

Testing the Heckscher-Ohlin-Vanek Paradigm in a World with Cheap Foreign Labor

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Abstract

Measuring factors services, not quantities, we examine the technologies and endowments of thirty-nine countries and five factors in 2005. We conduct three tests of the Heckscher-Ohlin-Vanek paradigm: (1) the conventional one; (2) a benchmark where every country has America’s technology; and (3) a test that converts foreign endowments into international efficiency units. The first predicts the direction of trade better than any former study. The second shows no statistically significant evidence of missing trade. The third performs just as well, and it accounts for international differences in both factor prices and unit input requirements.

***The data and the Matlab programs that are used in this paper are available upon request.**

Keywords: Heckscher-Ohlin-Vanek theory, factor services, international productivity comparisons

1. Introduction

By now it is well known that the predictions of the Heckscher-Ohlin-Vanek paradigm fail because countries have different technologies. Not only are their technologies different, their factor prices vary by at least an order of magnitude.¹ Although two generations of scholars since Leontief (1953) have tested the theory, almost all tests are based upon aggregating physically homogenous units, such as hectares of land or person-years of skilled labor, to predict which countries are abundant in which factors. Some authors make adjustments for the quality of a factor and base predictions upon efficiency units. But they are still adding physical units of quality-adjusted factors. This practice is wrong, and it is responsible for the horribly inaccurate predictions about the direction of the factor content of trade. Since the predictions are wrong, the rejections of the theory are spurious.

What do we do that's different? First, we return to basics. The factor content of trade in labor is not an exchange of person-years, but *trade in the services of labor*. A unit of labor is the annual value added attributed to a worker. For example, compensation to employees constituted about 57% of GDP in the United States in 2005. The analog in our sample of countries was 50% of aggregate GDP, indicating that American workers are much better paid than foreign labor. According to the strict logic of the Heckscher-Ohlin-Vanek paradigm, the United States is abundant in labor, even though its physical workforce is only seven percent of the sample aggregate. Indeed, the conventional application of the paradigm predicts that United States should *export* \$587 billion of labor services, but it actually imports \$306 billion.² This wrong

¹ Table 1 in Treffer (1993) shows that wages in Bangladesh are 5% of those in the United States.

² All values in this paper are measured in 2005 international dollars. The share of American labor measured as physical workers in the sample aggregate was computed from FAO Statistical Yearbook 2007-2008, Table A.3.

prediction is an anomaly, and it occurs because American wages are so high. For a large majority of countries, the direction of trade in labor services is predicted correctly.

In Heckscher-Ohlin-Vanek theory, a factor is mobile between sectors and immobile across countries. Land is surely such a factor. The rent paid to land in the United States was about 0.9% of GDP, and the analog for sample aggregate was 2.4%, indicating that the United States is scarce in land. Again this argument has nothing to do with how much arable land America has or how big its footprint is in the temperate zone. In this case, the prediction is that United States should import \$210 billion of the services of land, but it actually imports only \$11 billion. Now the direction of factor trade is correct, but its magnitude is too small.

We conduct three simple tests that strongly confirm the broad validity of the Heckscher-Ohlin-Vanek paradigm: (1) the conventional approach; (2) a benchmark where every country has an identical technology; and (3) one based upon converting all factors into common international efficiency units. In this literature, it is customary to begin by rejecting the theory resoundingly; then one analyzes increasingly arcane modifications that eventually confirm some ancillary versions of the paradigm. Since our tests confirm the theory, it is unnecessary to consider any complicated modifications of it. Indeed, our fundamental contribution is to give the theory its due, to treat the data with respect, and to develop corrections for international differences in productivity that are rooted in economic theory.

Data on the values of factor payments already include important corrections for productivity. *The services of labor incorporate local wages, an excellent measure of skill, and the services of land include local rents that reflect crop yield, another good measure of quality.* These market-based adjustments have a profound empirical implication. In fact, when

endowments and factor trade are measured properly, the conventional approach predicts the direction of trade better than any simple test before. In a sample of thirty-nine countries and five factors, it predicts 123 of 195 cases correctly. Under the null hypothesis that the paradigm predicts the direction of factor trade no better than a coin flip, the p -value of this statistic is 0.01%. *One only had to measure and predict factor services, not factor quantities.*

Although the direction of factor trade is predicted accurately, its magnitude is much too small. This finding reconfirms Trefler's (1995) missing trade. The second approach uses a simple benchmark in which every country's output is converted to factor services it would employ if it had to produce its output using the United States' technology. This benchmark predicts 168 of 195 cases correctly. Also, using the simplest possible regression and a Wald test of conventional size, one cannot reject the null hypothesis that measured factor trade matches the predictions completely. So this benchmark solves the mystery of missing trade.

The benchmark confirms that *the main reason for missing trade is that countries have different technologies*. In particular, the paradigm's demand-side assumptions are innocuous. This finding has several important empirical implications. First, one can assume that all goods and services are traded. Second, there is no need to adjust for home bias in consumption. Third, there is no need to account for transportation costs or other barriers to trade in final goods and services. Fourth, it is not necessary to keep track of which intermediate inputs are made where. Fifth, assumptions about imperfect competition or intra-industry trade are not relevant. In sum, the simple assumption that every country consumes its absorption share of the world endowment works very well.

