

**The Development and
Testing of Heckscher-
Ohlin Trade Models:**

A Review

Robert E. Baldwin

The MIT Press
Cambridge, Massachusetts
London, England

© 2008 Massachusetts Institute of Technology

All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means (including photocopying, recording, or information storage and retrieval) without permission in writing from the publisher.

MIT Press books may be purchased at special quantity discounts for business or sales promotional use. For information, please e-mail special_sales@mitpress.mit.edu or write to Special Sales Department, The MIT Press, 55 Hayward Street, Cambridge, MA 02142.

This book was set in Palatino on 3B2 by Asco Typesetters, Hong Kong and was printed and bound in the United States of America.

Library of Congress Cataloging-in-Publication Data

Baldwin, Robert E.

The development and testing of Heckscher-Ohlin trade models : a review / Robert E. Baldwin.

p. cm. — (Ohlin lectures)

Includes bibliographical references and index.

ISBN 978-0-262-02656-7 (hc : alk. paper) 1. International trade—Econometric models. I. Title.

HF1379.B355 2008

382.01'5195—dc22

2008016995

10 9 8 7 6 5 4 3 2 1

1.1 The Heckscher-Ohlin Proposition

It has been 75 years since the publication of Bertil Ohlin's (1933) pathbreaking treatise on interregional and international trade and nearly 90 years since the publication of the article by Ohlin's teacher, Eli Heckscher (1919), that significantly shaped Ohlin's thinking about trade theory.¹ No names are more closely associated with modern trade theory than those of Heckscher and Ohlin. As the basis for international trade, their model focuses on differences among countries in relative factor supplies and on differences among commodities in the intensities with which they use these factors. They show how differences in the relative supplies of factors of production influence the nature of intercountry differences in comparative costs under autarky conditions and explain how these differences affect not only the pattern of international trade but also factor prices and factor allocations in producing goods and services.² Furthermore Ohlin recognized that trade theory could be expressed in general equilibrium terms, where the prices and quantities of all goods and factors are

determined simultaneously and the unsatisfactory real cost analysis of the classical model is avoided.

A century earlier David Ricardo (1817) had recognized that differences in comparative rather than absolute costs among countries are the basis of international trade and, therefore, that all countries can benefit from trade, even a country that is absolutely more productive in all goods. He did not investigate in any detail just why intercountry differences in comparative advantage arise, however. Intercountry differences in fixed-coefficient technology are simply assumed.

The basic Heckscher-Ohlin (HO) proposition about the nature of the commodity and the factor composition of interregional and international trade is as follows: "Roughly speaking, abundant industrial agents are relatively cheap, scanty agents relatively dear, in each region. Commodities requiring for their production much of the former and little of the latter are exported in exchange for goods that call for factors in the opposite proportions. Thus, indirectly, factors in abundant supply are exported and factors in scanty supply are imported." (Ohlin 1933, p. 92). It is the statement in the latter sentence that is referred to here as the basic HO proposition. General equilibrium theories in which relative factor endowments play an important role in determining the factor content of trade are termed to be HO trade models.

One of the reasons that Ohlin began this statement of the HO proposition with the phrase "roughly speaking" was his awareness that differences in relative factor prices under autarky conditions that would result just from differences in relative factor supplies could be offset by relative differences in consumer preferences for products between the two countries. For example, consumers in the country with the

higher capital/labor endowment ratio could have such a strong preference for capital-intensive goods compared to the consumers of the labor-abundant country that, under autarky conditions, the prices of capital-intensive goods and thus the ratio of the return to capital to wages could be relatively higher in the capital-abundant country than the labor-abundant country. Consequently the opening of free trade between the two countries would result in the capital-abundant country importing capital-intensive goods and exporting labor-intensive goods. However, Ohlin (1933, pp. 16–17) believed that differences in relative factor endowments generally are more important than differences in relative preferences in shaping trade patterns.

