Understanding the Gains from Trade through the Window of Japan during the 19th-Century Globalization: Analysis of a Counterfactual

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Abstract

Many historical accounts of the Great Specialization, the emergence of North-South trade during the last third of the nineteenth century, argue that it harmed the growth prospects of countries on the periphery. An important weakness of these accounts is that they lack an explicit counterfactual to the world as it developed in the wake of new technologies for production, communication and ocean-going transport. A counterfactual could help to evaluate the benefits as well as the costs of participation in the emerging global economy. This paper employs a new framework that draws upon Ricardo (1817)'s insights about trade: the endowment augmentation approach. We employ this framework to evaluate the experience of Japan during its first full decade of participation in the global economy: 1865-1876. As it emerged from autarky, Japan displayed the extreme specialization in primary products of most countries on the periphery. It was also relatively poor. Our analysis shows that trade augmented all five factors of Japan's endowment. Evaluated at autarky factor prices, the value of the addition to the endowment was equivalent to over 30 years of growth at the pre-industrial level of performance. A closer look at the endowment augmentation in the context of imports of rice, cotton yarn, cotton cloth and worsted cloth suggests that technologies of the industrial revolution in tandem with growing international specialization in the production of raw materials and food conferred substantial benefits on one of the poorer economies of the periphery ca. 1874: Japan.

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Historical accounts of the emergence of an international economy during the nineteenth century up to World War I received a new interpretation during the 1990s with a large research project focused on the Atlantic economy. O'Rourke and Williamson (1999) summarize the key findings of this research, which concludes that Heckscher-Ohlin forces unleashed by a transportation revolution dominated the emergence of specialization on both sides of the Atlantic, as the developing countries of the Americas exchanged land-intensive agricultural raw materials and food for the manufactures of the rapidly-industrializing European core. The focus of this work was primarily on regions of recent settlement, roughly characterized by countries in the temperate zones of both the northern and southern hemispheres. An important element of their development was mass in-migration and inward flows of capital. As Kravis (1970) noted 45 years ago, these countries and the North American-European core largely benefitted from this phase in the economic history of the international economy.

The others—the "periphery"— had been drawn headlong into the global economy by the mid-19th century either as newly-independent central and south American countries freed of the colonial yoke, newly colonized countries and regions of Africa and Asia, or countries that remained independent, but were forcibly integrated into the emerging global economy by a series of treaties that imposed liberal trade regimes on them over the first two-thirds of the century.[2] Findlay and O'Rourke (2007) provide a helpful summary of this period of economic history, which they term "The Great Specialization." After the American Civil War and the Franco-Prussian War, a period of 40 years of relative peace among the

[2] These countries included the Treaty of Balta Liman between the United Kingdom and the Ottoman Empire, the leasing of Hong Kong and the creation of the Treaty Ports in China in 1842 and 1858 as a result of the First and Second Opium Wars, the Bowring treaty of 1855 with Siam (Thailand), the Harris Treaty of 1858 with Japan and Kanghwa Treaty of 1876 with Korea. This group of countries is essentially the "Third World" identified in O'Brien (2004).

European powers accompanied an unprecedented expansion of North-South trade as the world economy as a whole experienced a trade boom. The well-known generalization about the composition and the destination of “Third World” exports have been known for many decades since Yates (1959) published his compendium of trade statistics. They were concentrated in primary products, for which the industrializing and industrialized “core” constituted the primary market. Remarkably, although Findlay and O'Rourke (2007) focus on the importance of North-South specialization in their account, O'Brien (2004, Table 5) suggests that this region’s share of primary product trade was about constant from 1860 through 1910. Of course, the other side of this trade that has attracted attention was the importation of manufactured goods from the core countries, which was first documented in Yates (1959) and is summarized in Findlay and O'Rourke (2007, Table 7.4).Table 1 documents the patterns of exports and imports for the four largest core economies ca. 1900. The upper panel of each table focuses on the composition of exports and imports and the lower panel documents the main export markets by continent. As is readily apparent, the imports of raw materials and food were important for these countries and raw materials and food constituted for the most part constituted a small share of exports. The reliance on non-core countries for imports ranged between 17 and 40 percent and averaged about 31 percent. Only the United Kingdom depended substantially upon non-core countries for export markets, where the average for all four countries was 26 percent.

Table 2 documents the patterns of trade for 18 non-core countries. Most show the same tendency to specialize in exports of raw materials and food. Cuba (cigars), China, India, Australia and Japan (in 1900) are the main exceptions. About one-quarter of imports for these countries were raw materials and food. Other non-core countries accounted for about one-quarter of imports and about one-fifth of export markets. In sum, despite the overall patterns of specialization, the destinations of exports and sources of imports were not all that different between the core and non-core countries.

Identifying the sources of these patterns of trade for the period 1870 to 1913 and the consequences for the well-being of the non-core countries—and their growth and development—has prompted lively debates since at least the 1940s. The usual narrative for why the international economy grew to incorporate the non-temperate periphery includes a focus on increased demands for industrial raw materials and exotic tropical foods from the rapidly-growing countries of the core (see Williamson (2011)). Based upon results from a panel over the period 1913-1938, Estevadeordal, Frantz et al. (2003) argue that the elasticity of trade volume with respect to real GDP was about one. If the coefficient applies to the 1870-1913 period, that would account for more than half of the increase in world trade. The result presumably applies to the periphery as well, although their specification does not separate out the trade flows of countries of the core and periphery. To understand an increase in the trade to GDP ratio, they appeal to a substantial fall in transportation costs throughout the world and the adoption of the gold standard by the countries of the core (see Estevadeordal, Frantz et al. (2003, Table III)).

