7.6 Econometric Evidence on the Ricardian Model

The Ricardian model's basic assumptions are that there is a single factor of production (labor), outputs are subject to constant returns to scale, and international variations in labor productivity are exogenously given by technological differences. These are extremely strong claims that we can reject simply by observing the world around us. There are many factors of production, including capital, land, and labor of varying skill levels. We can think of many industries that have increasing returns to scale. And, while technologies may be fixed at a point in time there are incentives to invest in better techniques or higher quality that could change the productivity rankings. Furthermore, we can easily reject a basic prediction of the model, that countries completely specialize in particular products or industries. Extreme specialization may be relevant for countries with dominant natural resources, such as Saudi Arabia and its heavy reliance on oil exports. However, this outcome is more related to resource endowments than to technolgical differences. In truth, the Ricardian model is a pronounced abstraction from reality designed to make important points about comparative advantage and the gains from trade rather than to serve as a basis for explaining real-world trade.

Still, it may be true that actual international trade flows are generated to an important degree by differences in labor productivity, making it worth studying the Ricardian model empirically. The theory makes a central claim that in principle should be testable with data and sufficient care to control for other influences on trade. Specifically, relative differences in industry-level productivity across countries should be strongly correlated with comparative differences in exports or net exports. Equivalently, within a country those industries with the highest relative labor productivities should have the highest comparative levels of exports or net exports.

Before describing one study of this hypothesis let us take a brief look at some recent data. One fundamental point of the technology-differences model worth checking first is the extent to which labor productivity and real wages are correlated. Recall from the model that countries with higher labor productivity should experience higher real wages in both autarky (which is unobservable) and free trade. In Table 1.1 we provide recent figures for several countries on a centtral measures of productivity in the overall manufacturing sector: value added per hour of work. *Value added* refers to the gross value of a product minus the costs of purchased intermediate inputs such as raw materials and processed components. For example, in automobiles the value added in a car is the price received by a manufacturer minus that firm's costs for the parts needed to assemble it. It is a measure of the net revenues available to pay for labor and capital (including profits) and certain taxes. This is the best measure of output actually generated in a firm or industry. Indeed, GDP is defined as the sum of value added across all producing sectors. The table also has data on earnings per hour worked in manufacturing and annual earnings per employee.

Table 1.1 shows that in 2004 the United States had the highest levels of hourly productivity, whether the data for other countries are measured in market exchange rates or in purchasing power parity (PPP) exchange rates.[1] It is immediately evident that the richer countries are more productive, with value added per hour ranging from just 64 cents in India to $46.10 in Sweden. Hourly earnings are less than value added per hour because value added also goes to paying for capital, land, profits and some taxes. Still, there is clearly a strong relationship between productivity and the hourly wage, with Indian workers averaging 19 cents per hour, Mexican workers $1.77 per hour, and Swedish workers over $17 per hour. The correlation between the first two columns is 0.94. Average annual earnings also clearly fall as workers become less productive. Although the rankings are slightly different, the same conclusions hold for the PPP-based calculations. The correlation between hourly productivity and hourly earnings using that set of exchange rates is 0.91.

It is also straightforward to show that there is a strong association between *growth* in productivity and compensation over time. Thus, for example, in a sample of 12 countries over the period 1997-2007, South Korea's value added per hour in manufacturing rose by 8.5 percent per year on average while its average real (inflation-adjusted) hourly compensation rose by over 6.0 percent per year, both the highest figures.[2] The growth rates in productivity and compensation were highly correlated in that sample.

While these data are interesting, no one should be surprised that earnings rise with labor productivity, if only because more productive workers generate more value added that supports their incomes. A considerably more rigorous test of Ricardian theory should relate figures on international trade to underlying labor-productivity coefficients that differ by industry and country. This is the approach taken by Stephen Golub and Chang-Tai Hsieh (2000) in a comparison of the United States with seven other industrialized economies and two emerging economies.[3] Their idea was to study econometrically the relationship between measures of bilateral comparative advantage, based on actual trade flows, and relative labor productivities. Thus, they specified and estimated the following econometric equation:

$$\log(X_{ijk} / M_{ijk}) = \alpha_{jk} + \beta_{jk} \log(a_{ik} / a_{ij})_{-1} + \varepsilon_{ijk} \qquad (7.15)$$

The variable X_{ijk} refers to exports of good *i* from country *j* to country *k*, while M_{ijk} refers to imports of the same good coming into country *j* from country *k*. Thus, the authors argued for using *net exports*, or the ratio of exports to imports, as the appropriate measure of bilateral comparative advantage.

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[1]PPP exchange rates were explained in Chapter One.

[2]These figures (not shown here) were calculated by the authors using data available from the U.S. Department of Commerce, Bureau of Labor Statistics.

[3]This article followed much earlier studies by MacDougall (1951), Stern (1962) and Balassa (1963).