Although Ohlin regarded differences in relative factor endowments as the main determinant of a country's pattern of trade, he did not regard them to be sufficiently important to justify focusing only on this relationship in theorizing about the nature of trade patterns or in empirically investigating them. He frequently emphasized the importance of scale economies in shaping the commodity composition of trade and sometimes put this relationship on an equal level of importance to that of relative factor endowments (Ohlin 1933, pp. 106–108; see earlier Ohlin 1924, p. 83, of the English translation of Ohlin's doctoral dissertation in Flam and Flanders 1991). He also emphasized the importance of qualitative differences in productive factors among countries, the use of entirely different technical processes of production by countries, intercountry variations in the stability of economic conditions, and different social conditions of production. Thus, apparently because he was concerned about abstracting too much from real world conditions, Ohlin did not formulate a simple factor proportions model with, for example, only two goods, two factors, and two

countries. With such a model he could have much more readily investigated not only the assumptions necessary for the HO proposition to hold in a rigorous manner but also the possible effects of trade on factor prices.

In a mathematical appendix in which he explains how the factor proportions framework can be integrated into a general equilibrium pricing system, he does explicitly assume identical, constant returns-to-scale production functions in the two trading regions. However, in explaining the set of goods traded between the two countries, he assumes that each country specializes in a unique set of goods that are cheaper than in the other country at an exchange rate that balances the value of each country's exports and imports.³ In modern terminology, he assumes that the two countries produce within different cones of factor diversification.⁴ This enables Ohlin to avoid concluding, in contrast to Heckscher, that factor prices are equalized across countries with constant returns-to-scale production functions under free trade and no transportation costs. He apparently believed that factor price equalization was so unrealistic as a real world outcome that he did not want his theoretical framework to permit this possibility.

Ohlin's theory involves many productive factors and many goods, but it does not explain how the ordering of a country's ratios of its endowment of each factor to the world endowment of each factor is related to the ordering of the ratios of the country's net exports of each factor (embodied in goods) to the world endowment of each factor. Abundant factors are simply exported and scarce factors imported. It is not until Vanek's (1968) generalization to the many-factors, many-goods case that such an exact relationship is established.

In addition to adopting a very broad approach to analyzing the influences shaping trade patterns, Ohlin's analytical framework takes into account feedback effects of changes in trade on such determinants as the relative quantities and qualities of productive factors, the rate of technological change, the preferences of consumers, and the various economic and social institutions in each country. In other words, Ohlin explored not only the static general equilibrium effects of changes in the basic determinants of trade on the prices and outputs of both goods and factor services but also studied the dynamic implications of these effects on the quantitative and qualitative nature of the determinants as well. He did not attempt to undertake rigorous empirical tests of the HO proposition, however. Instead, Ohlin relied mainly on historical examples of the relationship among countries' trade patterns and their relative factor endowments to support this proposition.

The basic proposition set forth by Heckscher and Ohlin, namely that a country exports factors (embodied in goods) that are relatively abundant compared to the rest of the world and imports its relatively scarce factors, is still a key component of modern trade theory, but much has changed from Ohlin's analysis in *Interregional and International Trade* (1933) in terms of both theoretical formulation and empirical testing. Subsequent authors have not shown Ohlin's reluctance in making assumptions that result in factor price equalization and in constructing models from which strong, quantitative propositions about the predicted and actual factor content of trade can be rigorously derived (the Vanek theorem). In addition their models produce strong predictions about directional changes in factor prices as a consequence of changes in product prices (the Stolper-Samuelson

theorem) and about directional changes in outputs in response to changes in relative factor supplies (the Rybczynski theorem). Indeed their theoretical contributions have been sufficiently significant that their names are often added to those of Heckscher and Ohlin in describing the model. For example, the familiar two-good, two-factor, two-country version is often referred to as the Heckscher-Ohlin-Samuelson (HOS) model in recognition of Samuelson's contributions in formulating the Stolper-Samuelson and factor price equalization theorems. The model that serves as the initial basis of most modern empirical trade tests is usually described as the Heckscher-Ohlin-Vanek (HOV) model in recognition of Vanek's contribution in formulating the theory in factor-content terms within a multi-good, multi-factor, multi-country framework. The key relationship of the HOV model is that the amount of a particular factor of production embodied (directly and indirectly) in a country's net trade of goods and services equals its endowment of this factor minus the world endowment of this factor multiplied by the country's share of the world's consumption of goods and services.