Attempts to build upon the results of these empirical investigations have focused some attention on accounting for the increase of trade and the pattern of trade, but most historians have concentrated on what the Great Specialization meant for the development prospects of the periphery. Williamson (2011, p.53) recent contribution, for example, appears to favor a Heckscher-Ohlin explanation for the pattern of "Third World" specialization.[3] Estevadeordal and Taylor (2002) use a diverse range of sources to test several variations of the Heckscher-Ohlin-Vanek approach to factor proportions theory to see if it could be applied more generally to the expansion of world trade. They use a matrix of cross-sectional trade data in 1913 that are unfortunately restricted primarily to countries of the core.[4] Relative scarcity of agricultural land ("renewable resources") seems to have met the HOV tests most often, but other factors of production, including capital and labor, did not. Overall, they conclude that "with respect to the full set of factors, the simple factor content approach seems to work as well in its own time as it does today-that is, not very well at all."(Estevadeordal and Taylor (2002, p. 392)).

[3] Countries with a "generous endowment of natural resources, climate, good harbors, and other environmental factors" would have had a comparative advantage in a primary product.
[4] The analysis assumes identical technologies and employs data on US-American technologies from the 1919 Leontief input-output matrix, a direct factor usage matrix for the late nineteenth century grafted on to data from the mid-1940s and trade data from core countries, Argentina and Australia.

A second approach builds upon the extended gravity model of international trade that has been derived using micro-foundations. As Jacks, Meissner et al. (2011) note, this modern version of the model is consistent with the Ricardian and New Trade Theory models of international trade, which motivate international trade based upon on country-level differences in technology, monopolistic or oligopolistic competition in the tradeable goods sector, or firm-level differences in productivity. Using a version of the gravity model to derive a measure of trade costs that includes a range of trade frictions (transportation costs, costs of communication, tariffs, etc.), Jacks, Meissner et al. (2011, Table 5) find that for the period 1870-1913, the growth in GDP emphasized by Williamson and Estevadeordal, Frantz et al. (2003, Table III) would account for about 46 percent of the growth of bilateral trade in their sample of core and periphery countries. The decline in trade costs would account for the rest. Their approach has the advantage of allowing for variation in the importance of trade costs across differing sets of trading partners. For the bilateral pair most likely to involve core-periphery trade (Asia/Oceania-Europe), the contribution of GDP growth is only about one-quarter. "Trade costs" soak up the remainder of the predicted change, but it is not clear which aspect contributing to trade costs—reductions in costs of shipping, improved methods of communication, or reductions in protection—matters the most.

If the search for explaining the emergence of the pattern of trade observed in Tables 1 and 2 has not resulted in any robust conclusions, the debate over the consequences of core-periphery trade appears to have moved towards a majority opinion that favors a pessimistic assessment. Findlay and Lundahl (1999) ably summarize the terms of the debate ca. 2000, even as the fin-de-siècle anti-globalization movement reached a local maximum in its fervor. The work of Angus Maddison and his successors has provided some quantitative underpinnings to tales of relative success and failure, which have been supplemented by the energetic construction of "internationally comparable" real wage indices during the past fifteen years or so. A "liberal school" has argued that the growth performance of many of the non-core countries, particularly those in temperate zones, allowed for them to keep pace and perhaps start to catch up with countries of core. That process of catching up may (or may not) have included a process of industrialization to the extent that export-led growth prompted backward and forward linkages. Even the non-temperate countries appeared to experience economic growth, but for the most part the growth was of an extensive variety that led to only modest increases in real GDP per capita. Nonetheless, the growth rates for these beneficiaries of "resource-intensive" growth could help many of these countries—particularly those in Latin America—almost keep pace with the core countries.

The optimistic liberal perspective faces a challenge of pessimism from two quarters, both of which make the case that the integration of the (non-temperate) periphery into the international economy occurred under conditions that exacerbated, rather than ameliorated, the gap in incomes that existed at the beginning of the 19th century. The pessimistic challenge had lain dormant for a few decades after the catastrophic failure of import-substitution strategies endorsed by the Prebisch-Singer *dependista* school resulted in the turn towards ("neo"-) liberalism in Latin America and the successes of export-led growth in south and east Asia. Pomeranz (2000) argument in the *Great Divergence* revives it. He concludes that asymmetry in political and military power, which the United Kingdom exploited in its imperial expansion after 1600, and the luck of geography accounted for China's failure to maintain the pre-industrial lead in technology and productivity that it had held over Europe over the millennia. Divergence became evident in the 18th century. By the mid-19th century, absolute British dominance in the new technologies of the industrial revolution led to the humiliation of the first and second Opium Wars by the mid-19th century.

By dint of its ability to exploit the "ghost acreage" of the sugar-growing Caribbean Islands during the 17th and 18th centuries and the vast acreage of the cotton-growing American South during the first half of the 19th century, the United Kingdom was able to fend off impending scarcity in food and fuel that undermined Chinese living standards and eventually deprived it of the benefits of Smithian growth as the 18th century wore on.[5] Access to ghost acreage staved off the specter of Malthusianism for long enough so that the inventive forces of the industrial revolution—and the international trading system—could

[5] A similar argument is made for late Tokugawa Japan, where "ghost acreage" in this case was the rich fishing grounds of the Pacific. Fish fertilizer manufactured out of sardine and herring helped sustain the productivity of Japanese agriculture.

enhance the ability of the United Kingdom and eventually the core to take advantage of ghost acreage worldwide using the spectacular productivity advances tied to coal-powered steam technologies.

The Pomeranz version of the sources of the Great Divergence is within the tradition of the Williams thesis about the relationship between slavery in the West Indies and the British industrial revolution. Williamson (2011) draws upon Bairoch's work on pre-industrial industrialization and two core themes of the contemporary literature on the economic development of resource-exporting countries: Dutch disease (a favorable shock to an exported non-manufactured commodity that pulls resources out of manufacturing) and the impact of commodity price volatility on growth (perhaps through an investment channel). In his account, the Great Specialization is an episode rife with potential Dutch disease effects on traditional manufacturing production and commodity price volatility. Both features of specialization in primary products lead Williamson to place the blame for the Great Divergence of much of the South on the trade boom of the late nineteenth century.

