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The Empirics of Comparative Adavantage: Overcoming the Tyranny of Non-Refutability

by

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Abstract

I assess the empirical evidence on comparative advantage. I argue that the Heckscher-Ohlin-Vanek (H-O-V) relationship is not a refutable general equilibrium proposition. Consequently, the empirical Heckscher-Ohlin literature has been suffering from *the tyranny of nonrefutability*. The trade governing principle of comparative advantage, the Ricardo-Haberler-Deardorff (R-H-D) theorem, yields a refutable general equilibrium prediction about the pattern of international trade and allows for a theory-based assessment of the magnitude of the gains from trade. The recent experimental evidence on Japan's 19th century opening up to world trade provides a strong case for the hypothesis that comparative advantage governed Japan's international trade in its early trading years. The aggregate gains from that trade are estimated to be no larger than 9 % of Japan's GDP.

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Outline

1. Introduction

Although it is common to talk about different models, or sources, of comparative advantage, there is just a single mechanism through which international trade affects an economy in the framework of static general equilibrium trade theory: through changes in relative commodity prices.[1] In this framework, *intrinsic* differences in country-specific opportunity costs, or autarky prices, cause international trade and predict the direction of such trade. The analytical beauty of this opportunity cost formulation is that in a competitive market equilibrium autarky prices embody all the relevant information about economic fundamentals like preferences, endowments and technologies.

Generations of researchers have contributed to our overall understanding of the complexity and subtlety of the mechanism of comparative advantage. However, three dates can be singled out as *turning points* in the intellectual history of comparative advantage. In 1817 David Ricardo discovered the mechanism. In 1930 Gottfried Haberler initiated its modern opportunity cost formulation, which enabled the subsequent trade theory literature to link this mechanism to general equilibrium price theory. Half a century later, Alan Deardorff (1980) developed a fully-specified multi-country, multi-good general equilibrium formulation of comparative advantage. The latter provided us with a refutable general equilibrium prediction about comparative advantage. Honoring the contributions of Ricardo and Haberler, I will refer to this prediction as the Ricardo-Haberler-Deardorff (R-H-D) theorem of comparative advantage.

This paper makes two contributions. First, I discuss and compare the R-H-D theorem with the Heckscher-Ohlin-Vanek (H-O-V) relationship. I show that the R-H-D theorem yields a refutable general equilibrium prediction with a well-specified alternative hypothesis. In contrast, the H-O-V relationship provides only meaningful predictions for individual factors of production. If one views H-O-V through the general equilibrium lens, it is simply a factor market equilibrium condition. It is not a refutable general equilibrium proposition. The empirical Heckscher-Ohlin literature has been suffering from the tyranny of nonrefutability.

Second, I summarize the recent experimental implementation of the theory of comparative, drawing heavily on Bernhofen and Brown (2004, 2005). Here I use Haberler's production possibility curve as a device for illustrating the counterfactual

[1] See Matsuyama (1995) for an excellent discussion of how, in the framework of monopolistic competition, increasing returns provides another mechanism through which trade affects an economy.

reasoning required for testing the R-H-D prediction and assessing the comparative advantage gains from trade.

2. The Ricardo-Haberler-Deardorff prediction of comparative advantage

The R-H-D theorem embodies the analytical beauty of the opportunity cost formulation of comparative advantage. For a small open economy, it requires just two pieces of information: a country's n-good autarky price vector p^a and its corresponding n-good net import vector T. In an Arrow-Debreu world of perfect competition and complete markets, the autarky price vector p^a contains all the revelevant information about the economy's intrinsic conditions in isolation. The net import vector T contains all the relevant information about the conditions of the country's trading partners. Ruling out the imposition of export subsidies, the Ricardo-Haberler Deardorff theorem can be stated as[2]:

$$\text{R-H-D Theorem: } p^aT>0 \qquad (1)$$

In the theoretical trade literature, (1) is generally referred to as the weak law of comparative advantage. It is considered weak since it does not provide any prediction about the trading pattern of individual commodities. However, to a student familiar with the competitive general equilibrium literature this is not surprising. Unless one is willing to impose some fairly restrictive assumptions like gross substitutability, the complexity of general equilibrium relationships prevent predictions on a good by good basis.[3]

From an empirical perspective, the R-H-D theorem is highly attractive. In fact, it is a *meaningful* theorem, where *meaningful* is meant the way Paul Samuelson defined it many years ago (Samuelson, 1947, p.4):

"*By a meaningful theorem I mean simply a hypothesis about empirical data which could conceivably be refuted, if only under ideal conditions…It is meaningful because under ideal circumstances an experiment could be devised where one could hope to refute the hypothesis*".

