An Empirical Assessment of the Comparative Advantage Gains from Trade: Evidence from Japan

By DANIEL M. BERNHOFEN AND JOHN C. BROWN*

We provide an empirical assessment of the comparative advantage gains from trade argument. We use Japan's nineteenth-century opening up to world commerce as a natural experiment to answer the following counterfactual: "By how much would real income have had to increase in Japan during its final autarky years of 1851–1853 to afford the consumption bundle the economy could have obtained if it were engaged in international trade during that period?" Using detailed historical data on trade flows, autarky prices, and Japan's real GDP, we obtain upper bounds on the gains from trade of about 8 to 9 percent of Japan's GDP. (*JEL* F11, F14, N10, N75)

The one point on which most economists will agree is that opening up to international trade will increase a country's economic welfare. Economists base their faith in the benefits of free trade primarily on theoretical reasoning, predominantly the theory of comparative advantage.[1] While the theoretical case for the gains from trade is well established, we still know very little about the empirical magnitudes of the gains from international trade and the mechanisms generating these gains. This paper estimates the magnitude of the gains resulting from one of the most dramatic trade liberalizations in recorded economic history: Japan's nineteenth-century reopening to world commerce after over 200 years of self-imposed isolation.

A common characteristic of any theoretical discussion of the gains from trade is that it presumes an underlying cause of international trade: "first one explains the causes of trade ... and then one explains the gains, given these causes" (W. Max Corden, 1984, p. 72). By specifying and estimating different empirical models of comparative advantage, the empirical trade literature has made considerable progress in identifying the causes of international trade.[2] Since comparative advantage is defined in terms of relative autarky prices, which are generally not observable, the empirical comparative advantage literature has had to take the intermediate step of relating autarky prices to observable features such as factor supplies and measures of technological differences. Although the trade literature has yielded important results on the empirical importance of the factors that explain the pattern of international specialization and trade, it has not yet provided any evidence on how much specialization according to comparative advantage contributes to an economy's overall income. This paper fills this gap in the literature. It provides the first

* Bernhofen: Department of Economics, Clark University, Worcester, MA 01610 (e-mail: dbernhofen@clarku.edu); Brown: Department of Economics, Clark University, Worcester, MA 01610 (e-mail: jbrown@clarku.edu). We are indebted to Yukie Okuyama, Sumiko Otsuka, and Stephen Papadopoulos for excellent research assistance. We thank Michael Burda, Alan Deardorff, Albrecht Ritschl, Dave Richardson, Mark Spörer, two anonymous referees, and seminar participants at Brandeis University, Clark University, Indiana University, Syracuse University, Humboldt Universität Berlin, Universität Tübingen, the Annual Cliometrics Conference at North Carolina State University, the Empirical Investigations in International Trade Conference at Purdue University, and the Midwest International Economics Meetings at Penn State University for helpful comments. Osamu Saito and Yasakuchi Yasuba provided invaluable suggestions for sources.

[1] The seminal papers on the gains from trade are Paul Samuelson (1939, 1962) and Murray Kemp (1962). Max Corden (1984) contains a comprehensive treatment of the theoretical gains from trade literature.

[2] Alan Deardorff (1984); Edward Leamer and James Levinsohn (1995); Donald Davis and David Weinstein (2003); and James Harrigan (2003) provide excellent surveys of this literature.

hard evidence on the magnitude of the static gains from trade resulting from comparative advantage.

For the most part, computable general equilibrium (CGE) models have been used to generate estimates of economy-wide gains from trade. To develop estimates, CGE models rely on specific functional forms, and behavioral parameters are often either assumed or adapted from estimates that stem from elsewhere. While computable general equilibrium modeling is an indispensable tool for policy analysis and forecasting, the results of these studies do not provide hard evidence on the gains from trade.[3]

The gains-from-trade argument also motivates another empirical literature on the relationship between trade and economic growth. Cross-country studies have established overwhelming evidence of a positive statistical correlation between trade and growth in real income.[4] This literature has been wrestling, however, with two major empirical challenges: the endogeneity of both trade and income and the difficulty of controlling for "the other factors" that determine a country's income level.[5] Jeffrey A. Frankel and David Romer (1999) have recently suggested a simple but innovative approach to dealing with these two issues. Using the geographic characteristics of countries as instruments for trade, they obtain instrumental variable estimates of the effect of trade and provide plausible evidence for the hypothesis that trade has a positive effect on income. They note that specialization according to comparative advantage is only one channel through which trade can influence income; other channels are increasing returns and geographic proximity. They concede that "[their] approach cannot identify the specific mechanism through which trade affects income" (Frankel and Romer, 1999, p. 381).

By contrast, this study embeds the analysis of the gains from trade within a theoretical framework that also identifies the underlying cause of international trade. It uses Japan's nineteenth-century trade liberalization as a natural experiment to estimate the effects of trade on national income. In our previous work (Bernhofen and Brown, 2004), we have provided supportive evidence for the hypothesis that the Japanese trading pattern during 1868–1875 was in accord with the positive prediction of the theory of comparative advantage. Given that Japan's trade after its opening up was governed by the law of comparative advantage, this paper takes the next step and provides estimates of the gains from trade resulting from comparative advantage.

Three key features of the Japanese case make it an attractive natural experiment. First, both shortly before and after its opening up in the late 1850s the economy arguably met the key assumptions of the neoclassical trade model: competitive markets, product homogeneity, and price-taking behavior on international markets. Second, the free trade period used for empirical analysis—the late 1860s through the mid-1870s—predates the importation of foreign production technologies and the rapid transformation of the set of technologies available to the Japanese economy that characterized subsequent economic growth. It also occurs after non-tariff barriers to trade established during the initial opening up had been eliminated. In short, the opening up to international trade characterizes the main change in the economy during this period. Third, the opening up confronted the Japanese economy with a dramatic change in the vector of relative prices that it faced.[6] The Western powers so compromised Japan's tariff autonomy that it had little leverage to cushion the affected sectors of its economy from these price shocks. Thus, within seven years the country went from nearly complete autarky to virtually free trade.

Our empirical analysis is rooted in a general equilibrium framework that links the Deardorff-Dixit-Norman (DDN) index of comparative advantage (the inner product between net imports

[3] Recent representative studies include Glenn Harrison, Thomas Rutherford, and David Tarr (1996); Joseph Francois, Bradley McDonald, and Hakan Nordstroem (1996).

[4] Ann Harrison (1996) provides a critical survey of this literature.

[5] For example, countries often undertake trade liberalization as part of a comprehensive program of financial reform, deregulation, and privatization. It is difficult to identify the separate effect of trade liberalization.

[6] See Yasakuchi Yasuba (1996, p. 546) who argues that the Japanese terms of trade rose about 2.8 times during the six years after opening up.

and autarky prices) to the Slutsky compensation measure of welfare.[7] The availability of detailed and high-quality data on commodity prices and trade flows enables us to construct this index of comparative advantage and apply it to the following counterfactual: *"By how much would real income have had to increase in Japan during the autarky years of 1851–1853 to afford the consumption bundle the economy could have obtained if it were engaged in international trade during that period?"* Using alternative approaches to estimating Japan's GDP during the final years of autarky, we estimate that at most the gain in real income was 8 to 9 percent of GDP.

Our estimates provide an important reassessment of the work by J. Richard Huber (1971), who was the first to attempt to quantify the gains to the Japanese economy from opening up to world commerce. Huber's approach was primarily descriptive. He focuses on some key commodities and his approach lacks a theoretically coherent framework for measuring the gains from trade. He claims that "Japan's real income (for a constant population) may have increased by as much as 65 percent in the transition from autarky to trade" (Huber, 1971, p. 614). Huber implicitly justifies these large estimated gains by pointing to the significant changes in some of the relative prices following Japan's trade liberalization. Our results suggest that focusing on price changes alone can be misleading; assessing the welfare gains resulting from a reallocation of resources requires information on the interaction between relative prices and trade flows. The measure of comparative advantage employed in this study captures this interaction.