The de-industrialization thesis takes note of the productivity differentials between the new technologies of the industrial revolution and pre-industrial technologies. De-industrialization in the textile sectors of the periphery, where household or workshop production of yarn and cloth gave way to imports from core, takes front and center in this account. Rather than focus on the cost advantages of the new technologies, this account focuses on documented large increases in the terms of trade for most primary products. A single factor three-good model (export commodity, manufactured good such as textiles, and non-tradeable food) with unlimited supplies of labor (and a wage fixed in a non-competing food sector) yields relative de-industrialization as an improvement in the two-good terms of trade for the export commodity. The increase in the real cost of labor in the (domestic) manufacturing sector leads to more imports of textiles from the core, and de-industrialization proceeds. The evidence for the de-industrialization thesis is a series of case studies, which illustrate that indeed, the textile sectors in many countries declined in the face of imports of inexpensive British cotton yarn and cloth. Key to the process were episodes of improvements in the terms of trade for the export commodity or commodities.

We note that this argument rests on two additional assertions. First, a decline in the pre-industrial textile sector and other sectors using pre-industrial technology necessarily undermined the peripheral country's growth potential. According to this view, de-industrialization prompted a decline in just those urban-centered "industrial" activities that showed the most potential for rapid increases in total factor productivity.[6] Second, the static gains from trade most likely did not offset the adverse impact on long-term development prospects:

> Since the industrial leaders retained for themselves most of the export sector productivity advances (of the industrial revolution), and since they did not have to share any of the productivity advance that took place in their big nontradeable sectors, the terms of trade slump [of the core] did not make it possible for the poor periphery to keep up with economic growth in the industrial core. Williamson (2011, p. 27)

The export pessimist view receives additional support from the new global history school, which recasts the development of the international economy from the 1600s onwards as successive phases of capitalist development that successfully deployed private power and enlisted state power to confer advantages to the capitalists of the core. In Beckert (2014)'s telling, each successive wave of expansion in the global economy eroded and then swept away the dense network of production and social relationships that characterized the traditional cotton and textile economies of the. In most economies of the pre-industrial cotton belt, growing cotton was part of a food and fiber strategy that farmer-households pursued for the best use of household labor time and the acreage available to them. Household members spun yarn from the farm's cotton and wove cloth both for household consumption and sale on the market, yet "no growers depended on their cotton crops alone" (see Beckert (2014, p.14)). Until the incursions of what he terms "war capitalism," Beckert (2014, p. 22) argues that the "household, and the [spinning and weaving] technology associated with it, remained at their center." The global expansion of specialized cotton production, first briefly in the West Indies and then in a more spectacular fashion, in the American

[6] See Williamson (2011, pp. 49-50).

South and in Egypt, wreaked havoc on this "delicate equilibrium" between cotton and other crops. As capitalism concentrated cotton production in a few regions specialized production, imports of European (and eventually Japanese) yarn and cloth manufactured using modern technologies launched a "tsunami of [rural] de-industrialization" with mass unemployment and "devastating consequences for spinners, and weavers, and rural cultivators alike."[7] Beckert (2014, pp. 328 and 333)The case of India is particularly compelling, as former "craft" weavers were forced to abandon the loom and again take to the plow.

The pessimistic de-industrialization argument poses two core challenges as we attempt to assess it. First, much of the argumentation is in terms of the long-term influence of specialization within the international trading order on the development paths of peripheral economies. At the same time, the fundamental models in use, whether Heckscher-Ohlin with the stress on relative factor endowments or Ricardo, with the assertion of differences in economy-wide productivity, are static. Second, the absence of explicit modeling of the ways in which comparative static gains from trade may come about for countries of the periphery prevents us from developing a meaningful counterfactual of a world where the country had no involvement in the international trading regime as it emerged after 1850. Without a counterfactual, we are unable to assess what the true net costs or benefits of that trading regime may have been for the millions whose lives it influenced. We are also unable to assess the relative contributions of "de-industrialization" (and the purchase of goods produced using advanced technologies) and the gains from specialization in response to differences in factor endowments. Both reasons for specialization could result in "Dutch disease" effects, but surely evidence of immense gaps in the productivities of technologies between center and periphery would have differing implications for stories about de-industrialization than would an account based primarily shifts in the terms of trade brought about by reductions in trade costs.

We address these two concerns with a case study of the Japanese economy during the first decade that it was open to the international trading regime of the late nineteenth century. Our case study employs

[7] Beckert (2014, pp. 328 and 333

a new framework for evaluating the gains from international trade that focuses on the trade in factors of production embodied in exports and imports. The framework draws on an insight from Ricardo (1817), which offers a thought experiment about how to measure the gains "Portugal" secured in its sale of wine to England in exchange for cloth. Those gains are simply the difference between the domestic labor cost of the imported cloth and the labor cost of the exported wine. Although our framework could be applied in any country involved in the Great Specialization, our case study of Japan during the period just after opening up offers two distinct advantages. First, we can evaluate the gains (or costs) in terms of traded factors evaluated at the pre-industrial technologies in use in Japan just prior to and shortly after the opening up. We develop the argument that Japanese technologies were widely representative of the pre-industrial methods in use in many countries of the periphery. Second, we can map the factor gains into an estimate in terms of a numeraire (in this case, the ryō) using autarky factor prices. Our estimates allow us to assess the amount of inefficiency the Japanese economy would be subject to were trade to be cut off. Finally, our approach allows us to allocate the gains to either Heckscher-Ohlin or Ricardian forces. We will discover that the gains to the Japanese economy were substantial and due largely to the much higher productivity of technologies of its trading partners, particularly the industrialized countries of western Europe. Reduced costs of ocean-borne transport and enhanced communication technologies play a supportive role, and may have been in some cases a necessary condition for the gains to be realized.