[2] Since export subsidies are permissible for individual goods, this condition is actually fairly weak. It only requires that net export subsidies are, on average, nonpositive.
[3] See Drabicki and Takayama (1979) for a detailed discussion of theses issues.

The attractiveness of the R-H-D theorem stems from its refutability, which can be illustrated as follows. R-H-D embodies a linear transformation of a net import vector T into a real number p^aT. Formally, this defines a function: $f:R^n \rightarrow R$, with $f(T)=p^aT$. The R-H-D prediction partitions the real line R in two subsets with equal measure. Formally, $R= S \cup S^c = \{s=p^aT, \text{ where } p^aT>0\} \cup \{s=p^aT, \text{ where } p^aT \leq 0\}$. In probabilistic terms, the R-H-D predicts that S will be a sure event, i.e. for any net import vector T, p^aT will always be positive. However, the R-H-D prediction is refutable since p^aT can fall either in S or in S^c. Since S and S^c are of equal measure we can specify, as the alternative, that p^aT is random and that this inner product is positive with probability ½. The null and the alternative hypothesis can then be stated as follows:

$$H_0: \Pr(p^aT>0)=1; \qquad H_1:\Pr(p^aT>0)=1/2, \tag{2}$$

where Pr(.) denotes the probability measure. A great virtue of the opportunity cost formulation of comparative advantage is not only that it leaves us with an alternative, i.e. p^aT is just random, but also with a probability statement about that randomness. This provides as much theoretical guidance for empirical work as one can hope for.

3. Heckscher-Ohlin-Vanek: a view through the general equilibrium lens

Motivated by the observation that in the case of more than two factors the factor proportion theory does not yield any meaningful theorems about the pattern of commodity trade, Jaroslav Vanek (1968) suggested to consider the factor-content of trade. Focusing on factor services embodied in commodity trade, Vanek was able to identify an unambiguous sign prediction on a factor-by-factor basis. This version of the Heckscher-Ohlin theorem has been called the Heckscher-Ohlin-Vanek (HOV) model. For a single economy, the H-O-V prediction for each factor i can be stated as follows:

$$\text{H-O-V factor prediction:} \quad FT_i=V_i-sV_{iw}. \tag{3}$$

FT_i denotes the economy's net export, V_i the economy's endowment and V_{iw} the world economy's endowment of factor i and s denotes the country's share in the world economy. For the last two decades, equation (3) has been at the center stage of the empirical

comparative advantage literature.[4] This literature has justified its empirical inquiry of H-O-V by looking at it through the factor prediction lens. In particular, if factor i is relatively abundant, i.e. if $V_i > sV_{iw}$, then H-O-V predicts that the economy will export the services of that factor, i.e. $FT_i > 0$.

However, this perspective hides the fact that H-O-V is a special formulation of a competive general equilibrium model where prices bring all markets into equilibrium. If factors move across economies –embodied in commodities as Vanek envisioned it- each factor market must be in equilibrium. In particular, this means that the world price vector p_w has to be such that the country's supply of factor V_i equals its demand from home $s(p_w)V_{iw}$ and abroad $FT_i(p_w)$. H-O-V is simply a factor balance of trade equilibrium condition:

$$V_i = s(p_w)V_{iw} + FT_i(p_w). \quad (4)$$

From this viewpoint, H-O-V does not provide a testable hypothesis. Also if we had 'perfect data' and the world were such that all countries produced the same goods with the same production functions and all consumers had identical homothetic preferences, we could never refute (4). Since H-O-V is not a refutable general equilibrium proposition, an empirical analysis of H-O-V becomes, in essence, an accounting exercise. Consequently, the empirical literature on H-O-V has been suffering from the tyranny of nonrefutability.