I. Theoretical Framework

The gains-from-trade argument is about causality. The theoretical literature on the gains from trade has established such causality using an analytical paradigm that compares an economy in a state of autarky to a state of unrestricted international trade. Using this analytical framework as a guide for an empirical analysis requires a correct interpretation of the autarky-free trade comparison. This paper follows the advice of Elhanan Helpman and Paul Krugman (1985, p. 39), who point out that the autarky-free trade framework is not about the comparison of an economy "before" and "after" trade liberalization, but rather a comparison of an economy "if trade had *not* been allowed" versus "if trade *had* been allowed." Our subsequent methodological discussion is based on this counterfactual interpretation of the autarky-free trade paradigm.[8]

TABLE 1—TWO THOUGHT EXPERIMENTS OF JAPAN'S OPENING UP

	First welfare comparison	Second welfare comparison
Factual world	1850s under autarky	1870s under free trade
Counterfactual world	1850s under free trade	1870s under autarky

The natural experiment of Japan provides a comparison of an observed autarky regime during the early 1850s with an observed free trade regime in about 1870. The case of Japan suggests two thought experiments for investigating the gains from trade, which are illustrated in Table 1. First, one can consider the income of the Japanese economy during its observed autarky period relative to the economy's counterfactual income if trade had occurred during the 1850s. Alternatively, one can consider the real income of the Japanese economy during its free trade period relative to the economy's counterfactual income if Japan had operated in isolation during the 1870s. From a theoretical point of view, both welfare comparisons are legitimate for addressing the gains from trade. From an empirical point of view, the credibility of the analysis hinges on our ability to construct the counterfactuals with a satisfactory degree of precision.

[7] This index has been developed independently by Deardorff (1980) and Avinash Dixit and Victor Norman (1980).

[8] The term counterfactual is used quite often by economists, but it is sometimes not clear in its meaning. We use the term counterfactual for a contrary-to-fact state of the world, as it is defined in the analytical philosophy literature. Specifically, our methodological framework has been inspired by the seminal work of the philosopher Jon Elster (1977). Donald McCloskey (1987) provides a succinct discussion of counterfactual reasoning in economics.

To establish causality, the construction of a counterfactual requires a specific theory that explains international trade. Traditionally, the trade literature has developed theories that focus on a single cause of trade, which are then associated with different kinds of gains from trade. The most prominent are the theory of comparative advantage and the "new" theories that explain trade in the presence of scale economies. Section II provides historical evidence that the Japanese economy at the time was compatible with the key assumptions of the comparative advantage trade model, which rules out gains from trade considerations based on arguments regarding increasing returns to scale.

The comparative advantage trade model has another advantage for measuring the gains from trade. The welfare gains that result from the reallocation of resources that lies at the heart of the model can be expressed in income equivalents. In economic theory, welfare is measured in terms of utility attained from consumption. Although welfare changes expressed in utility levels are not observable, changes in utility can be linked to changes in income through the compensation measures of welfare. Economic theory suggests two alternative measures of compensation: Hicksian compensation and Slutsky compensation.[9] The Hicksian compensation measure, which the theoretical gains-from-trade literature uses almost exclusively, links changes in utility to changes in income. Alternatively, the Slutsky compensation measure links changes in equilibrium consumption bundles to changes in overall income. From an empirical standpoint, the Slutsky notion of compensation is preferable to the Hicksian notion since it does not require any knowledge of the underlying preferences. The only assumption required is that consumption choices satisfy the weak axiom of revealed preference.

The Slutsky compensation measure of welfare can be formulated in terms of an expenditure function $e(\mathbf{p},\mathbf{c})$, which is defined as the minimum income the economy has to spend to obtain the consumption bundle $\mathbf{c}$ facing the price vector $\mathbf{p}$.[10] The expenditure function can be used to describe the gains from trade, ΔW, associated with each counterfactual listed in Table 1. The first counterfactual is the amount of income the Japanese economy would have seen as *equivalent* to the gain it would have achieved if international trade had taken place during the 1850s:

$$(1)\quad \Delta W_{1850s} = e(\mathbf{p}^a_{1850s}, \mathbf{c}^f_{1850s}) - e(\mathbf{p}^a_{1850s}, \mathbf{c}^a_{1850s})$$

where $\mathbf{p}^a_{1850s}$ denotes the vector of autarky prices prevalent during the autarky regime, $\mathbf{c}^a_{1850s}$ denotes the consumption bundle the economy actually attained in the autarky regime and $\mathbf{c}^f_{1850s}$ denotes the counterfactual consumption bundle the economy could have attained if trade had taken place during the 1850s. Following the weak axiom of revealed preference, the free trade consumption bundle $\mathbf{c}^f_{1850s}$ must not have been affordable to the Japanese economy at the autarky price vector $\mathbf{p}^a_{1850s}$. The equivalent variation measure in equation (1) captures the increase in income that would have made this free trade consumption bundle affordable under autarky prices.

Alternatively, the expenditure function can be used to describe the gains from trade associated with the second counterfactual: the loss of income that would have occurred if international trade had been suspended during the 1870s:

$$(2)\quad \Delta W_{1870s} = e(\mathbf{p}^f_{1870s}, \mathbf{c}^f_{1870}) - e(\mathbf{p}^f_{1870s}, \mathbf{c}^a_{1870s})$$

where $\mathbf{p}^f_{1870s}$ denotes the vector of world prices under free trade, $\mathbf{c}^f_{1870s}$ denotes the equilibrium consumption bundle the economy actually attained under free trade and $\mathbf{c}^a_{1870s}$ denotes the economy's counterfactual consumption bundle if trade had not occurred during the 1870s. The compensation measure in equation (2) gives the income the Japanese economy would have been willing to give up to avoid being moved to the autarky consumption vector $\mathbf{c}^a_{1870s}$ at free trade prices.

[9] For a general discussion of these two welfare measures, see Hal Varian (1982, pp. 135–37).

[10] Defining an expenditure function in terms of consumption instead of utility implies immediately that $e(\mathbf{p},\mathbf{c}) = \mathbf{pc}$. We nevertheless prefer to write $e(\mathbf{p},\mathbf{c})$ instead of $\mathbf{pc}$ to remind the reader that the income level is the result of an optimization problem.

Ideally, we would have liked to analyze the gains from trade using both counterfactuals. However, since data on consumption spending are not available for this period, empirical estimation of (1) and (2) requires that these welfare measures be linked to available data on prices and trade flows. Below we will show that the DDN index of comparative advantage–the inner product between net imports and autarky prices–constitutes an upper bound for the equivalent variation measure of welfare from equation (1). It is straightforward to derive a lower bound for the compensation variation measure: the inner product between net imports and world prices. However, balanced trade implies that this gives the trivial lower bound of zero. The intuition for why it is possible to estimate (1) but not (2) is that the latter expresses income at free trade prices while the former expresses it at autarky prices. Since the welfare gains arise from comparative advantage, autarky prices provide the relevant information about opportunity costs that are central to the comparative advantage gains from trade argument.

Denote by $\mathbf{x}^i_{1850s}$ the economy's production vector under autarky ($i = a$) and free trade ($i = f$). Under autarky, the economy's consumption spending must be equal to its income from production, or $\mathbf{p}^a_{1850s}\mathbf{c}^a_{1850s} = \mathbf{p}^a_{1850s}\mathbf{x}^a_{1850s}$. Since the equivalent variation measure of welfare can be written as $\Delta W_{1850s} = \mathbf{p}^a_{1850s}\mathbf{c}^f_{1850s} - \mathbf{p}^a_{1850s}\mathbf{c}^a_{1850s}$, we obtain

$$(3)\qquad \Delta W_{1850s} = \mathbf{p}^a_{1850s}(\mathbf{c}^f_{1850s} - \mathbf{x}^f_{1850s}) + \mathbf{p}^a_{1850s}(\mathbf{x}^f_{1850s} - \mathbf{x}^a_{1850s}).$$

Defining the net import vector as $\mathbf{T}_{1850s} = \mathbf{c}^f_{1850s} - \mathbf{x}^f_{1850s}$, where positive (negative) components of $\mathbf{T}_{1850s}$ pertain to imports (exports), the welfare gain is

$$(4)\qquad \Delta W_{1850s} = \mathbf{p}^a_{1850s}\mathbf{T}_{1850s} - \mathbf{p}^a_{1850s}(\mathbf{x}^a_{1850s} - \mathbf{x}^f_{1850s}).$$

The equivalent variation measure of welfare is equal to the DDN index of comparative advantage, $\mathbf{p}^a_{1850s}\mathbf{T}_{1850s}$, minus the additional term $\mathbf{p}^a_{1850s}(\mathbf{x}^a_{1850s} - \mathbf{x}^f_{1850s})$. GDP maximization implies that the letter term is nonnegative, i.e., $\mathbf{p}^a_{1850s}\mathbf{x}^a_{1850s} \geq \mathbf{p}^a_{1850s}\mathbf{x}^f_{1850s}$.