A Ricardian framework for measuring the gains from trade

The framework presented here develops in summary form a gains from trade formulation that is analogous to standard consumer measures that capture the distance between aggregate consumption under autarky and under open trade.[8] Consider first the production economy that is trading. The economy has a vector of k factors (**L**) that describe its endowment. For the purposes of our analysis, the endowment is fixed. The economy has at its disposal production technologies summarized by a k (factors) X n (products)

[8] For more details on this approach, please see Bernhofen, Brown et al. (2015). That paper provides a comparison with the more widely-used consumer expenditure measures of the gains from trade. See Bernhofen and Brown (2005) for an empirical application of that approach to the case of Japan.

matrix **A**, with individual elements a_{ij} that describe the amount of factor i required to produce one unit of product j.[9] If the economy is in full employment, $\mathbf{L}= \mathbf{AY^t}$, where $\mathbf{Y^t}$ is the economy's production under trade. Figure 1 shows the situation in the case of two goods, y1 and y2. Under trade, the economy is able to separate the vector of consumption ($\mathbf{C^t}$) from the vector of production, and the difference is the vector **T**, or $\mathbf{T}=\mathbf{AC^t}$. This vector is known as the trade triangle.

In a famous passage, Ricardo (1817, p. 82) describes the trading relationship between England and Portugal that involved the exchange of English cloth for Portuguese wine. He interprets England's gains from exchange as the amount of labor England saves when it consumes Portuguese wine produced with (less) Portuguese labor than the same amount of (admittedly inferior) wine produced with more English labor. Similar gains arise for Portugal, which saves some domestic labor for other uses when it imports English cloth produced with less labor than would be expended using domestic Portuguese technologies. Our approach formalizes this insight by developing a counterfactual for the case of autarky that answers the question: how much would the endowment need to be augmented in order to be able to produce the consumption available under trade? That new endowment vector would be $\mathbf{L^{aug}=AC^t}$. From this perspective, the endowment augmentation measure of the gains to trade would be the vector $\Delta\mathbf{L}=\mathbf{L}^{aug}\text{-}\mathbf{L}$, or the difference between the Portuguese and English labor required to produce cloth imported in exchange for wine. To clarify the source of the gains, note that we can break the **A** matrix up into two matrices. The first, $\mathbf{A^{xd}}$, has the input coefficients required to produce all exported goods. The second, $\mathbf{A^{md}}$, has the matrix of (domestic) total factor requirements that when applied to $\mathbf{L}^{aug}$, would be sufficient to produce $\mathbf{C}^t$. If **M** denotes the vector of imports and **X** denotes the vector of exports, we can recast the endowment augmentation as

(1) $\Delta\mathbf{L^{aug}}= \mathbf{L}^{aug}\text{-}\mathbf{L}= \mathbf{A^{md}M}\text{-} \mathbf{A^{xd}X}$.

[9] Note that this definition of the **A** matrix includes final factor usage for the production of a good (both direct factor usage and indirect factor usage via input-output relationships). The equivalent matrix in Estevadeordal and Taylor (2002) defines **A** as the input-out relationships and $\mathbf{B}^d$ as the direct factor usage: $\mathbf{B}^d(\mathrm{I}\ \text{-}\mathbf{A})^{-1}$.

If it is possible to produce the vector of imports or substitutes for those imports using domestic technologies, the counterfactual (autarky) gross augmentation of resources from trade, or what the trading country receives in exchange for its exports in resource terms, is $\mathbf{A^{md}M}$. The reader will note that the land element of this vector of factors that results from multiplying $\mathbf{A^{md}}$ and $\mathbf{M}$ features prominently in Pomeranz's discussion of the *gross* gains to England's endowment of land from the "ghost acreage" in the West Indies used to produce sugar and from the plantations in the US American South used to produce cotton. The Pomeranz argument focuses on England's imports of sugar and cotton, neither of which could be grown in England. The "domestic" technology equivalents for the factor land would be the amount of land required to produce a quantity of wheat that would yield the same caloric content as a unit of sugar imports and the amount of land used in the raising of sheep that would be required to produce a pound of washed and cleaned wool as the equivalent of a pound of imported ginned cotton.

Of course, in a trading equilibrium imports are not free. The vector $\mathbf{A^{xd}X}$ represents the factor cost of the exports that are sold in exchange for imports. Since exports are necessarily produced using domestic technologies, the $\mathbf{A^{xd}}$ matrix represents the per-unit factor requirements for them. Note that the submatrices $\mathbf{A^{xd}}$ and $\mathbf{A^{md}}$ refer to the full range of products produced in the country, and the components of each matrix depend upon what the country exports and imports. If a good does enter into international trade, then the entry for that good in the $\mathbf{X}$ or $\mathbf{M}$ vector would be zero.[10]

Figures 1 and 2 present simple diagrammatic representations of the factor endowment measure in goods space. Assume that an economy uses only one factor, labor, to produce two goods: shirtings and wine.[11] The amount of labor required for the domestic (d) production of a unit of shirtings is a_S^d and the amount of labor required to produce British wine is a_W^d. Under trade, the country produces at the production point exports $\mathbf{Y^t}$=(S,W). It exports S_X units of shirtings and imports W_M units of wine, so that

[10] We note that the Pomeranz argument is silent on measuring the factors expended to gain access to imports produced on the ghost acreage.

[11] Shirtings were a standard Birtish export cloth of lighter weight (about 0.18 lbs per square yard). The largest exports were unfinished shirtings, but dyed and bleached shirtings were sold as well.

its consumption point is $\mathbf{C^t}$=($S-S_X$,$W+W_M$). The familiar trade triangle is the vector (S_X, W_M), designated in red. Given the preferences of the country's representative consumer, the autarky consumption given its endowment would be $\mathbf{C^a}$ rather than the consumption under trade, $\mathbf{C^t}$.