4. Testing the R-H-D prediction: the natural experiment of Japan

The R-H-D theorem evaluates a country's net trading vector T at the corresponding autarky price vector p^a. From an empirical standpoint, this requires data on an economy under two regimes: open trade and autarky. Japan's 19th century opening up to world trade provides almost ideal circumstances for testing the prediction of the theory. First, during its final years of autarky (i.e. 1851-1853) and its first two decades of open international trade, the Japanese economy was compatible with the critical assumptions of neoclassical trade theory. Second, Japan's export and import goods during its early trading years (i.e. 1868-

[4] Leamer and Levinsohn (1995), Davis and Weinstein (2003) and Feenstra (2004) survey this literature.

1875) can be justifiably classified as fairly homogenous; the available price data are good measures of relative opportunity costs. This justifies calling the case of Japan a "natural experiment" for testing the prediction of the theory.

The detailed description of the experimental conditions and the strategy for testing the prediction can be found in Bernhofen and Brown (2004). In what follows, I will use Haberler's production possibility curve to illustrate the counterfactual reasoning required for testing a static theory when, in fact, the autarky and open trade regimes are observed at different points in time.

Figure 1 depicts Japan's transformation curves, denoted by PPF_{1850s} and $PPF_{1870s,}$ during its autarky period (early 1850s) and its free trade period (early 1870s). PPF_{1870s} lies outside of PPF_{1850s}, capturing the fact that the economy's production opportunities pertain to different historical points in time. The economy's consumption/production point under autarky C^a_{1850s} occurs at the tangency between the autarky price line p^a_{1850s} and the economy's autarky transformation curve PPF_{1850s}. International trade permits a separation between production and consumption. Under free trade, the economy's production point P^f_{1870s} occurs where the free trade price line p^f_{1870s} is tangent to the transformation curve PPF_{1870s}. The free trade consumption point is depicted by C^f_{1870s}.

[insert Figure 1 here]

The theory of comparative advantage, in its static form, involves a comparison between autarky and free trade under the same production possibility curve PPF_{1870s}.
In its two-good formulation, the theory predicts that the country will export good 1 (i.e. $T_1<0$) and import good 2 (i.e. $T_2>0$) if good 1's relative opportunity cost under autarky is lower than its opportunity cost under free trade. Using the trade triangle relationship, this slope prediction is equivalent to the two-good formulation of the R-H-D theorem given in (1):

$$p^a_1 T_1 + p^a_2 T_2 > 0. \qquad (5)$$

From an empirical viewpoint, this prediction requires a counterfactual interpretation. Specifically, the economy will export good 1 if the free trade relative price of good 1 (i.e. the slope of the line p^f_{1870s}) is larger than the relative price (i.e. the slope of

the line p^a_{1870s}) that would have prevailed if the economy had operated under autarky in the 1870s. Although the latter price is not observable, one can postulate a sufficient condition for substituting the observable autarky price p^a_{1850s} for the counterfactual autarky price p^a_{1870s}. This identification condition does not require that these prices are necessarily the same. Loosely speaking, it requires only that the slope of p^a_{1870s} has not become larger than p^a_{1850s}. Assuming unchanging preferences, this condition can be interpreted that the economy's growth path from PPF_{1850s} to PPF_{1870s} was either balanced or biased towards its exportable. Formally, this can be written as:

$$(p^a_{1850s} - p^a_{1870s})T \leq 0, \qquad (6)$$

In the n-good case (6) says that the economy experienced, on average, a growth path which was either balanced or biased towards the export goods.

In Bernhofen and Brown (2004) we have provided a reasonable justification for this identification condition for the Japanese economy. We then constructed an autarky price vector p^a , the average of the prevailing market prices during the last three autarky years 1851-1853. As the *experimental free trade period*, we chose the years 1868 through 1875, a period for which the Meiji restoration has not yet kicked in, at least economically. This average autarky price vector p^a was then applied to the net import vector for each of the eight

trading years, i.e. $T_{1868},\ldots T_{1875}$. The fact that each of the 8 inner products had a positive sign provides a strong empirical case for the prediction of the theory. In fact, the alternative hypothesis, i.e. H_1:$Pr(p^aT>0)=1/2$, can be rejected with the likelihood of 99.6%.