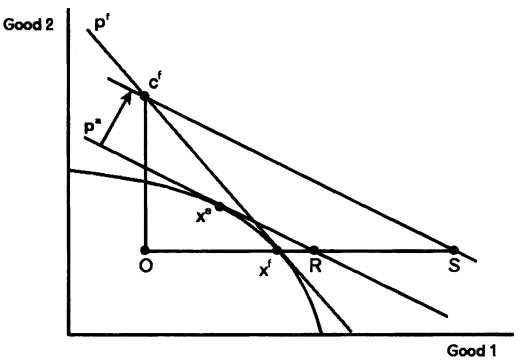

FIGURE 1. RELATING THE INDEX OF COMPARATIVE ADVANTAGE TO THE GAINS FROM TRADE

Figure 1 illustrates equation (4) in the case of two goods.[11] Under autarky, the economy's production point coincides with its consumption point, denoted by $\mathbf{X}^a$. Since the relative price of good 1 is assumed to be larger under free trade than under autarky, or $p^f > p^a$, the economy has a comparative advantage in good 1. Through international trade the economy can obtain consumption at $\mathbf{C}^f$ that differs from its production point $\mathbf{X}^f$. $\mathrm{OC^fX^f}$ is the familiar trade triangle; OX^f measures the export volume of good 1 and OC^f measures the import volume of good 2. Starting from the economy's autarky consumption point, the welfare gain from international trade is the increase in income necessary to afford the free trade consumption point $\mathbf{C}^f$ at the autarky price p^a. If income is measured in units of good 1, the welfare gain is equal to the length of the line segment RS.

The DDN index of comparative advantage subtracts the economy's exports from its imports, which are valued at autarky prices. In Figure 1, this is captured by $OS\text{-}OX^f = X^fS$. The DDN index exceeds the welfare gain by the line segment X^fR. The difference arises since trade requires a transformation of the production vector $\mathbf{X}^a$ into $\mathbf{X}^f$, which can drive up the opportunity costs of production. If the economy's

[11] For the sake of exposition, the graphical discussion of the 2-good case suppresses all time subscripts.

production possibility curve were characterized by constant opportunity costs of production, specialization according to comparative advantage would not increase opportunity costs and the DDN index would provide an exact measure of the gains from trade. Under increasing opportunity costs, the comparative advantage index provides an upper bound to the gains from trade.

Using equations (1) and (4) to express income changes relative to national income under autarky, we obtain:

$$(5)\qquad \frac{e(\mathbf{p}^a_{1850s}, \mathbf{c}^f_{1850s}) - e(\mathbf{p}^a_{1850s}, \mathbf{c}^a_{1850s})}{GDP_{1850s}} \leq \frac{\mathbf{p}^a_{1850s}\mathbf{T}_{1850s}}{GDP_{1850s}}.$$

Since Japan did not actually engage in international trade during the early 1850s, the term $e(\mathbf{p}^a_{1850s}, \mathbf{c}^f_{1850s})$ in (5) pertains to the income spent on the counterfactual (or fictitious) consumption point $\mathbf{c}^f_{1850s}$ that the economy could have reached with the counterfactual net import vector $\mathbf{T}_{1850s}$.

The left-hand side of equation (5) formalizes the counterfactual that we consider in this paper: the percentage increase in real income the Japanese economy would have needed to afford the counterfactual consumption point $\mathbf{c}^f_{1850s}$. The subsequent empirical discussion argues that the case of Japan provides us with a unique natural experiment to estimate the right-hand side in (5) and that the available evidence seems to indicate that it comes close to providing a reasonable point estimate of the gains from trade.

II. Japan's Opening Up as a Natural Experiment

The tale of Japan's opening up to international trade in 1859 after over 200 years of economic isolation is well known.[12] The Tokugawa rulers of Japan initiated the policy of seclusion in 1639 as a response to the perceived threat posed by Christian converts in Japan and their Portuguese supporters.[13] It forbade all Japanese from traveling outside the home islands and allowed only the Dutch and Chinese to trade under stringent restrictions on the volume and content.[14] Treaty arrangements limited the Dutch to one ship per year. The Dutch presence was restricted to Deshima, a tiny island in the harbor of Nagasaki, where goods were unloaded for purchase by merchants who were agents of the shogun's treasury. The shogun then sold the goods to Japanese wholesale merchants. No other Japanese were allowed to trade with the Dutch, nor were the Dutch allowed to travel in Japan for commercial purposes. The Chinese faced similar restrictions. During the heyday of the Chinese trade in the eighteenth century, 10 to 15 junks would make the trip to Japan each year. By the 1820s, about 3.5 junks per year made the trip.

The chief export good for the trade of both the Dutch and Chinese was Japanese copper. Small amounts of camphor and seaweed made up most of the remainder. The miniscule amount of trade allowed by treaty declined further after 1800. By 1825, the export trade was about 1.4 cents per capita; by the mid-1840s, it had declined to 1.2 cents per capita.[15] Sugar dominated the import trade, although the Dutch and Chinese also imported small quantities of woolens and silk. Total imports were about 0.4 cents per capita by the mid-1840s. By contrast, exports were 5 cents per capita for the first one-half year of open trade in 1859 and 17 cents per capita by 1860, the first full year of trade. Imports were 2 to 3 cents per capita for the one-half year of trade in 1859 and rose to 7.2 cents per capita for the first full year of trade.[16]

[12] Christopher Howe (1996, ch. 3) and Shinya Sugiyama (1987).

[13] The Tokugawa was a powerful clan that dominated Japan militarily and politically from 1603 until its overthrow in 1868, when direct rule by the emperor was restored in the Meiji revolution. The system under the Tokugawa was a centralized state that nonetheless granted lords some control over their own domains. The head of the government was the shogun.

[14] See G. F. Meylan (1861) for a standard contemporary account.

[15] Values are expressed in terms of the Mexican silver dollar, which was the standard unit of currency for trade in East Asia during this period. The Mexican dollar was worth just a bit more than the U.S. dollar.

[16] These estimates are based primarily upon the value of the exported copper and other goods (for exports) and contemporary estimates of the declared value of imports.

For 200 years, seclusion cut Japan off from most of the economic and technological change in the rest of the world economy. Through the Dutch, the Japanese had some access to information about Western technologies and Western science, but very little of it was actually applied in the economy.[17] Prompted by the appearance of a powerful American naval squadron in Tokyo harbor in 1853, Japan eventually agreed to an 1858 treaty that ended the autarky regime on July 4, 1859.[18]

Japan's move from autarky to free trade after 1859 offers a unique natural experiment to estimate the comparative advantage gains from trade. The argument requires us to examine several important conditions. First, Japan's economy should conform to the terms of the neoclassical trade model outlined in Section I. Second, the "experiment" itself should conform reasonably well to the key criteria for a natural experiment: the impetus for the experiment is essentially exogenous to the economy and the change is very rapid. The speed of the transition permits us to construct an estimate $\tilde{\mathbf{T}}_{1850s}$ of the counterfactual vector of net imports $\mathbf{T}_{1850s}$. We exploit the rapidity of the transition by drawing upon the period (the late 1860s through the mid-1870s) when we can make full use of the detail of the Japanese trade data, and it can be reasonably argued that the trade behavior of the economy reflects primarily its adjustment to new relative prices. In addition, we can be reasonably assured that by the late 1860s earlier efforts of the government to impose non-tariff barriers to trade had given way to a regime characterized by essentially free trade.

Consider the conformity of Japan's economy to the key assumptions of the neoclassical trade model: price-taking behavior in domestic and international markets and product homogeneity. Historians have revised our understanding of how the Japanese economy functioned just prior to and after the opening up in 1859. Earlier historians of Japan drew a sharp contrast between the *feudal* Japan of the period of autarky and the non-feudal and modern Japan of the Meiji era that began in 1868. More recent research emphasizes continuity; by the late Tokugawa era prices of goods and factors of production were generally set by competitive markets. Competitive markets had also hollowed out many of the formal restrictions of the system by the time Japan opened up, including eliminating the power of the merchant associations to set monopsony prices by the 1840s (Satoru Nakamura, 1990, pp. 90–92). Susan Hanley and Kozo Yamamura (1977, p. 86) reached a similar conclusion about labor markets: "Labor markets, both in the agricultural and non-agricultural sectors, were competitive by the beginning of the eighteenth century." Finally, local lords attempted to maintain the income they derived from the all-important tax on rice production by prohibiting the transfer of land out of rice. Nonetheless, with the expansion of internal trade and opportunities for specialization in such other agricultural products as silk, tea, or cotton, farmers "produced in response to market opportunities" (Conrad Totman, 2000, p. 250) and most growth in agricultural output after 1700 was apparently in non-food crops.