Figure 2, also in goods space, shows the impact that the endowment augmentation ($\Delta\mathbf{L}$) has on the counterfactual autarky production possibilities of the country, which are designated with a dashed line. $\Delta\mathbf{L}$ reflects the net amount of labor that would be needed for the country to cover both the resource cost of its exports and the additional needed labor to produce its consumption of wine using domestic technologies (a_W^d). For the case of one factor, the implicit augmentation of the endowment could be readily measured in factor units. If we would like to create a metric for factor gains that would be comparable to the distance measures used in the standard measures of the gains from trade, we can multiply ΔL by the domestic opportunity cost of the resource, w.[12] Whether we prefer to use the cost of the resource(s) in autarky or in open trade depends upon the question at hand. In this application, since we are interested in the autarky or no trade counterfactual, we will use the autarky price of the factor w^a.

The endowment augmentation approach to the gains from trade offers additional insights into factor exchange if we consider a situation where a country uses two factors of production, L_1 and L_2, to produce goods. Without loss of generality, we can describe the matrix of domestic production technologies as $\mathbf{A^d}$**,** which as noted above can be readily partitioned into two submatrices on the basis of whether the country is a net importer or exporter of a particular product. Of course, our assumption of full employment means that , $\bar{L}_1+\bar{L}_2=\mathbf{L}$, where $\bar{L}_i$ is the economy's endowment of factor i. The country's national income under autarky is the inner product of the vector of (autarky) factor prices (w_1,w_2) and factor supplies, or $\mathbf{w^a\,L}$**.** As seen in Figure 3, the factor usage for exports can be represented as the vector pointed to the south and west that is labelled $\mathbf{A^{dx}X}$. If the export goods use more of factor 1 compared

[12] Bernhofen and Brown (2005) uses an equivalent variation measure based upon the autarky value of the difference between $\mathbf{C^t}$ and $\mathbf{C^a}$. Note that the approach used in that paper requires the assumption that the preferences of consumers in the trading country meet the assumption of the weak axiom of revealed preference. Since the approach discussed here focuses on factor exchange, it requires no assumption about consumer preferences.

with factor 2, the vector will be pointed towards the south south west. The vector in the northeast direction is $\mathbf{A^{md}M}$. By vector addition, the endowment augmentation as noted above is $\mathbf{\Delta L}= \mathbf{A^{md}M} - \mathbf{A^{xd}X}$. At the vector $\mathbf{L}+\Delta\mathbf{L}$, factor supplies are sufficient to produce $\mathbf{C^t}$. Figure 3 illustrates the implicit endowment augmentation. The scalar $\mathbf{w^a \Delta L}$ is the autarky valuation of the endowment augmentation. Bernhofen, Brown et al. (2015) demonstrate that this value is the equivalent variation ($\mathbf{L}^{EV}$) in factor income terms. That is, it shows the increase in factor income at autarky factor prices that would be equivalent to obtaining the augmented endowment point $\mathbf{L}^{aug}$. We will use the measure $\rho = \frac{\boldsymbol{w^a L}}{\boldsymbol{w^a L + w^a \Delta L}}$ as our measure of the relative (in) efficiency of autarky compared with the trading equilibrium. A lower value of ρ is consistent with higher inefficiency of autarky.[13] Our measure is less than or equal to 1 (if there is no endowment augmentation, there is no gain from trade) and greater 0. The larger the value of the endowment augmentation ($\mathbf{L}^{EV}$) relative to autarky income, the smaller the value of ρ and the greater is the efficiency cost of autarky when a trading equilibrium is available to the economy.

Figure 3 also suggests an additional insight into how technological differences may contribute to efficiency gains from trade. Note that in reality, the *actual* amount of factors embodied in imports will be determined by the technology at the (foreign) location of production, or $\mathbf{A^{m*}}$. That means that we can decompose the endowment augmentation as

$$(2)\ \Delta\mathbf{L^{aug}}= \mathbf{L}^{aug}\text{-}\mathbf{L}= \mathbf{A^{m*}M}\text{-}\ \mathbf{A^{xd}X} +(\mathbf{A^{md}}\text{-}\mathbf{A^{m*}})\mathbf{M}$$

The term $\mathbf{A^{m}*M}\text{-}\ \mathbf{A^{xd}X}$ represents the actual factor exchange, and the term $(\mathbf{A^{md}}\text{-}\mathbf{A^{m*}})\mathbf{M}$ captures the difference in technologies that may lead to additional endowment augmentation. In the case where $\mathbf{A^{m*}=A^{md}}$, then trade must be driven purely by relative factor scarcity. We can readily see that as the proportion $\theta=\frac{\mathbf{w^a(A^{md}-A^{m*})M}}{\mathbf{L^{EV}}}$ grows, the overall gains from trade must arise primarily from differences in technology—and not relative factor scarcities.

[13] See Bernhofen, Brown et al. (2015., p. 16) for details. This measure is based upon the general discussion found in Debreu (1951) about distance measures of welfare gains.

To summarize, our framework builds on Ricardo's insight about how the gains from trade can be construed as an augmentation of a trading country's factor endowment. A quick review of the concept of "ghost acreage" suggests that the resource saving for a trading economy from imports, whatever the source, necessarily overstates the net augmentation of the factor endowment. Our application of this framework to the case of Japan during the first years of its participation in the "Great Specialization" will focus on four key outcomes:

1. The pattern of gross and net factor trade
2. The autarky valuation of the gains to the economy (L^{EV})
3. The efficiency gains implied for the Japanese economy (ρ)
4. The extent to which technological differences (θ) or Heckscher-Ohlin forces ($1-\theta$) account for those gains.

The Case of Japan: 1865-1876

The story of Japan's entry into the world economy after over two hundred years of relative isolation has been summarized in many places, including Bernhofen and Brown (2004) and Williamson (2011). Despite the unusual circumstances of its entry into the global economy, we believe that Japan's trading pattern during the first years of open trade, its extensive use of iconic pre-industrial technologies and its (relative) factor endowment share many commonalities with other countries of the periphery.