Analyses of situations in which factor price equalization does not occur under free trade have also been undertaken by trade economists (e.g., Jones 1956–57; Bhagwati 1972; Deardorff 1979; Brecher and Choudhri 1982b; Helpman 1984a). In his 1984 paper Helpman rigorously establishes a set of conditions concerning the factor content of *bilateral* trade patterns that *must* hold under free trade in a non-factor price equalization model without any restrictions on preferences. He does assume identical technologies between the countries, however. Interestingly this is the model that Ohlin set forth in his mathematical appendix. Although

Helpman points out that his predictions should prove useful in empirical tests of factor proportions trade theory, it has only been within recent years that they have been used for this purpose. (His model is described in detail in chapter 2, and the empirical evaluation of the model by Choi and Krishna 2004 is discussed in chapter 4.)

1.2 General Purpose and Some Conclusions

In this book I review both the theoretical development of the basic insights of Heckscher and Ohlin into the modern factor-content trade model and the results of empirical tests of HO models.⁵ I devote particular attention to examining the extent to which the factor-content version of the HO proposition is supported in these empirical tests. I also examine the results from investigating other predictions of HO models, in particular, the search for Stolper-Samuelson, Rybczynski, and factor price equalization effects. My general purpose is to evaluate how well the formulation and testing of HO models have succeeded in improving our understanding of the forces shaping international trade and its economic impact.

My basic conclusion on this matter is that we have made considerable theoretical and empirical strides over the last fifty or so years in improving our understanding of the economic forces affecting the factor trade embodied in traded commodities. However, it does appear that most empirical trade economists (myself included) became overfascinated with the elegant but highly unrealistic factor price equalization models developed from the insights of Heckscher and Ohlin to the detriment of empirically investigating other theoretical models without this relationship. Since bilateral

tests involving the United States and the rest of the world produced mixed results with regard to the HO proposition, leading empirical trade economists began to devote much of their efforts to assembling detailed multi-country data sets on trade and factor endowments in order to tie the tests of the HO proposition to the basic HOV model. The tests revealed little support for the HO proposition that countries export their relatively abundant factors (embodied in goods) and import their relatively scarce productive factors. Specifically, they showed that the signs predicted by the HOV model for the net exports of productive factors matched the signs of measured net exports of these factors in only about 50 percent of the cases, or by the proportion one would expect simply by chance. More detailed analysis also revealed that the measured net trade embodied in productive factors is an order of magnitude smaller than predicted by the basic HOV equation: there is a huge gap between the amount of factor trade predicted by the equation and the actual factor trade measured by researchers. This gap has been described by Trefler (1995) as “the case of the missing trade.”

These economists then sought to determine if they could account for the very poor performance of the HOV model by introducing a few econometrically simple modifications of its assumptions that would lead both to a much better quantitative fit between the actual and predicted factor content of trade and to an increase in the proportion of sign matches between the predicted and actual factor content of trade. Introducing “best-fit” Hicks-neutral differences in factor efficiency among countries is an appealing modification, since factor price equalization in efficiency units still exists with this modification. As I show in detail in chapter 4, introducing this modification significantly reduces the

amount of missing trade. However, it does not appreciably improve the results of the basic test of the HO proposition with regards to the proportion of sign matches between the predicted and actual factor content of trade.

It is only when the assumptions of the HOV model are further modified to yield nonuniform differences among factor input requirements within and among countries (see the discussion in chapter 4 of Davis and Weinstein 2001a) that there is also strong support for the HO proposition.⁶ The modification by these authors involves introducing both Hicks-neutral estimates of intercountry efficiency differences based on their data set and observed differences in capital/labor endowment ratios among countries as indicators of the extent to which industry factor inputs differ across countries.⁷ This matching of the predicted and actual factor content of trade in an accounting sense is an ingenious accomplishment, but the resulting model is very different from the HOV model with factor price equalization from which they started. Although the successive modifications help account for why the HOV model fails, the basic reasons why factor efficiency differences occur or why multiple cones of factor diversification arise are not explained. Although we end up concluding that relative factor endowments matter in accounting for the embodied factor content of trade, there remains a black box of other important forces influencing this trade whose components and determinants are not well understood. Further research efforts directed at formulating and testing theories dealing with these determinants are very much needed.

In hindsight, in investigating the empirical relationship between relative factor endowments and the factor content of international trade, it may have been more productive to place greater emphasis on the non-factor price equalization

model investigated by Brecher and Choudhri (1982b), more fully developed by Helpman (1984a), and finally tested by Choi and Krishna (2004). This might have avoided what seems to have been excessive attention on trying to account for the “missing trade” that is a key result of strong tests of the unmodified HOV model. Efforts might have been devoted earlier to such highly relevant topics of recent empirical research as testing for the existence and number of cones of diversification (e.g., Schott 2003a, b), the exchange of factor services involved in intra-industry trade (e.g., Davis and Weinstein 2001b), and the importance of economies of scale (e.g., Antweiler and Trefler 2002; Davis and Weinstein 2003).