The coefficients a_{ik} and a_{jk} are measures of inverse labor productivity, in this case employment per dollar of value added in good *i*. Note that because the coefficients of the exporting (importing) country *j* are in the numerator (denominator) of the independent variable, an increase in this ratio implies a rise in the relative productivity of the exporter. The coefficient α_{jk} is the constant term in the bilateral regression and β_{jk} is the slope coefficient, which captures the direct impact of relative productivity variations on net exports. If the Ricardian model is correct this coefficient should be significantly positive for that would imply that the country with more productive labor in a good has a higher ratio of exports to its trading partner than imports from its partner. The final term, ε_{ijk}, is a residual error capturing the unexplained difference between net exports and relative labor productivity for each good.

Four comments should be made at the outset about this specification. First, it is too simple to capture reality, for there are many variables other than labor productivity that affect trade flows. Among these are factor endowments, transport costs, and trade barriers. Thus, the authors assumed that such omitted variables are captured in the error term and need not be considered further, a claim that we discuss below. Second, astute readers may wonder why the independent variable is the ratio of absolute labor coefficients rather than the ratio, in each country, of productivity in a good relative to average manufacturing productivity. The latter is what the Ricardian model would suggest in the presence of multiple goods. In fact, this is not a problem because regression techniques actually estimate the impacts of deviations of particular observations from sample averages. Third, the authors implicitly assumed that labor productivity coefficients are fixed, or exogenous in econometric terms, rather than being themselves a function of variables that change with international trade flows. In models other than the strict Ricardian case this is not a tenable assumption for productivity would depend on, say, factor intensities and output scales, themselves dependent on factor prices that can change with international trade. In that regard, the regressions may suffer from an *omitted variables bias*, which arises from the endogeneity of labor-value added coefficients. To try to control for this problem Golub and Hsieh simply lagged the right-hand side variable by one year to make it pre-determined. In general this is not a sufficient remedy for the endogeneity problem. Finally, the equations are estimated using data for 21 manufacturing industries. Note that these sectors are defined quite broadly, including such items as food, beverages and tobacco; chemicals excluding drugs; electrical machinery; and motor vehicles. Thus, in each category there are hundreds of individual commodities that are aggregated into a single dollar value of exports or imports, raising the problem of *aggregation bias*. In practice it is unlikely that labor productivity in producing baked goods is the same as that in soft drinks, or that they are identical in all kinds of electrical machinery, which covers both industrial machines and household appliances.

To estimate this equation the authors assembled data on bilateral trade between the United States (as one partner) and Japan, Germany, the UK, France, Italy, Canada, Australia, South Korea and Mexico for the 21 industries over the period 1970-1992.[4] They also found figures on value added per worker. Because value added was reported in national currencies, Golub and Hsieh translated those figures into dollars using both annual market exchange rates and PPP rates. They pooled the data for each year and estimated a *seemingly unrelated regression (SUR)* specification. In this approach the assumption is that the error terms in any yearly cross-section are independent across bilateral trading partners, and therefore not correlated, as required by basic ordinarily least squares. However, the errors are likely correlated for any bilateral pair over time because trade patterns do not change rapidly, particularly for highly aggregated industries. The SUR technique in effect estimates the 23 cross-section equations simultaneously but permits an unchanging vector of non-zero time-series correlations. It should be noted that data availability varied by country over time, so the estimation period in effect was different for each country pair and the pooled panel was not balanced.

We present their primary results on the slope coefficients in Table 7.2. Because this is a double-log specification the coefficients may be interpreted as elasticities. Thus, for example, in the slope column under market exchange rates the coefficient 0.41 for US-Germany suggests that a one-percent increase in the ratio of US to German labor productivity should expand US net exports with Germany by 0.41 percent. The main question, however, is whether these coefficients are positive and significant as suggested by the Ricardian model. In general the results are supportive: six of the nine coefficients are significantly positive using market exchange rates while three are significantly negative. These negative results for the UK, France and Korea are surprising for they indicate an inverse relationship between productivity and trade performance. However, using PPP rates seven coefficients are significantly positive, including that for Korea, while those for the UK and France become insignificant. Because PPP rates are superior means of comparing costs and productivity across countries than are the more variable market rates, it seems that the technology-differences model is well supported by the data.

On this basis economists should be encouraged in thinking that comparative advantage really matters in driving trade. This is an intriguing result and supports studying the Ricardian model for its practical relevance in addition to its theoretical elegance. Still, we should not get carried away because the results can be criticized on a number of grounds. Begin with econometric issues. First, as noted, this simple regression of trade on one variable – relative labor productivities – fails to control for other key determinants of international exchange. It is easy to see from the low R^2 terms that this specification does not explain much of the variation in relative net exports.[5] Second, and more importantly, if those determinants, such as trade barriers, economic infrastructure, imperfect competition and capital and land endowments, are correlated with labor productivity the coefficients may be biased to an unknown degree. This omitted

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[4]These data are available from the Organization for Economic Cooperation and Development (OECD) and interested students may access them at http://puck.sourceoecd.org/vl=2724352/cl=19/nw=1/rpsv/home.htm.