Table 2 suggests that Japan's trade in 1874 fit the pattern of other peripheral countries quite well. Textiles, both those made of cotton and of wool, constituted almost three-fifths of its imports, or twice the average of the 17 peripheral countries in Table 2 for which we have the data. Japan's textile imports competed with domestic production of cotton yarn, cotton cloth and silk cloth. Even as inexpensive cotton yarn (and cloth) started to displace the household-based spinning and weaving of cotton and undermined the remaining domestic production of inexpensive hemp cloth, the run-up in the domestic price of silk squeezed margins in the silk weaving industry. In turn, Japanese consumers turned to alternatives offered by Japan's European trading partners, primarily worsteds, mixed woolens and mixed cotton and worsted goods. Figure 5, which shows the ratio of the price of raw silk to the domestic price of cotton yarn, illustrates the extent of the price squeeze even after the tumultuous years of the 1860s, which featured the cotton famine, the Meiji Revolution and the worst harvest failures since the Tempō famine years of the 1830s.

Japan's imports of raw materials (for processing), were relatively low. Its heavy reliance on primary product exports (mostly raw silk, silkworm eggs and tea) in 1874 placed it on par with Argentina and Egypt and well above China and India. Finally, among the Asian economies, which tended to be involved in more intra-Asian trade, Japan stood out for the importance of core countries as its export markets. Its raw silk and silkworm eggs went to England, France and Italy, and its green tea went to the United States. Only a few minor exports of food specialty items, such as mushrooms, dried seafood, seaweed and kanten (agar-agar) were destined for Asian markets.

Japan's (pre-industrial) technologies and reliance on rural household production units for manufacturing cotton and hemp textiles were for the most part typical of other Asian countries and pre-industrial Europe. Cotton growing and processing used the same hand methods for ginning and skutching that were employed in India and China. Spinning and weaving methods were similar to traditional methods in use throughout Asia. The flying shuttle was not introduced until the 1870s. Japan's copper mines and smelting operations were considered by Europeans such as Mezger (1884) as living museums of pre-industrial European technology. Iron production was adapted to the use of sand iron, since iron ore of the kind found on the Asian mainland and in Europe was not present in Japan. *Tatara* furnaces for smelting sand iron required rebuilding every year. The blast for the furnaces relied upon human rather than water or steam power to drive the bellows. In agriculture, draft animals were limited in use. Mining of most ores and coal was only possible in shallow adits, since the technology for maintaining proper subsurface drainage relied almost exclusively on the use of pumps powered by foot treadles.

As Figure 6 suggests, of all of the Third World peripheral countries for which we have data, Japan did experience the greatest relative scarcity of land. A quarter century of industrial progress from 1874 to 1900 enabled Japan to move from the second to the third income quartile of the "Third World" periphery, but efforts to increase agricultural productivity were mostly able to just keep pace with population growth.

Finally, we note that we restrict our analysis to the period that includes the first fifteen years of open trade in order to avoid some of the inevitable historical complications that begin to cloud the picture and disrupt our static framework after the mid-1870s. Most important, up until the mid-1880s, we can be assured that the technologies available to and employed in the Japanese economy retained their pre-industrial character. We can readily identify the exceptions to this general rule, coal mining and the copper smelting and refining industry, and incorporate the richly documented evidence on technological change in these industries in our analysis. Second, by the mid-1870s, Meiji-era reforms began to influence the labor force, the financial sector and other aspects of the Japanese economy. These reforms began to influence the economy's production possibilities in ways that would move us too far away from our static equilibrium framework.

Data Development and Sources

As our theoretical framework suggests, our interpretation of the implicit augmentation of the endowment as the gains from factorial trade places heavy demands on data. Not surprisingly, the most readily available data are on Japanese trade. We used published Meiji-era trade statistics for the period 1868-1876 for the core of our trade dataset (see Shuzeikyoku (1893)). In addition, the consular reports of Great Britain, the German states (Prussia and the North German Confederation), Belgium and France for the years 1865 through the mid-1870s helped us fill in the missing trade data for 1865 and 1867 as well as refine some of the early Meiji statistics.[14] Although Japan was officially open to trade on July 4, 1859, we

[14] Along with Brennwald (1865) and Scherzer (1872), the consular reports also provide rich and detailed commentary on western goods imported into Japan.

chose to begin our analysis during what can be viewed as the first year of fully open trade under the treaty port system: 1865. Until western military intervention in 1864, the shogunate was able to restrict exports of silk and silkworm eggs. We note as well that trade statistics for 1866 for the treaty port with the largest trade volume, Kanagawa (near Edo), were lost to fire.

The detailed sources and methods used to develop the $\mathbf{A}^{xd}$, $\mathbf{A}^{md}$ and $\mathbf{A}^{m*}$ matrices are found in our working paper Bernhofen, Brown et al. (2014). As noted above, the **A** matrices include both direct and indirect factor usage. For Japan, indirect factor usage included fertilizer, charcoal, wood, cotton, silkworm eggs, silkworm cocoons and mulberry leaves among other inputs. The fundamental source for much of the domestic Japanese **A** matrix is the 16-volume compendium of prefectural- and county-level data on the detailed input requirements for cultivated crops and sericulture known as the Nōji Chōsa, which was reprinted in an edition by Chō, Shōda et al. (1979). Based upon the data in this source and contemporary commentary, we chose to represent the relevant technologies for Japan's trading sector with three types of labor (skilled male, unskilled male and female), capital and land. We recognized the fact that land is not homogenous. Rather than create multiple types of land, we standardized land inputs so that they were equivalent to what are known as "dry fields" in Japan or simply arable in the west. Our adjustments allowed us to account for rice paddy (an upward adjustment) and pasture and grazing land (a downward adjustment). Additional sources for Japan's sericulture, mining, smelting and manufacturing industries include de Bavier (1874),Ota (1880), Smith (1879), Tanimoto (1998), Nohara (2008) and Coignet and Ishikawa (1957). Tamura (2004) provides invaluable information on the ways in which imported textiles substituted for domestic cloths; his research into the case of woolens and worsteds is particularly helpful for our understanding of why they constituted such a large share of the textile imports noted in Table 2. We also investigated production technologies for three Japanese near substitutes for woolens: okata obi (heavier silk used in belts), habutae and chirimen. Overall, about 130 sources were used to construct the

