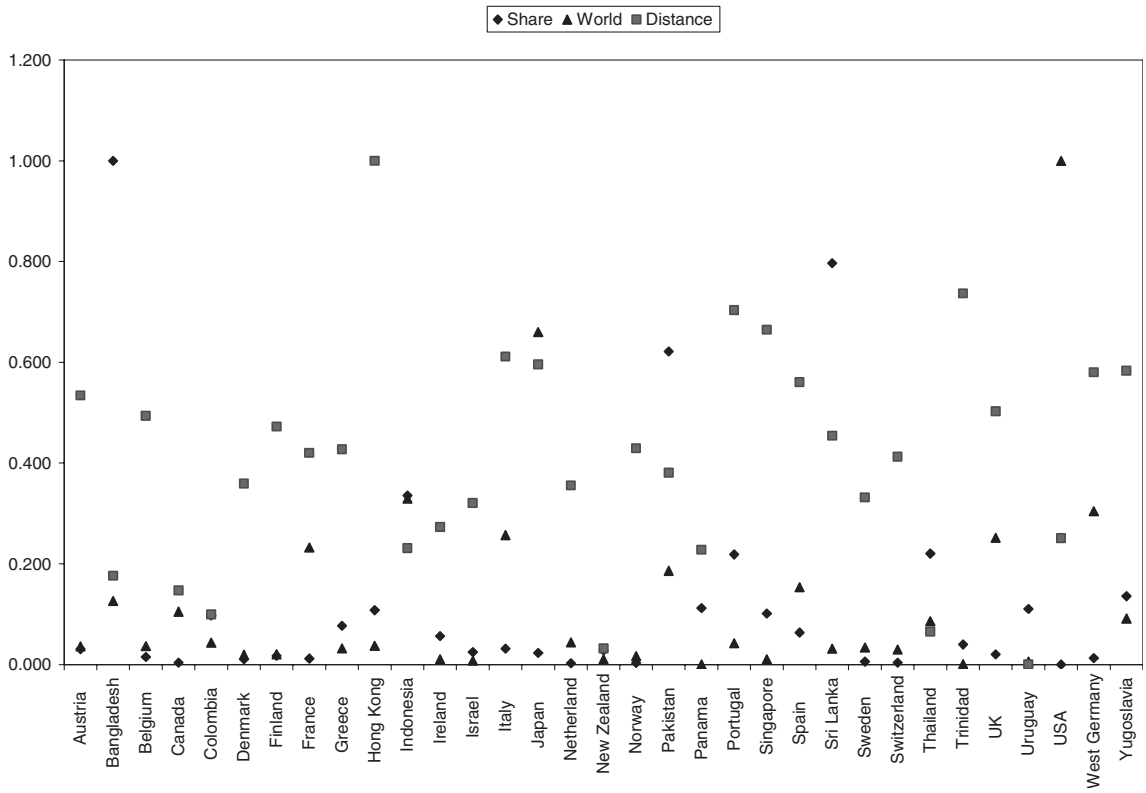

Fig. 4. Manufacturing labor abundance.

pastureland content. These countries use labor or capital intensive techniques to produce and export meat and dairy products. The odd case is France, importing pastureland content in spited of its abundance.

Table 4
Correlations of abundance measures

	Capital	Labor						Land	
		Professional	Clerical	Sales	Service	Agriculture	Manufacturing	Cropland	Pasture
Share–world	−0.686	−0.746	−0.738	−0.145	−0.735	0.656	−0.598	0.428	0.736
Distance–share	0.071	0.033	−0.070	0.379	−0.132	0.669	0.059	0.573	0.342
Distance–world	0.170	0.058	0.227	0.458	−0.025	0.815	0.009	0.428	0.123

Table 5
US factor content relative to world means

Factor content	−	−	−	−	−	+	−	+	+
Share	−	−	−	−	−	−	−	+	+
World	+	+	+	+	+	−	+	+	+
Distance	−	−	−	−	−	−	−	+	+

Table 6
Factor content sign test

	Share	World	Distance
Austria[a]	9	3	9
Bangladesh	4	9	9
Belgium[a]	7	4	9
Canada[a]	6	5	8
Columbia	1	9	9
Denmark[a]	8	3	8
Finland[a]	7	3	8
France[a]	5	8	8
Greece[a]	4	5	8
Hong Kong	3	5	9
Indonesia	2	4	9
Ireland[a]	1	8	9
Israel	6	5	9
Italy[a]	7	9	9
Japan[a]	9	6	9
Netherlands[a]	4	3	9
New Zealand[a]	2	9	9
Norway[a]	5	3	8
Pakistan	4	7	8
Panama	3	6	9
Portugal[a]	6	4	9
Singapore	7	4	9
Spain[a]	3	8	9
Sri Lanka	3	6	9
Sweden[a]	8	6	9
Switzerland[a]	5	4	9
Thailand	2	7	8
Trinidad	1	4	9
UK[a]	8	8	9
Uruguay	1	9	9
US[a]	9	3	9
W. Germany[a]	5	8	9
Yugoslavia	5	4	8
% Correct	54%	65%	97%

[a] OECD countries.

It is safe to say that tests of factor content theory with many factors and countries depend on the measure of factor abundance. The strength of share abundance is that it is part of a fully determined model of production and trade, but the assumption of static factor price equalization should greatly restrict its application. For the OECD countries in the present sample, share abundance correctly predicts factor content for 65% of the observations.

World abundance is useful as an empirical descriptor but does not relate to the underlying concept of factor abundance or production and does not perform very well in predicting factor content in the present data set.

Distance abundance has no necessary links to production short of restrictive assumptions, but it is an almost perfect predictor of factor content in the present sample.

5. Conclusion

Theory requires translation into testable hypotheses as noted by Bowen, Hollander, and Viane (1998), and distance abundance translates factor abundance from a two-dimensional concept. Distance abundance is empirically different from share and world abundance, and outperforms both in predicting the factor content of trade in the present data set.

One empirically valid approach to testing theory is to formulate an empirical model that captures as many theoretical specifications as possible as in the Stolper–Samuelson study of Rassekh and Thompson (1997). Another approach is to search for theoretical specifications that work best as in Davis and Weinstein (2001) for capital and labor inputs. Empirical trade theorists using either approach want a reliable independent measure of factor abundance, and distance measure has the potential to more completely illustrate the empirical scope of factor proportions trade theory.

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