[5]The R^2 statistic captures the ratio of variation in the dependent variable that is explained by variation in the independent variable(s). An R^2 of 0.02 means that just two percent of the changes in net exports can be attributed to changes in labor productivities.

variable bias is likely to be significant in these regressions. Third, the fact that data are missing for a number of countries and years, making the panel unbalanced, raises concerns about the stability and robustness of these estimates, though this problem is unlikely to imply that the true coefficients are negative. The net result of all these shortcomings is that while the authors have succeeded in demonstrating that there is a positive correlation between relative labor productivity and net exports, they have not established a causal relationship.

Ultimately, the economic logic of the test is really what matters here. On this score one basic criticism can be raised. Specifically, the results in Table 7.2 are consistent with trade theories other than the Ricardian model. For example, it is easy to show that in a world where trade is caused by differences in factor endowments but where factor prices are not equalized, the relative productive of labor will be higher in capital-abundant countries for most or all industries.[6] Similarly where industries are characterized by increasing returns to scale labor may be more productive for this reason alone, rather than having innate productivity differences. Thus, the econometric results may be picking up these kinds of factors and cannot be considered a true test of the Ricardian theory in the sense of accepting it and rejecting others. We conclude that labor productivity is certainly correlated with sectoral export performance but at best offers only a partial explanation for actual trade flows.

[6]On factor-endowments trade and factor price equalization see Chapter 8.

References

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Table 7.1 International Comparisons of Productivity and Wages in Manufacturing, 2004

	Market Exchange Rates			PPP Exchange Rates		
Country	VA per hour	Earnings per hour	Average Earnings	VA per hour	Earnings per hour	Average Earnings
US	$ 47.47	$ 16.15	$34,263.84	$ 47.47	$ 16.15	$34,263.84
Sweden	$ 46.10	$ 17.16	$33,459.65	$ 38.36	$ 14.28	$27,847.19
Netherlands	$ 42.85	$ 22.66	$41,238.26	$ 42.20	$ 22.32	$40,613.83
Japan	$ 38.94	$ 14.37	$32,506.47	$ 31.46	$ 11.61	$26,263.97
Australia	$ 36.94	$ 16.78	$33,247.49	$ 40.10	$ 18.22	$36,090.21
UK	$ 34.89	$ 19.22	$40,972.09	$ 32.34	$ 17.81	$37,978.26
France	$ 34.60	$ 20.37	$38,985.14	$ 33.62	$ 19.79	$37,870.91
Canada	$ 33.38	$ 15.37	$30,281.55	$ 36.05	$ 16.59	$32,702.79
Spain	$ 30.34	$ 14.91	$27,750.56	$ 35.86	$ 17.62	$32,800.87
Rep. of Korea	$ 16.40	$ 9.39	$23,145.03	$ 23.92	$ 13.70	$33,773.86
Mexico	$ 8.76	$ 1.77	$ 4,102.92	$ 12.40	$ 2.50	$ 5,811.97
Costa Rica	$ 8.57	$ 1.75	$ 4,325.54	$ 17.49	$ 3.58	$ 8,827.07
Philippines	$ 3.78	$ 0.48	$ 1,097.95	$ 15.81	$ 1.99	$ 4,588.86
Egypt	$ 3.39	$ 0.47	$ 1,374.00	$ 10.68	$ 1.48	$ 4,321.29
India	$ 0.64	$ 0.19	$ 458.55	$ 3.18	$ 0.95	$ 2,292.76

Sources: calculated by the authors from International Labor Organization, *Laborsta Database*; World Bank, *World Development Indicators*; International Monetary Fund, *International Financial Statistics*; and figures at www.NationMaster.com.

Table 7.2 Primary Results from Regressions of Bilateral Net Exports on Relative Labor Productivities

		Market Exchange Rates		PPP Exchange Rates	
Country Pair	Period	Slope (b)	R^2	Slope (b)	R^2
US-Japan	1984-91	**0.14**	0.09	**0.20**	0.10
US-Germany	1977-90	**0.46**	0.06	**0.83**	0.11
US-UK	1979-90	**-0.08**	0.03	-0.02	0.02
US-France	1978-90	**-0.21**	0.02	0.02	0.02
US-Italy	1979-89	**0.26**	0.11	**0.25**	0.01
US-Canada	1972-89	**0.41**	0.02	**0.73**	0.01
US-Australia	1981-91	**0.72**	0.05	**0.89**	0.10
US-Korea	1972-90	**-0.64**	0.02	**0.93**	0.18
US-Mexico	1980-90	**0.46**	0.14	**0.56**	0.18

Source: Golub and Hsieh (2000). Coefficients in bold are significantly different from zero at the one-percent level (99-percent confidence level), based on standard errors that are consistently estimated in the presence of heteroskedasticity.