Japanese **A** matrices. To the extent possible, we tried to accurately represent production conditions for the late Tokugawa and early Meiji eras.[15]

Of necessity, compilation of the $\mathbf{A}^{m*}$ matrix drew upon a wide range of American, French, British and German sources. The consular reports helped us identify the main source country for individual imports. The series of reports prepared for American investigations of competitiveness found in Wright (1891) and Wright (1892) provide starting points for describing the technologies used by British firms in textiles and metals. France. Corps législatif (1870), Daumas (2004) and Germany. Enquete-Kommission für die Baumwollen- und Leinen-industrie (1878) provide basic information on the French and German textile industries that competed with the British, particularly in woolens and worsted. Several contemporary reports and local studies supplemented this information, as did contemporary accounts of production conditions in the French, German, British, Argentinian and Australian wool industries. Finally, Isett (1995), Coquerel (1911) and Buck (1937) offer helpful accounts of Formosan sugar production, Indochinese rice production and Chinese production of cotton and soybeans. All of these countries were important suppliers of food and raw materials to Japan during the period of our study. Overall, we consulted about 170 sources to develop the $\mathbf{A}^{m*}$ matrix. In sum, the $\mathbf{A}^{xd}$ matrix covers about 94 percent of Japanese exports (by value) and the $\mathbf{A}^{md}$ and $\mathbf{A}^{m*}$ matrices cover about 80 percent of imports. The most important missing categories are weapons and ships, for which we were unable to find suitable information on Japanese production methods.

The factor price data come from several sources. Most of the sources for the wage data that we use are identified in Saitō (1973). They are primarily from two core economic regions of Tokugawa Japan. The area around Kyōtō and Ōsaka is known as the Kansai or Kinki region. The Kantō region is in eastern Japan and centered on Edo (Tōkyō) and the districts to the north and east. Data on rents are likewise primarily from these two regions. We tackled the contribution of capital to factor usage by

[15] In other work (see Bernhofen and Brown ((in press)), we find that observed variation in the input-output relationships and parameters for key products such as silk and tea do not appreciably influence our findings.

drawing upon the standard definition in OECD (2009).[16] In most cases, actual estimates of depreciation are available in local currency. Usually, information on the relevant interest rates is included as well. For Japan, the interest rate during the late Tokugawa era in autarky is assumed to be 12 percent.[17] Finally, all values of the user cost of capital are converted to the equivalent value of the Japanese ryō based upon its buying power in 1851-1855. We can thus define the factor price of the user cost of capital as the numéraire equal to one.

Japan's factor trade: 1865-1876

The first set of results from calculation of the three matrices defining Japan's counterfactual trade in factors during the early years of open trade are presented in Table 3. As the table suggests, Japan was a net importer of all five factors during all of the years of our study. Net imports of female labor appeared to dominate all imports of labor throughout our study period; they had tripled by 187. Imports of unskilled male labor showed the least growth. In addition, imports of land surge ca. 1869-1871, only to subside by thereafter.

Figure 7 shows the evolution over time of net imports of all of the factors (except for capital) expressed as shares of their respective endowments.[18] The estimates in Figure 7 understate the importance of factor inflows for the Japanese economy, since our estimates of factor imports cover only about 80 percent of imports (by value). Overall, the rising volume of Japanese trade over the period increased the augmentation of the economy's endowment. Unskilled labor had the lowest augmentation of one to four percent of the endowment. Skilled and female labor played an increasingly important role in

[16] User cost of capital is $(\delta+i)P_k$, where P_k is the price of capital. δ is the rate of annual depreciation and i is the interest rate.
[17] See Saitō and Settsu (2006).
[18] We use the endowment of labor based upon the population ca. 1846 and the occupational distribution in 1872. Th endowment of land is from 1850. Saito and Takashima (2015, Table 1) report the population ca. 1846 and Broadberry, Fukao et al. (2015) offer estimates of the arable land endowment in 1850. Van Buren (1880) reports the distribution of the population by age and employment sector in 1873. The calculations assume 330 days of work for labor.

augmentation of the endowment, so that by the mid-1870s, or 15 years after the opening up, imports of both factors were up to six to eight percent of their respective autarky endowments.

The surge in imports of land and unskilled labor over the period 1869 to 1871 reflects another advantage of international economic integration that receives scant attention in most accounts. As Matsuo Masato (1977) shows, starting in mid-1869, northern Japan (the Tohoku region) experienced a sequence of abnormally cold weather, heavy rain and eventually early frosts that led to substantial destruction of the rice and other crops. Over the past two centuries, only the poor weather during the 1830s that is associated with several years of poor harvests and the Tenpō famine exceeded the cold and rainy weather of the summer and fall of 1869.[19] The size of the harvest shortfall is difficult to measure given the sources, but we do know from Matsuo Masato (1977, Table 1) that it exceeded 70 percent in the four most northernmost provinces of Japan and was in excess of one-half further to the south and east. Imports of rice from China and Cochin-China (southeastern Indochina) and soybeans from China began in 1869 and increased in 1870 and continued through 1871. As Figure 7 suggests, total net imports essentially augmented Japan's endowment of land by eight percent, which was well in excess of what we observed before and after the years of poor harvests. Calculating the savings in health and reduced mortality from the this addition to the endowment is beyond the scope of this paper, but as Saito (2010, p. 273) notes, 1400 years of Japanese famine history essentially ended in 1869. Without a doubt, the borrowing of an area equivalent to 3200 square kilometers in 1869-1870 (and the labor needed to till it) saved lives and reduced mortality. Over the entire study period, net factor imports implied an average increase in the endowment of land about three percent.