The heavy focus on the HOV model may also help explain why trade economists have not devoted as much attention as Ohlin to the dynamic feedback effects of trade on such basic determinants as the quantity and quality of productive factors and the state of technology. Perhaps the prospects that an analysis of these effects would not yield such sweeping and sharp economic conclusions as has emerged from the static HOV framework have served to discourage research along these lines. Probably a more important explanatory factor, however, is the long tradition of classical and neoclassical economists of analyzing international trade mainly in comparative static terms.

While there have been important exceptions to the usual comparative statics approach to trade theory (e.g., see Grossman and Helpman 1991), trade economists need to devote more attention to the effects of trade on technological conditions, on the domestic supplies and international movements of capital and labor as well as on such factors as consumer tastes, the competitive nature of markets, and

the nature of economic institutions. By not analyzing the dynamic effects of trade with the same depth as they analyze their static determinants, trade economists tend to underemphasize the manner in which trade influences the nature of an economy's development over time and the policy issues that affect this matter. In my view, Ohlin rightly took a much broader view of the conditions determining the commodity patterns of trade compared to most modern analysts of the subject and correctly stressed more strongly how the feedback effects of trade, in turn, affect the nature of these conditions. Of course, while it is easy to discuss such matters qualitatively, the real need is for rigorous analytical results that lead to sensible empirical results.⁸

The study is organized in the following manner. Chapter 2 briefly surveys the development of HO trade theory. No attempt is made to undertake a full and detailed history of economic thinking on HO models. The chapter simply presents the perspective of one academic who has observed much of the development of these models as it occurred. As will be explained, key scholars involved in the formulation and extension of the primary proposition of Heckscher and Ohlin into a two-good, two-factor, two-country general equilibrium model were Stolper and Samuelson (1941), Samuelson (1948, 1949, 1953–54), and Jones (1965a). Travis (1964), Melvin (1968), and especially Vanek (1968) then played key roles in generalizing this model into the modern multi-good, multi-factor, multi-country factor-content HOV model. As the chapter emphasizes, these extensions of the basic intuitions of Heckscher and Ohlin into an elegant, yet simple general equilibrium model with strong relationships between relative factor supplies of countries, relative prices and outputs of the goods they produce, and the relative

returns earned by the productive factors represent a major accomplishment in trade theory. They quickly replaced the real cost approach that had long dominated the modeling of the causes and consequences of international trade. The non-factor price equalization model of Helpman (1984a), which builds on earlier work by Brecher and Choudri (1982b), is also discussed in the chapter.

Chapters 3 and 4 review and critique empirical tests of the basic HO proposition, which states that a country exports factors (embodied in goods) that are relatively abundant compared to the rest of the world and imports its relatively scarce factors. Chapter 3 covers the early period of testing beginning with Leontief's famous 1953 paper to about the mid-1980s during which trade economists mainly measured the factor content of a single country's trade with the rest of the world for only two or three productive factors. Particular attention is devoted to the so-called Leontief paradox. Chapter 4 then examines test results of the HO proposition in a multi-factor, multi-country framework that began with Maskus (1985) and Bowen, Leamer, and Sveikauskas (1987) and have continued to be carried out by Trefler (1993, 1995), Davis and Weinstein (2001a), and others. This chapter also focuses on empirical tests of the basic HOV relationship that the amount of a particular factor of production embodied (directly and indirectly) in a country's net trade of goods and services equals its endowment of this factor minus its share of world consumption times the world endowment of this factor. Among other topics covered are country-pair tests of the HO proposition and empirical investigations into the importance of intra-industry trade and increasing returns. The test of Helpman's (1984a) non-factor price equalization model undertaken by Choi and Krishna (2004) is also reviewed in this chapter.

Chapter 5 reviews selected empirical investigations of the other basic propositions of the HO model, namely, the Stolper-Samuelson, Rybczynski, and factor price equalization theorems. Chapter 6 then concludes with a brief summary of what we have learned from the various empirical tests and a discussion of lines of research topics that seem to warrant greater attention in the future.