Goods traded on international markets were also bought and sold under competitive conditions. The treaties that opened Japan to international trade required acceptance of a liberal trading regime. The Japanese were only able to negotiate a restriction of trade initially to designated treaty ports, a prohibition on the importation of opium, a prohibition on the export of raw copper, and restrictions on the export of rice. Western interests forced the Japanese to accept very low tariffs. By 1866, ad valorem tariff rates averaged 2 to 3.5 percent with a maximum of 5 percent (Ippei Yamazawa and Yamamoto Yūzō, 1979, Table 22; Karl von Scherzer, 1872). Export tariffs were set at a maximum of about 3 to 4 percent. Historians recount some government efforts to employ restrictions on trade in raw silk, which was Japan's most valuable export commodity. Other observers pointed to the continued influence the Japanese government exerted over trading ar-

See Yōko Nagazumi (1987) for the volume of Chinese trade through 1833, John Phipps (1836, pp. 192–95 and 276–77) and Ernest W. Clement (1906, pp. 274–75) for prices of Japanese exports ca. 1833 and the volume of Dutch trade; Great Britain, *Consular Reports* for the volume of trade in 1859; and Sugiyama (1988, Table 3–4) for the volume of trade in 1860.

[17] See Erich Pauer (1987 and 1992).

[18] See Sugiyama (1988, p. 35). Initially two ports were opened up. Another two were added by 1863.

rangements. The shelling of Shimenoseki in 1864 by Western ships and continued pressure from the West put an end to these efforts by 1866.[19] A dense network of Western and Chinese traders linked domestic Japanese markets with international markets and ensured that imports would be priced competitively. Efforts by the Prince of Satsuma to maintain a monopoly in camphor (the source of which grew naturally in his domain) were also a failure (C. Brennwald, 1865, pp. 68–99). The remaining exports (chief among them, silk and tea) were produced under highly competitive conditions.

Finally, goods that Japan traded were for the most part homogenous. The main export commodities were silk and tea. They could be graded, but were distinguishable only by the source district, not the producer. Three kinds of goods dominated imports. About one-third was various kinds of cloth, most of which were unfinished, and cotton yarn. Another fifth was goods that the Japanese simply did not produce (primarily woolen cloth and blankets) and some more sophisticated weaponry. The remainder was foodstuffs and raw materials of all kinds, including rice, beans, raw cotton, sugar, and vegetable oil.

Japan's opening up offers an unusual natural experiment for studying the gains from trade. Mark R. Rosenzweig and Kenneth I. Wolpin (2000, p. 828) offer key insights into the potential role that natural experiments can play in empirical analysis. Empirical economics sometimes employs what might be termed "non-natural" natural experiments: *serendipitous* differences in rules governing economic behavior over time or over space that allow significant control over other confounding variables. Non-natural experiments merit critical appraisal. To act as a treatment, changes in rules must truly have "arisen serendipitously." In the case of Japan, these considerations imply that the initial change in policy—the opening up to trade—must have arisen exogenously and the treatment effect (the relative price shock and the degree of exposure to prevailing world prices) must have been strong enough to identify the reallocation of resources posited by the theory of comparative advantage.

The economic history of Japan provides ample evidence that this case meets these two criteria. Although the closure of Japan was primarily a response to domestic political concerns, the transition from autarky to free trade and the terms of that transition were for all practical purposes beyond Japan's control. The British victories over China in the Opium Wars of 1841–1842 ended the closed regime of Asia's most powerful nation and served as an example to the remainder of East Asia. Japan's military weakness precluded any serious attempt to resist the demands of the Western powers to pry open its markets.

When it reopened its economy after 200 years of isolation, Japan encountered some significant differences in relative prices brought about by the industrial revolution and increased integration of international markets for bulk commodities.[20] Between the 1780s and 1840, innovations in cotton textiles had cut the real price of cotton cloth and cotton yarn by three-quarters and the real price of iron by three-fifths (C. Knick Harley, 1998, Tables 3 and 4; Harley, 1982, p. 272). Although the Japanese were informed of many of the new developments in technology through the Dutch, their production of cotton yarn and cloth relied on methods of hand spinning and weaving reminiscent of the mid-eighteenth century. Production technologies in iron used low-volume batch methods reminiscent of fifteenth-century Europe (Ishime Tōru and Yoneda Horoguki, 1995).

The speed of adjustment of the Japanese economy to these differences in relative prices is evident in the 100-fold growth of imports per capita through the early 1870s. This rate of growth was far in excess of anything experienced elsewhere in Asia. After one and a half

[19] Note the comments of the acting British consul in Kanagawa (Yokohoma): "The Year 1864 will be memorable as that in which every reasonable man in this country must have been convinced of the utter folly of any Japanese Prince or party attempting to dispute by force the rights of foreigners in Japan." (Report of Acting Council Flowers, 1865, p. 292). See Regina Mathias-Pauer and Erich Pauer (1992, p. xvi) and the correspondence of Dutch agents in Japan at the time.

[20] See Kevin H. O'Rourke and Jeffrey G. Williamson (2002, pp. 36–37) on the rapid decline in transport costs that may have started as early as 1820.

decades of open trade, Japan was on par with Thailand as the East Asian economy with the most significant import penetration (James C. Ingram, 1971, pp. 7 and 332–33). At the same time, the period of free trade following autarky was of sufficient length to allow for the reallocation of resources in response to new opportunities. To take full advantage of export opportunities, for example, silk producers required about three years to bring the mulberry trees that were used for feeding silk worms into production. Producers of tea required four years for new tea bushes to be fully productive (S. Syrski, 1872, pp. 211 and 231).

III. Empirical Implementation

A. *Data Sources and Construction of Variables*

Three variables are needed for calculating the right-hand side of (5): the vector of autarky prices $\mathbf{p}^a_{1850s}$, an estimate of the counterfactual net import vector $\tilde{\mathbf{T}}_{1850s}$, and an estimate of GDP_{1850s}. Japanese economic historians have uncovered price series for many traded and nontraded goods that span the period of autarky and free trade. In addition, the price reports of the British consulates and other European observers provide some added market price data for the end of the autarky period. Together, these sources supply market prices for about 52 key commodities that were involved in international trade. The quality of the autarky price data permits careful matching with the corresponding import and export quantities.[21] For some goods, primarily different kinds of cotton cloth, the degree of finish and the type of weave could influence the relative price. Hoshimi Uchida (1988, p. 162) notes that yarn-dyed cloth, which required the additional step of dying the yarn before it was woven into the traditional Japanese "cotton stripes," cost about twice as much as white cloth during the first half of the nineteenth century. Prices were adjusted upward of the base bleached cloth (Kinyū Kenkyūkai, 1937) to reflect these higher costs of finishing under autarky. Von Scherzer (1872, p. 393) suggests that the import cloth closest to domestic Japanese cloth for which price data exist was the *taffachela*. This was the base cloth chosen for the analysis.

Autarky price data are available for about 96.5 percent of exports by value and 61 percent of imports. For the remaining traded goods, two strategies were employed to approximate autarky prices. For about 15 percent of imports and the remaining exports, the Japanese economy provided ready substitutes, but detailed price data were simply not available. Autarky prices during 1851–1853 for these goods were approximated with the average import (or export) price during the period 1868–1875, deflated by Hiroshi Shinbo's indices of import (or export) prices (1978, Table 5-10).[22]

A second group of imports includes products that the Japanese economy did not produce under autarky. Such goods as glass, boots and shoes, opera glasses, butter, watches, and a small amount of machinery (0.7 percent of imports) were imported primarily for the consumption of Westerners living in Japan, or were still considered novelties during the early free trade period.[23] The prices for these goods, which made up about 2.5 percent of imports, were also approximated with the deflated average import price during the test period.

Two other imports that were not produced in Japan accounted for the remainder of the goods not produced under autarky: woolens and muskets. The Japanese did not raise sheep, so there was no domestic production of woolens. After importing Portuguese know-how through the early 1600s, Japanese weapons technologies

[21] The sources include Nobuhiko Nakai (1989), Mataji Miyamoto (1963), Takeo Ono (1979), Kinyū Kenkyūkai (1937), and Ryūzō Yamazaki (1983). The sources from contemporary publications include Great Britain, *Consular Reports*, for the ports of Nagasaki and Kanagawa in 1859 and in 1860; von Scherzer (1872, p. 262) for silk worm eggs; and Friedrich August Lühdorf (1857, pp. 248–249) for several other commodities.

[22] Products in this group included dyes and paints, medicines, and safflower oil.

[23] Minor exceptions to this generalization include elephant tusks, whalebone, some hides, and vermilion, all of which appear on the lists of goods imported from China during the period prior to opening up. See von Scherzer (1872, p. 403) on the limited prospects for glass. Brennwald (1865, p. 47) is equally pessimistic about the near-term prospects for Swiss producers of watches and clocks.

stagnated for the next two hundred years and weapons produced in the West were highly valued.