5. A counterfactual assessment of the comparative advantage gains from trade

Given that Japan's pattern of trade was in accord with the prediction of the theory, the next step is to empirically investigate the gains from that trade. An additional virtue of the theory is that the size of the inner product p^aT provides information about the magnitude of the comparative advantage gains from trade. In particular, in Bernhofen and Brown (2005) we have shown that the inner product is an upper bound for the Slutsky compensation measure of a welfare change:

$$\Delta W_{Slutsky} = C^f_{1850s}\, p^a_{1850s} - C^a_{1850s} p^a_{1850s} \leq p^a_{1850s}\, T_{1850s}. \qquad (7)$$

[insert Figure 2 here]

The welfare change is illustrated in Figure 2. Under autarky, the country faces the autarky price vector p^a_{1850s} and is able to afford the autarky consumption point C^a_{1850s}. The Slutsky compensation measure $\Delta W_{Slutsky}$ gives the increase in income that would be required to afford the consumption point C^f_{1850} that the economy could have obtained if trade had been allowed. An empirical assessment of the gains from trade requires information on the autarky price vector p^a_{1850s} and the counterfactual net import vector T_{1850s}. The empirical challenge is how to construct this counterfactual net import vector T_{1850}. More specifically, which goods would Japan have traded if it were open to international trade in the 1850s and in what quantities? The gains from trade are closely linked to the pattern of trade.

The circumstances of Japan's opening up provide an unusual opportunity for using the observed net import vector T_{1870s} as a basis for the construction of the counterfactual net import vector $T_{1850s.}$ Since the opening up was a truly exogenous event, it seems reasonable to presume that the counterfactual trading vector T_{1850s} would not have been too different from the observed trading vector T_{1870s} and that this trade would have been also governed by the law of comparative advantage. In Bernhofen and Brown (2005) we exploit this line of reasoning for the construction of T_{1850s}. Using different approaches to estimate Japan's GDP during 1851-53, we found that the counterfactual gains from trade wouldn't have been more than 9% of GDP.

6. Concluding Remarks

In her insightful essay on the progress of economic thought, Joan Robinson (1964, p.22) remarked that "Economics…all along has been striving to escape from sentiment and to win for itself the status of a science." But how does a science operate? By formulating and testing hypotheses. One of the guiding principles for theoretical work is to derive hypotheses that can, in principle, be refuted by the data. The guiding principle for scientific empirical work is to construct or identify experimental environments compatible with the assumptions of the theory. Only if the assumptions of the theory are reasonably justified, does it make sense to take the theory to the data.

The H-O-V theorem provides sign predictions for individual factors of production. However, comparative advantage is about general equilibrium. And general equilibrium is about the *interaction* of markets. Consequently, a refutable comparative advantage

hypothesis should involve a country's *entire* trading vector T or its *entire* factor content of trade vector FT. The R-H-D theorem provides a refutable prediction about an economy's entire trading vector, i.e. $p^aT>0$. In contrast, the H-O-V model *embeds* FT into a general equilibrium equation system, i.e. $FT=V-sV_w$,. Such a relationship is not refutable.

Japan's 19th century opening up to world trade provides an experimental environment for a scientific test of the theory of comparative advantage with nonexperimental data. Since the experimental environment is compatible with the critical assumptions of the theory, the theory is given, a priori, a fair chance. However, the predictions of the theory could have been refuted. The fact that Japan's trading pattern confirmed the theory's prediction for each of the 8 experimental data points provides a strong empirical case for the theory. The theory of comparative advantage truly deserves the status of a crown jewel, not only from a theoretical but also from an empirical stand point.