The reader may feel uncomfortable with the benchmark because it involves a virtual world. The third and final step is to make an adjustment—based fully in economic theory—to the actual endowments of each country to convert them into efficiency units comparable with the American endowment. This adjustment has two alternative interpretations. First, it lists the American factor content of foreign Rybczynski effects. Second, its transpose lists the Stolper-Samuelson effects in the foreign country of an exogenous change in American factor prices that affects world prices. Factor conversion matrices arise directly from data on technologies by country. These matrices generalize factor-specific international productivity differences, and they are the best linear mapping between factor uses by sector in different countries. A factor conversion matrix is an important theoretical contribution in its own right, and we hope trade theorists might benefit from studying its properties closely.

These international productivity adjustments are novel. Measuring factors in terms of services already incorporates factor prices, the best scalar adjustment for international differences in factor quality. But countries' technologies differ more fundamentally than a lack of factor price equalization. Factor conversion matrices make the necessary second adjustment. Indeed, in this third test, there are 159 correct predictions about the direction of trade, and there is no statistical evidence of missing trade. *Using raw data on endowments and technologies, converting them into American efficiency units, estimating nothing, and making no ancillary demand-side assumptions, we find overwhelming support for the Heckscher-Ohlin-Vanek paradigm in a wide sample of countries.*

How does this technique help to account for the anomalous prediction about American labor services? In a world of cheap foreign labor, the American labor endowment is too large. Once one adjusts for differences in technology, America's share of world labor, measured in

efficiency units, becomes smaller. Then the theory correctly predicts that the United States will import labor: the prediction is imports of \$214 billion and the measure is imports of \$306 billion.

If countries have identical technologies and factor prices are the same everywhere, the difference between physical units and the services of factors is moot; indeed, it's just the common world wage-rentals ratio in a model with two factors. Hence, once one scales factor content—as is the norm in the literature—there is no harm in thinking either in terms of quantities of a factor or the services (value added) attributed to it. When one acknowledges that technologies and factor prices differ across countries, the distinction between a person year and the annual services of a worker is fundamental. Under the assumption of perfect competition, the labor's compensation exactly matches its value added in GDP. So measures in values are fundamentally consistent, both with local national accounts and across countries. Working with physical quantities of factors has outlived its usefulness for empiricists interested in Heckscher-Ohlin-Vanek theory. Our contribution is to push this insight as far as it will go.

2. Review of the Literature

Leontief (1953) measured the local factor content of capital in 1947 dollars per million dollars of exports and the local factor content of labor in man-years per million dollars of exports. His work was predicated upon the assumption of identical technologies, and he wanted to calculate American resources saved by importing goods instead of producing them locally. The early work on the American input-output table focused on quantities of labor for good reason. As Evans and Hoffenberg (1952) explain, the initial research at Harvard and the Bureau of Labor Statistics on the American input-output table was designed to predict the employment

effects of the demobilization after World War II. The unintended consequence was that Leontief began the practice of measuring labor in physical units and the capital stock in real dollars.

Many important contributions in this literature continued to measure quantities of factors, not their services. This practice made sense when researchers could only use the United States input-output matrix and data on factor uses by sector in foreign countries were recorded only in physical units. Leamer's (1984) monograph is the classic contribution that has influenced a generation of scholars. Examining quantities of factors and using the United States as a reference country, Bowen, Leamer, and Sveikauskas (1987) tested the assumption of Hicks-neutral international technological differences. They concluded that differences in technology were likely behind the failure of tests of the theory. Trefler (1993) extended this work by computing a complete list of country-specific and factor-specific productivity differences that fit the measured factor content of trade exactly. He did not have as rich a set of data as we have, and part of our analysis evaluates Trefler's productivity adjustments. We find that such simple modifications do not account properly for the heterogeneity of technologies across countries.

Analyzing consistent input-output data on ten countries, Davis and Weinstein (2001) made a path-breaking contribution. They emphasized that it was obvious by inspection that countries do not have the same technologies, but they followed the tradition of measuring factors as quantities. Hakura (2001) recognized the difficulty of testing the theory when countries have different local production techniques. She cautions, "Biased factor contents of trade in the strict HOV can lead to a discrepancy between the calculated factor content of trade and that predicted from endowments." Romalis (2004) analyzed a model with imperfect competition, but his empirical work was based on factor usages in quantities. Again using quantities to measure

factors, Maskus and Nishioka (2009) estimate factor-specific productivity adjustments that improve predictions about the factor content of North-South trade.

When countries produce the same thing in different ways, it may be important to trace the path of value added to calculate the factor content of trade. This is Reimer's (2006) approach, and Trefler and Zhu (2010) build on it by constructing an input-output matrix for the world. They prove two theorems that show how to measure factor content in a world with arbitrary technical differences. Their measure of factor content is quite appealing; it is Deardorff's (1982) "actual factor content of trade". If it takes one hour of Mexican labor to make a sombrero and one hour of American labor to retail it in California, then the "actual factor content" of the retailed sombrero is two hours of world labor. Trefler and Zhu establish necessary and sufficient conditions under which this measure is equal to Vanek's putative prediction.

Unfortunately, Trefler and Zhu describe Vanek's prediction incorrectly. They implement their ideas empirically by studying (scaled) person years of labor. But Vanek himself was careful in his dissertation (1963) and his famous article (1968) to define the factors with "each content being measured in its money-value." *The factor content of trade is trade in the value of factor services, not trade in the physical units of the factors themselves.*³ Leamer (1987, p. 985) emphasized this point by stating, "The theory ... is properly interpreted to refer to value added,

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