These goods merit an alternative approach. An upper bound estimate of the market participants' willingness to pay for these imports under autarky is the virtual price: the height of the (import) demand curve at or near zero imports. Although data that would permit econometric estimation of the virtual price do not exist, another feature of the Japanese natural experiment allows for approximating it.[24] Although most of the miniscule amount of trade carried out by the Dutch and the Chinese prior to opening up involved the importation of sugar and silks in exchange for Japanese copper, they also imported small amounts of woolens and weapons.

Because of their rarity, woolen cloth and worsteds (cloth produced with combed long staple wool) commanded relatively high prices. Prior to opening up, imports were primarily a lower-quality medium woolen cloth (*Laken*) used for military uniforms, and a worsted cloth (camlets) which was used by *yakunins*, officials of the shogunate. (Camlets could be made entirely of woolen yarn or contain a cotton warp.) During the early years of trade, these two kinds of cloths constituted an important share of the import trade. Ascertaining the volume of these imports requires looking at both Dutch and Chinese import data, since the small amount of Chinese import trade also included re-exports of woolens along with their chief imports into Japan: sugar and silks. Detailed accountings of these imports by cloth type and volume are available for the two Dutch trips that occurred over the period 1827 to 1830 and the three Chinese trips for 1827, 1829, and 1831. These data, along with trade volumes for woolen cloth (medium and broad cloths) and worsted cloth (camlets) during the first years of open trade, are reported in Figure 2. Over the period 1827–1831, annual average imports were very low: about 230 pieces (or about 8,000 yards) of woolen cloth (imported by both the Dutch and the Chinese) and about 85 pieces (or 3,100 yards) of worsted cloth.[25] For comparison, imports of all woolens during the first one-half year of trade in 1859 exceeded 15,000 pieces.

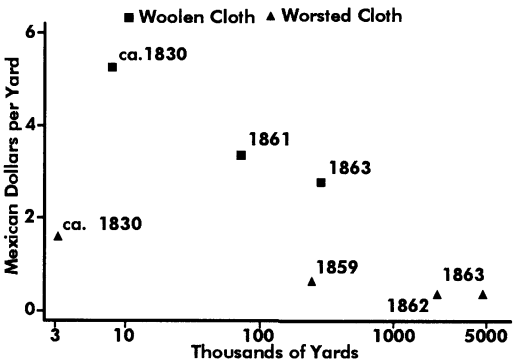

FIGURE 2. PRICES AND IMPORTS OF WOOLEN AND WORSTED CLOTH BEFORE 1870

The report on Asian markets for woolens compiled by M. Natalis Rondot (1847) on behalf of the French woolen industry suggests that the Dutch were able to capture a significant premium on the goods they sold to the Japanese market. The prices in Figure 2 (in Mexican dollars) reported for 1827–1830 for worsted cloth (camlets) and woolen broad cloth were two and one-half to almost five times the prices for similar goods prevailing in Canton at about the same time (Rondot, 1847, p. 116; Phipps, 1836, p. 194). Even after the opening up in 1859, the premium for camlets in Japan over prices prevailing in Canton was 65 percent (Jacob, 1861, p. 15).

To the extent possible, Figure 2 presents price-quantity pairs for the half decade subsequent to opening up. The notable decline in the dollar price for both camlets and woolen cloth is consistent with the suggestions that the prices from the period prior to the opening up are reasonable approximations of the virtual price. Incorporating this price information into

[24] Jerry A. Hausman (1997) reviews the conceptual background and approaches for econometric estimation of the virtual price.

[25] See Nagazumi, (1987, Table B) for the volume of Chinese trade based upon Dutch records and Rondot (1847, pp. 220–29) for detail on the Dutch imports of woolen and worsted cloth into Japan during the period 1827–1830. This estimate may overstate the volume of *annual* imports. While the Chinese typically sent the maximum number of junks permitted to trade with Japan at Nagasaki on the biannual visits, voyages by Dutch vessels became increasingly irregular during the nineteenth century. More than two years could elapse between these visits.

counterfactual prices for woolens under an autarky regime requires three additional steps. First, prices in Mexican dollars must be converted into the Japanese currency, the ryō. Japanese prohibitions on the export of any currency on pain of death meant that the actual exchange rate between the ryō and dollar can only be estimated. G.F. Meylan (1861, p. 222) placed it at 6.5 dollars per ryō in the late 1820s based on the weight of gold in the ryō, but the currency debasements of the Tempō period (1830–1843) led to inflation of about 40 percent throughout the final years of autarky. The second step is to adjust these prices to reflect the probable wholesale prices of cloth on the Japanese market. Meylan (1861, p.195) suggests that Dutch goods were sold by the shogun's treasury to Japanese merchants for prices that were a bit over twice the price received by the Dutch. The final step is to estimate prices for all 11 kinds of woolens imported. Detailed information on the quality and prices of cloth traded in China during the 1840s and in Japan during the 1860s allowed calculation of the prices of all other imports relative to the price in Japan of camlets and broad cloths that were imported by the Dutch.[26]

Less documentation is available on the import of weapons. Friedrich August Lühdorf (1857, pp. 135 and 141) supplies the evidence on the price the Dutch received for weapons they imported into Japan during the autarky period.

A plausible construction of the counterfactual net import vector $\tilde{\mathbf{T}}_{1850s}$ should conform as closely as possible to the key *ceteris paribus* assumption of the natural experiment, that is, that the changes in the pre- and post-autarky economy are confined primarily to the change in trade policy. This perspective argues for constructing the counterfactual vector from Japan's actual trade vector once it fully developed into an open economy (ca. 1866). Some key limitations on the data available at that time require us to use data from a few years later (1868–1875), by which time the Meiji government had been able to establish a customs service that was able to report data on a consistent basis from the four treaty ports that were then open.[27]

The research examines two concerns about using $\mathbf{T}_{1868-1875}$ as the counterfactual $\tilde{\mathbf{T}}_{1850s}$. First, one would expect that growth in the economy between 1851–1853 and 1868–1875 increased the production possibilities of the economy and hence the "size" of this vector beyond what would have prevailed under autarky. Consequently, we constructed the counterfactual $\tilde{\mathbf{T}}_{1850s}$ by deflating $\mathbf{T}_{1868-1875}$ by a conservatively estimated annual growth rate of GDP from 1851–1853 of 0.4 percent. Shunsaku Nishikawa (1987, p. 323) suggests that this is a reasonable average growth rate for the large and economically diverse domain of Chōshū from the 1770s through the 1840s.

The second concern is more critical. Substantial transfers of technology between the opening up and the test period could have modified Japan's technology set to the point that the pattern of exports and imports reflected the impact of both prices and changes in productive techniques. Indeed, the successful adoption of Western technologies such as mechanical spinning and metallurgy is a hallmark of economic growth during the later Meiji period.[28] Erich Pauer (1987) summarizes the documentation that is available for the cases of the wholesale adoption of Western technology and its adaptation. He argues that this process did not get underway until after the period chosen for the analysis. Formal government efforts to promote technological transfer, including sending delegations overseas and inviting foreign technology experts to visit Japan, were not initiated until the mid-1870s. Imports of new Western technologies embodied in machinery (spinning machinery, for example) were virtually nonexistent for the first 15 years of open trade (Pauer, 1992; Shinya Sugiyama, 1988). The only two exceptions are the government-run shipyards

[26] See Rondot (1847), Brennwald (1865, pp. 37–39) and von Scherzer (1872, pp. 396–99). The price of woolen blankets was estimated at three times the prevailing price in Canton.

[27] The data are taken from Japan (1893). Prior to 1868, the British consul in each treaty port collected information on imports and exports from the bills of lading of ships and other sources. The main drawback of these data is the inconsistent reporting of quantities and gaps in the records of some of the ports. A fire also destroyed records for 1866 at the chief port for imports, Kanagawa (Yokohama).

[28] But see Yasuba (1996, pp. 547–48) for a critical reassessment of this perspective for the later period

TABLE 2—CALCULATIONS OF THE PER CAPITA GAINS FROM TRADE
(*In gold ryō*)

	$p^a_{1850s}T_i$ (i = 1868 ... 1875)								$p^a_{1850s}\tilde{T}_{1850s}$
Group of goods	1868	1869	1870	1871	1872	1873	1874	1875	
(1) Goods with observed autarky prices	−0.05	0.03	0.16	0.08	−0.01	0.02	0.03	0.05	0.037
(2) Goods with estimated autarky prices	0.02	0.02	0.02	0.02	0.04	0.07	0.05	0.08	0.035
(3) Woolens and muskets	0.08	0.08	0.12	0.15	0.22	0.26	0.17	0.19	0.141
Gains per capita in ryō	0.05	0.13	0.30	0.25	0.24	0.34	0.26	0.32	0.219

Sources: Nakai (1989), Miyamoto (1963), Ono (1979), Kinyu Kenkyukai (1937), Yamazaki (1983), and Great Britain, *Consular Reports,* for the ports of Nagasaki and Kanagawa in 1859 and in 1860; von Scherzer (1872, p. 262) and Lühdorf (1857, pp. 141, 248–249) for price data. See the text for the estimate of the autarky valuation of imports of woolens and imports of muskets, and of goods without observed autarky prices. Crawcour and Yamamura (1970, Table A1) provide the exchange rate used to convert the inner product from momme into ryō.