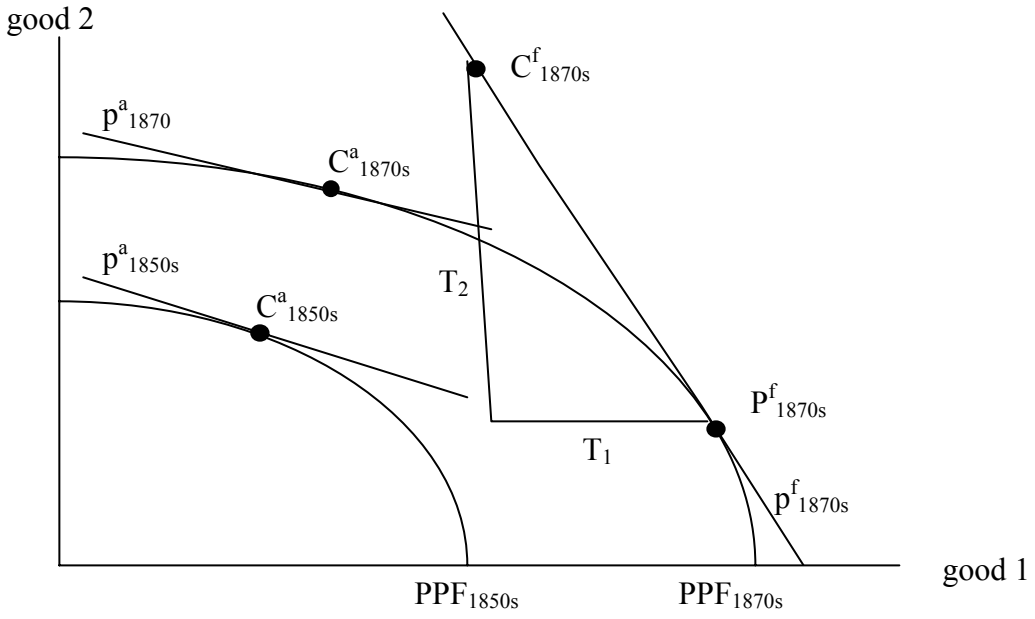

Figure 1. The pattern of trade prediction

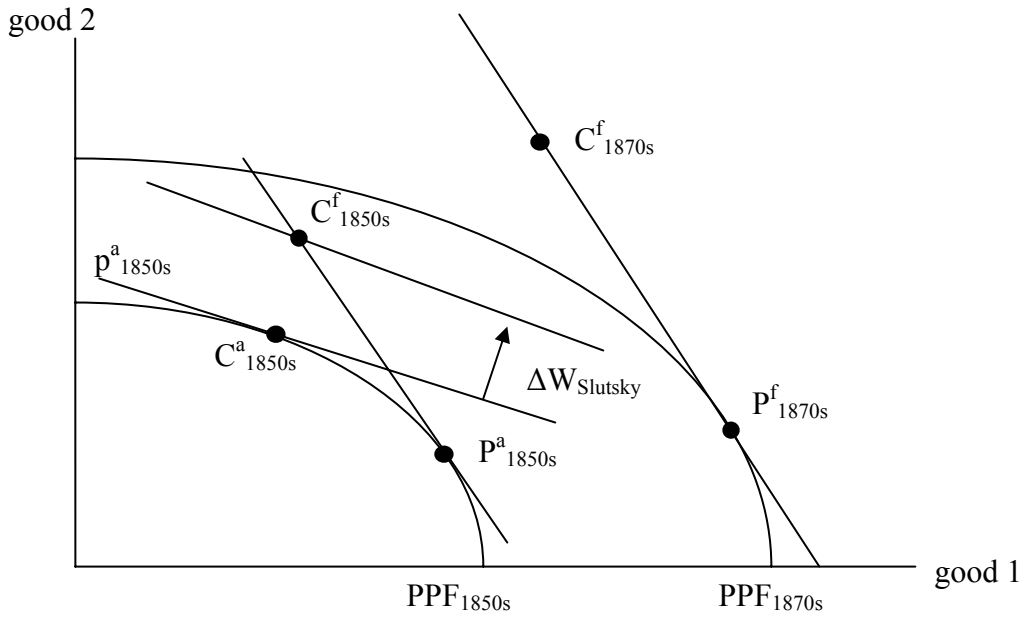

Figure 2: The counterfactual gains from trade

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