Notes: The inner product is decomposed into three groups of commodities: the goods for which autarky prices are available from the existing historical sources; woolens; and goods with estimated autarky prices. $p^a_{1850s}\tilde{T}_{1850s}$ is the average of the annual estimates from 1868 through 1875 with the additional assumption that GDP per capita grew by an annual rate 0.4 percent from 1851–1853 to the test period.

and armories that were set up during the 1850s to upgrade Japanese defenses; their impact would not be felt until the 1870s.[29]

The final piece of information required for evaluating the magnitude of the gains from trade is the GDP of Japan in the autarky years 1851–1853. Unfortunately, a complete series of national income accounts is not available for this period. Instead, the approach to evaluating the welfare consequences of the move from autarky to free trade will rely on controlled conjectures that draw upon estimates of GDP for a particularly well-developed region of Japan in the 1840s and estimates for the late 1870s.

B. *Empirical Results*

Table 2 provides the values of $\mathbf{p}^a_{1850s}\,\mathbf{T}_i$. They are expressed in terms of gold ryō per capita for each of the first eight years for which the Meiji trade data are available. In all years, the gains were positive, which confirms the prediction of the comparative advantage trade model. Overall, the gains were on the order of one-fiftieth to one-fifth ryō per capita. The final column offers our "most confident" estimate of $\mathbf{p}^a_{1850s}\,\tilde{\mathbf{T}}^a_{1850s}$. It is a simple average of the first eight years for which the trade data are available, deflated by a conservative estimate of the growth of production possibilities between 1851 and 1853 and the early free trade period.

Since estimates of per capita GDP do not exist for the autarky period 1851–1853, we employ two different methodologies to arrive at reasonable conjectures. The forecasting approach draws upon an estimate for 1840 that is available for one of Tokugawa Japan's regions and applies a range of estimates of the growth rate of per capita GDP to arrive at an estimate for 1851–1853. This "backcasting" approach takes what evidence is available on the GDP per capita from the 1870s and uses the same estimates of the real growth of per capita GDP to arrive at alternative estimates for 1851–1853.

The forecasting approach draws upon estimates of GDP that were developed on the basis of the BFC, a collection of village-level reports from the advanced southern Japanese domain of Chōshū.[30] This domain had a population of about 520,000 in the 1840s, or about one-sixtieth of the estimated population of Japan at the time. It

[29] Pauer (1987) documents the limited extent to which new shipbuilding techniques diffused through the economy because the skills of craftsmen could not be adapted to Western techniques. His fundamental argument is that the Japanese level of technology (and skill set) was insufficient to absorb Western technologies immediately.

[30] A series of papers (Nishikawa, 1978; Nishikawa, 1981; and Nishikawa, 1987) presents the results of an ambitious reconstruction of the Chōshū economy from this source to English-speaking economic historians. We are appreciative of the suggestions of Yasakuchi Yasuba and Osamu Saitō, who first directed our attention to Nishikawa's research.

was one of the more economically developed regions of Tokugawa (pre-1868) Japan. Since the region had a highly developed mixed agricultural and small industrial economy that produced cotton goods, salt, and paper, the share of domestic product from agriculture was about 61 percent, compared with about 67 percent in Japan as a whole during the much later period of 1878–1882 (Kazushi Ohkawa, et. al., 1957, Table 8, p. 26). The estimate of the per capita GDP used in this study for the forecasting approach was adjusted to reflect the slightly lower productivity of the population of Japan as a whole. The per capita output of goods and services can be estimated to be about 2.3 gold ryō in 1840.[31]

The backcasting approach takes the estimate of GDP per capita in yen for all of Japan for 1878–1882 (Kazushi Ohkawa et. al.1957, Table 1) and converts it to gold ryō of 1851–1853 at an exchange rate that reflects the depreciation of the yen relative to gold, using a price index that reflects the substantial inflation over the period. Subsequent research cited in Ohkawa (1978, p. 27) suggests that these early estimates should be adjusted upward. After making these changes, estimated real GDP per capita in the late 1870s is 4.76 gold ryō.[32]

Table 3 reports the results of applying a reasonable range of assumptions on the growth of per capita GDP to develop estimates for 1851–1853. The rate of 0.15 percent is based on the long-run growth in rice production and other commodities for Japan as a whole over the last one and one-half centuries of Tokugawa rule (Osamu Saito, 2003, Table 3). The rate of 0.4 percent is Nishikawa's estimate for growth in Chōshū from the mid-eighteenth century to the early 1840s (Nishikawa, 1981, p. 14). The rate of 1.5 percent is the growth Japan achieved during the latter part of the nineteenth century in the wake of a substantial transfer of technology and capital investment. Finally, the rate of 2 percent is the geometric average of the growth rate that Huber (1971) posits for the economy in the wake of opening up. It is most sensibly applied to the backcasting approach. The results of these alternative approaches yield reasonable ballpark estimates of per capita GDP that range from about 2.4 to 4.0 gold ryō for the autarky period.

TABLE 3—ALTERNATIVE ESTIMATES OF PER CAPITA GDP FOR THE AUTARKY YEARS OF 1851–1853
(*In gold ryō*)

	Assumed annual growth rate of GDP per capita			
Method and period	0.15%	0.4%	1.5%	2.0%
Backcast estimates from 1878–1882 to 1851–1853	4.07	3.79	2.79	2.44
Forecast estimates from 1840 to 1851–1853	2.40	2.47	2.82	2.99

Notes: The "backcast" estimates use the GDP per capita estimate from Ohkawa (1957, Table 1) in current yen for 1878–1882 adjusted for the new estimates of GNP per capita for the mid-1870s cited in Ohkawa (1978, p. 27). It is converted to gold ryō using the exchange rate for the silver yen found in Yamazawa and Yuzo (1979, Table 26) and the price index found in Shinbo (1995, Table 4). The estimates of the GDP per capita for the "forecast" estimates are based on data in Nishikawa (1987) for the feudal domain of Chōshū. These per capita estimates of 2.43 ryō in 1840 have been adjusted downward to reflect the possibility that only 15 percent of the economically active population in Japan (not 20 percent in the more developed region of Chōshū) was involved in production outside of agriculture.

Finally, Table 4 summarizes the various estimates of the right-hand side of (5), using the different methods for calculating real GDP during the final autarky years. In our judgment, the highest confidence can be placed in the estimates that assume growth rates of 0.4 and 1.5 percent. Our results suggest that real income would have had to increase by at most 9 percent during Japan's final autarky years for the economy to afford the same consumption level it could have obtained if it were engaged in international trade during that period.

As discussed in Section I, the index of comparative advantage will be an "exact" measure of the gains from trade if specialization according to comparative advantage doesn't increase the opportunity costs of production. The histor-

[31] The adjustment assumed that 85 percent instead of 80 percent of the population was in agriculture, where productivity was under one-half the level in services and manufacturing. For comparison, per capita consumption for a farming family was about 2.13 ryō. The additional per capita GDP would cover the consumption for the samurai, the retainers of the samurai, and the clergy, as well as investment.

[32] The conversion uses the dollar-yen exchange rate from Yamazawa and Yūzō (1979, Table 26) and the price index for the period from Shinbo (1995, Table 4).

TABLE 4—ALTERNATIVE ESTIMATES OF THE GAINS FROM TRADE FOR THE AUTARKY YEARS 1851–1853
(*As a percentage of GDP*)

	Assumed annual growth rate of GDP per capita			
Method and period	0.15%	0.4%	1.5%	2.0%
Using the "backcast" estimates of GDP	5.4	5.8	7.8	9.0
Using the "forecast" estimates of GDP	9.1	8.9	7.8	7.3

Sources: Tables 2 and 3.

ical literature makes a strong case that these upper-bound gains occurred in the wake of a significant reallocation of resources away from traditional activities toward the new growth sectors of silk and tea. Nakamura (1990, p. 95) estimates that the flood of imported cotton cloth and yarn prompted a massive shift of up to one-fifth of the mostly rural labor force away from the production of cotton textiles to other goods. At the same time, the Japanese economy belied the expectations of observers that it would not be in a position to supply much silk beyond its own needs. It more than doubled the production of raw silk within ten years. By the early 1870s, over 90 percent of tea production was being exported overseas (Sugiyama, 1987).

Potentially, this reallocation could have been purchased at the cost of some productive efficiency and a rising opportunity cost. Detailed cost and production data that would provide a definitive answer are not available. Nonetheless, the price evidence suggests that the economy achieved this reallocation without facing steeply rising costs. A comparison of the price of high-quality Maebashi silk with the price of rice suggests that after almost tripling, the relative price of silk settled down to about 50 percent higher than its value during the early 1850s. Silk production could apparently be expanded without noticeably higher prices once the economy adjusted to the new (world) relative price. The evidence on the price of tea is similar.[33] For these reasons, we would expect that the equivalent variation measure is likely to provide a reasonable estimate of the upper bound of 8 to 9 percent.

It is of interest to compare these estimates with the calculation offered by Huber (1971), who posited real benefits from the opening up to trade of as much as 65 percent.[34] Huber's estimate rests on one source of confusion and on one error. The theory-based counterfactual analysis adopted here avoids both of these objections. First, the period of time in his comparison (1845 through the late 1870s) explicitly includes a period after the mid-1870s when imports of Western technology began to grow in importance. Such a change in production possibilities brought about through imports of technology confounds the strictly reallocative effect that is the source of the classic gains from trade. Second, his comparison is not based upon estimated changes in *welfare*, but instead on estimated changes in real wages to urban workers. For two reasons, subsequent research suggests that this approach is incorrect. First, it is apparent that opening up *may* have had a substantial impact on relative returns to factors, but that should not be confused with the overall gains to the economy that can be measured only with an appropriately defined measure of economic welfare. Second, subsequent research by Japanese scholars has concluded that, at best, real wages rose only modestly. Osamu Saito (1993) suggests that there were no real increases in real wages during the period and, perhaps, substantial declines.[35]

IV. Conclusion

This paper addresses one of the oldest questions in economics: how does international trade affect the wealth of a nation? In economic theory, this is answered by comparing an economy in a state of autarky relative to a state of free international trade. Since a market economy is almost always engaged in some foreign trade, however, the empirical trade literature has not been able to generate estimates of the gains from trade that are based on the autarky-free paradigm of the theoretical trade literature.

[33] See Kinyū Kenkyūkai (1937, Table 1 and p. 82) for the price of rice and tea and Yamazaki (1983, Table 96) for the price of Maebashi silk and Zanier (1986).

[34] See Yasuba (1996, p. 548) for an earlier critique that focuses on the real-wage evidence.

[35] Urban day laborers would have experienced a halving of real wages, for example (Saito, 1993, p. 337).

Japan's rapid nineteenth-century transition from a state of autarky to open international trade is an exception and provides an unusual opportunity for a theory-based assessment of the gains from trade. Since the Japanese economy fits the assumptions of the neoclassical trade model and its trading pattern is in accord with the theory of comparative advantage, we are able to estimate the gains from trade resulting from comparative advantage.

We find that the gains to the Japanese economy resulting from static comparative advantage were most likely no larger than 8 or 9 percent of Japan's GDP at the time. Our estimates indicate that significant changes in commodity prices do not necessarily translate into large welfare gains. It also suggests caution in justifying free trade on the grounds of welfare gains based on static comparative advantage. Since the dynamic aspects of international trade probably have a much larger impact on national income, future empirical research on the nature and magnitude of these dynamic gains is indispensable.

REFERENCES

Bernhofen, Daniel M. and Brown, John C. "A Direct Test of the Theory of Comparative Advantage: The Case of Japan." *Journal of Political Economy*, 2004, *112*(1), pp. 48–67.

Brennwald, C. *Rapport generale sur la partie commerciale de la mission suisse au Japon.* Berne: J. A. Weingart, 1865.

Clement, Ernest W. *Japan as it was and is: A handbook of old Japan.* Chicago: A. C. McClung and Co., 1906.

Corden, W. Max. "The Normative Theory of International Trade," in Ronald W. Jones and Peter B. Kenen, eds., *Handbook of international economics,* Vol. 1. Amsterdam: North-Holland, 1984, pp. 63–130.

Crawcour, E. S. and Yamamura, Kozo. "The Tokugawa Monetary System: 1787–1868." *Economic Development and Cultural Change*, Part 1, 1970, *18*(4), pp. 489–518.

Davis, Donald R. and Weinstein, David E. "The Factor Content of Trade," in E. Kwan Choi and James Harrigan, eds., *Handbook of international trade,* Vol 1. Oxford: Blackwell, 2004.

Deardorff, Alan V. "The General Validity of the Law of Comparative Advantage." *Journal of Political Economy*, 1980, *88*(5), pp. 941–57.

Deardorff, Alan V. "Testing Trade Theories and Predicting Trade Flows," in Ronald W. Jones and Peter B. Kenen, eds., *Handbook of international economics,* Vol. 1. Amsterdam: North-Holland, 1984, pp. 467–517.

Dixit, Avinash and Norman, Victor. *Theory of international trade: A dual, general equilibrium approach.* Cambridge: Cambridge University Press, 1980.

Elster, John. *Logic and society: Contradictions and possible worlds.* New York: John Wiley & Sons, 1978.

Francois, Joseph F.; McDonald, Bradley and Nordstroem, Hakan. "The Uruguay Round: A Numerically Based Qualitative Assessment," in Will Martin and L. Alan Winters, eds., *The Uruguay Round and the developing countries.* Cambridge: Cambridge University Press, 1996, pp. 253–91.

Frankel, Jeffrey A. and Romer, David. "Does Trade Cause Growth?" *American Economic Review*, 1999, *89*(3), pp. 379–99.

Great Britain, Foreign Office. "Report of Acting Council Flowers." *British parliamentary papers*, Vol. 53, 1865.

Great Britain, Foreign Office. "Consular Trade Reports: Commercial Reports from Consulates." *British parliamentary papers*, various volumes, 1859–1867.

Hanley, Susan and Yamamura, Kozo. *Economic and demographic change in preindustrial Japan, 1600–1868.* Princeton: Princeton University Press, 1977.

Harley, C. Knick. "British Industrialization before 1841: Evidence of Slower Growth during the Industrial Revolution." *Journal of Economic History*, 1982, *42*(2), pp. 267–89.

Harley, C. Knick. "Cotton Textile Prices and the Industrial Revolution." *Economic History Review*, 1998, *51*(1), pp. 49–83.

Harrigan, James. "Specialization and the Volume of Trade: Do the Data Obey the Laws?" in E. Kwan Choi and James Harrigan, eds., *Handbook of international trade,* Vol. 1. Oxford: Blackwell, 2003.

Harrison, Ann. "Openness and Growth: A Time-Series, Cross-Country Analysis for Develop-

ing Countries." *Journal of Development Economics*, 1996, *48*(2), pp. 419–47.

Harrison, Glenn W.; Rutherford, Thomas F. and Tarr, David G. "Quantifying the Uruguay Round," in Will Martin and L. Alan Winters, eds., *The Uruguay Round and the developing countries.* Cambridge: Cambridge University Press, 1996, pp. 216–52.

Hausman, Jerry A. "Valuation of New Goods under Perfect and Imperfect Competition," in Timothy Bresnahan and Robert J. Gordon, eds., *The economics of new goods* (National Bureau of Economic Research Studies in Income and Wealth). Chicago: University of Chicago Press, 1997, pp. 209–37.

Helpman, Elhanan and Krugman, Paul. *Market structure and foreign trade: Increasing returns, imperfect competition, and the international economy*. Cambridge, MA: MIT Press, 1985.

Howe, Christopher. *The origins of Japanese trade supremacy: Development and technology in Asia from 1540 to the Pacific War.* London: C. Hurst and Company, 1995.

Huber, J. Richard. "The Effect on Prices of Japan's Entry into World Commerce after 1858." *Journal of Political Economy*, 1971, *79*(3), pp. 614–28.

Ingram, James C. *Economic change in Thailand, 1850–1970.* Stanford: Stanford University Press, 1971.

Irwin, Douglas A. "The Welfare Costs of Autarky: Evidence from the Jeffersonian Trade Embargo, 1807–1809." Unpublished Paper, 2001.

Jacob, C. "Bericht über die Handels-Verhältnisse von Japan," in Regina Mathias-Pauer and Reich Pauer, eds., *Hansastädte und Japan, 1855–1867: Ausgewahlten Dokumente.* Marburg: Fördervein Marburger Japan-Reihe, 1992, pp. 279–305.

Japan, Bureau of Revenue. *Returns of the foreign trade of Japan: For the twenty-five years from 1868 to 1892 inclusive.* Tokyo: Insetsu Kyoku, 1893.

Kemp, Murray C. "The Gain from International Trade." *Economic Journal*, 1962, (*72*) pp. 803–19.

Kenkyūkai, Kinyū. *Waga kuni shōhin sōba tōkei hyō (Statistics of national commodity prices).* Tokyo: Kinyū Kenkyūkai, 1937.

Leamer, Edward E. and Levinsohn, James. "International Trade Theory: The Evidence," in Gene M. Grossman and Kenneth Rogoff, eds., *Handbook of international economics,* Vol. 3. Amsterdam: North-Holland, 1995, pp. 1339–94.

Lühdorf, Friedrich August. *Acht Monate in Japan nach Abschluß des Vertrages von Kanagawa*. Leipzig: Heinrich Strack, 1857.

Mathias-Pauer, Regina and Pauer, Erich. *Hansastädte und Japan, 1855–1867: Ausgewählten Dokumente*. Marburg: Fördervein Marburger Japan-Reihe, 1992.

McCloskey, Donald. "Counterfacturals," in John Eatwell, Murray Milgate and Peter Newnan, eds., *The new Palgrave: A dictionary of economics,* Vol. 1. London: Macmillan, 1987, pp. 701–03.

Meylan, G. F. *Geschichte des Handels der Europäer in Japan*. Leipzig: Voigt and Günther, 1861. (Translation by F. W. Diederich.)

Nakai, Nobuhiko (Mitsui Bunko, ed.). *Kinsei kōki ni okeru shuyō bukka no dōtai (Movement of the prices of staple commodities).* Tokyo: University of Tokyo Press, 1989.

Miyamoto, Mataji. *Kensei Osaka no bukka to rishi (Prices and profit in early modern Osaka).* Tokyo: Sōbunsha, 1963.

Nagazumi, Yōko. *Tōsen yushutsunyūhin sūryō ichiran, 1637–1833-Nen (Summary of imports and exports on Chinese ships for the years 1637–1833).* Tokyo: Sōbunsha, 1987.

Nakamura, Satoru. "The Development of Rural Industry," in Chie Nakane and Shinzaburo Oishi, eds., *Tokugawa Japan: The social and economic antecedents of modern Japan.* Tokyo: University of Tokyo Press, 1990, pp. 81–96.

Nishikawa, Shunsaku. "Productivity, Subsistence, and By-Employment in the Mid-Ninetheenth Century Chōshū." *Explorations in Economic History*, 1978, *15*(1), pp. 69–83.

Nishikawa, Shunsaku. "Protoindustrialization in the Domain of Chōshū in the Eighteenth and Nineteenth Centuries." *Keio Economic Studies,* 1981 *18*(2), pp. 13–26.

Nishikawa, Shunsaku. "The Economy of Chōshū on the Eve of Industrialization." *The Economic Studies Quarterly*, 1987, *38*(4), pp. 323–37.

Ohkawa, Kazushi (in association with M. Shinohara; M. Umemura; M. Ito and T. Noda). *The*

Growth rate of the Japanese economy since 1878. Tokyo: Kinokuiya Bookstore Co., Ltd., 1957.

Ohkawa, Kazushi. "Initial Conditions: Economic Level and Structure," in Kazushi Ohkawa and Gustav Ranis, eds., *Papers and proceedings of the Conference on Japan's Historical Development Experience and the Contemporary Developing Countries: Issues for comparative analysis.* Tokyo: International Development Center of Japan, 1978, pp. 25–38.

Ono, Takeo. *Edo bukka jiten (Dictionary of the price of products in Tokyo).* Tokyo: Tenbosha, 1979.

O'Rourke, Kevin H. and Williamson, Jeffrey G. "When Did Globalization Begin?" *European Review of Economic History*, 2002, *6*(1), pp. 23–50.

Pauer, Eric. "Traditional Technology and Its Impact on Japan's Industry during the Early Period of the Industrial Revolution." *The Economic Studies Quarterly*, 1987, *38*(4), pp. 354–71.

Pauer, Erich. "Technologietransfer Deutschland-Japan von 1850 bis zur Gegenwart," in Erich Pauer, ed., *Technologietransfer Deutschland-Japan von 1850 bis zur Gegenwart.* Munich: Ludicum Verlag, 1992, pp. 48–72.

Phipps, John. *Practical treatise on the China and Far Eastern trade, compromising the commerce of Great Britain and India, particularly Bengal and Singapore, with China and the Eastern Islands.* London: W. H. Allen and Co., 1836.

Rondot, M. Natalis. *Étude pratique des tissus de laine convenables pour la Chine, le Japon, la Cochinchine et l'Archipel Indien.* Paris: Guillamin et Cie., 1847.

Rosenzweig, Mark R. and Wolpin, Kenneth I. "'Natural' Natural Experiments in Economics." *Journal of Economic Literature*, 2000, *38*(4), pp. 827–74.

Saitō, Osamu. "Bakamatsu-Meiji no Chingin Hendo Daiko (A Reconsideration of Late Edo-Meiji Wage Fluctuations)." *Keizai Kenkyū*, 1993, *44*(4), pp. 330–38.

Saitō, Osamu. "Wages, Inequality and Pre-modern Growth in Japan, 1727–1894," in R. C. Allen, T. Bentsson and M. Dribe, eds., *Living standards in the past: New perspectives on well-being in Asia and Europe.* Oxford: Oxford University Press (forthcoming).

Samuelson, Paul A. "The Gains from International Trade." *Canadian Journal of Economics and Political Science*, 1939, *5*(2), pp. 195–205.

Samuelson, Paul A. "The Gains from International Trade Once Again." *Economic Journal*, 1962, *72*(288), pp. 820–29.

Shinbo, Hiroshi. *Kinsei no bukka to keizai hatten: Zenkōgoyō shakai e no sūryōteki sekkin (Prices and economic development in early modern Japan: A quantitative approach to pre-industrial society).* Tokyo: Toyo Keizai Shinposha, 1978.

Shinbo, Hiroshi. *Kindai Nihon keizaishi (Economic history of modern Japan).* Tokyo: Sobunsha, 1995.

Sugiyama, Shinya. "The Impact of the Opening of the Ports on Domestic Japanese Industry: The Case of Silk and Cotton." *Economic Studies Quarterly*, 1987, *38*(4), pp. 338–53.

Sugiyama, Shinya. *Japan's industrialization in the world economy, 1859–1899: Export trade and overseas competition.* London: Athlone Press, 1988.

Syrski, Szymon. "Über Seidenkultur in Japan," in Karl von Scherzer, ed., *Fachmännische Berichte uber die österreichisch-ungarische Expedition nach Siam, China, und Japan.* Stuttgart: Julius Maier, 1872, pp. 228–86.

Tōru, Ishime and Yoneda, Hirogaki. "Changes in Iron-Casting Techniques," in Erich Pauer, ed., *Papers on the history of industry and technology in Japan,* Vol. 1. Marburg: Forderverein Margurger Japan-Reihe, 1995, pp. 153–74.

Totman, Conrad. *A history of Japan.* Malden: Blackwell Publishers, 2000.

Uchida, Hoshimi. "Narrow Cotton Stripes and Their Substitutes: Fashion, Technical Progress and Manufacturing Organization in Japanese Popular Clothing, 1850–1920." *Textile History*, 1988, *19*(2), pp. 159–97.

Varian, Hal. *Microeconomic analysis. 3rd Ed.*. New York: W. W. Norton, 1992.

von Scherzer, Karl. *Fachmännische Berichte über die österreichisch-ungarische Expedition nach Siam, China, und Japan.* Stuttgart: Julius Maier, 1872.

Yamazaki, Ryūzō. *Kinsei bukkashi kenkyū (Price history of the Edo Era).* Tokyo: Hanawa Shobo, 1983.

Yamazawa, Ippei and Yūzō, Yamamoto. Choki keizai tokei 14. (*Long-term economic statistics of Japan,* Vol. 14.): Bōeki to kokusai shūshi. (Foreign trade and balance of payments.) Tokyo: Toyo Keizai Shinposha, 1979.

Yasuba, Yasakuchi. "Did Japan Ever Suffer from a Shortage of Natural Resources before World War I?" *Journal of Economic History*, 1996, *56*(3), pp. 543–60.

Zanier, Claudio. "Japan and the Pebrine crisis of European sericulture during the 1860s," in Erich Pauer, ed., *Silkworms, oil, and chips:Proceedings of the economics and economic history section of the Fourth International Conference on Japanese Studies, Paris, September 1985.* Bonn: M. Wehle, 1986.