The other notable trend evident in Figure 7 is the increased imports of skilled and female labor and complementary factors, which grew by two and one-half to three times respectively. Figure 8 traces the contribution of key imports that help account for this pattern. Imports of English yarn in numbers at

[19] See Saito (2010) for an overview of the relationship between unusually cold and wet periods and harvest failures in Japan for the 18th and 19th centuries, which was in general a period of warming temperatures.

and above the numbers traditionally produced in Japan (20s and above) and imports of shirtings alone accounted for most of the increase in counterfactual imports of female labor. The main influence on the increase in the imports of skilled male labor was the expansion of imports of light worsted cloths to Japan from Great Britain (Orleans and lustres) and France and Germany (Mousseline de laine or woolen muslin). Both types of cloth were relatively lightweight and were increasingly used for kimonos as substitutes for Japanese silk cloth (*chirimen*), which required a relatively large input of male skilled labor. Compared with grey shirtings, which were used as linings of kimonos and or finished in Japan, light worsted cloths could only be sold on Japanese markets if the printing and finish met the current demands of Japanese fashion. Three innovations that occurred in a relatively short time—the opening up of the Suez Canal in 1869, the development of the high pressure compound steam engine and the extension of international telegraph service to Japan in 1871 and to Tokyo in 1873—boosted the ability of western merchants in Japan to meet the demands of this market. The Suez Canal cut the travel time between London (or Marseilles) to Yokohama from four to five months for a ship traveling via the Cape of Good Hope to perhaps two weeks. As was reported in the *Japan Weekly Mail*:

> "The French and German manufacturers seem to be running English manufacturers very hard in the production of goods specially adapted to this market. The clever and careful way in which (Japanese) patterns are imitated is an example worthy of attention… [B]y means of the telegraph… goods, for which there is any demand,… can be sent for and laid down in three-and-a-half to four months."[20]

Once we have calculated the net (counterfactual) imports of factors, finding the autarky valuation of $\Delta\mathbf{L}$ is straightforward. One concern to address is that for much of the study period, Japan operated with a substantial merchandise trade deficit. Of our study years, only during 1865, 1868 and 1876 was Japan able to post a trade surplus. For the most part, the trade deficits during the other years were financed with modest inflows of capital from a few Meiji government bond offerings and an outflow of specie in the

[20] See Notes of the Week (1873).

form of (old) gold and silver coins of the Tokugawa era. To provide a measure that is reflective of the long-term benefits to the economy of endowment augmentation, we calculated $\Delta\mathbf{L}$ under the assumption of balanced trade in each year. Assuming that preferences over all imported goods were homothetic, we simply scaled the import vector up and down by an amount that would ensure a balanced trade. The results of the "balanced trade" calculations are presented in the bottom section of Table 3. Since domestic supply and international demand conditions clearly fluctuated from year-to-year and trade offers an opportunity for consumption smoothing, we view the resulting estimate ($\Delta\mathbf{L}^{balance}$) as a lower bound on the extent to which participation in the international trading regime benefited Japan.

Calculation of the autarky value of the endowment augmentation $\Delta\mathbf{L}^{EV}$ ($\mathbf{w}^{a}\mathbf{L}^{aug}$) provides us a metric with which to assess the efficiency cost of the counterfactual course of history: remaining in autarky. Table 4 offers estimates of this measure based actual recorded trade (in row(1)) and under the assumption of balanced trade (row(3). For reference, estimates of the equivalent variation measure of gains from trade (ΔI^{EV}) from Bernhofen and Brown (2005) for the subperiod 1868 through 1875 are found in row(2). The results are generally consistent with each other, although the year-to-year variation in the trade balance and in the calculation methods do result in some discrepancies.

Our counterfactual measure of resource augmentation is most informative when it is placed in comparison with the size of the Japanese economy during the last few years of autarky. Since the augmentation of the endowment through trade resulted in increased production and factor incomes in the Japanese economy, we measure its impact in terms of a counterfactual: what fraction of factor income would be retained if the economy reverted to autarky? As noted above, the value of our measure (ρ) can vary between just greater than zero to 1. We have four alternatives for forecasting the autarky counterfactual factor income for our study period. The first two alternatives draw upon Nishikawa (1987) and his pioneering reconstruction of the GDP of the Chōshū domain in the early 1840s in monetary terms from a comprehensive survey carried out at that time. The third and fourth alternatives use the estimates of real GDP per capita found in Saito and Takashima (2014, Table 4) expressed in terms of rice equivalents (in *koku*). Their (higher) estimate can be expressed as a ratio to Nishikawa's koku estimates of real GDP to provide a second monetary measure. For each variant of real GDP per capita estimated for the late Tokugawa era (prior to trade), we calculated a growth path forward into the era of open trade. Saito and Takashima (2014) suggest the Japanese economy realized that an annual growth rate of 0.4 percent over the period 1850 to 1874, particularly as it responded to opportunities presented by open trade. As an alternative, we used their estimate of an growth of about 0.2 percent, which appears to have been the case for the century preceding the opening up to trade and reflects the modest growth potential of the Tokugawa economy through mid-century.

Rows (5) and (6) and (8) and (9) provide the estimates of ρ. The average efficiency ranged between 93 and 95 percent, so that reverting to autarky would have sacrificed between five and seven percent of output. For a few years the loss was above eight percent of the economy's potential. Japan's autarky was costly indeed. An alternative perspective can ask how many years Japan's economy would require to make up the seven percent lost due to autarky. Growing at the glacial pace of growth that characterized the pre-industrial era (0.2 percent), the economy would require more than three decades. We note finally that the efficiency gains associated with open trade occurred when Japan's participation in international trade, while significant, did not reach the levels found in other countries of the periphery. Based upon the 1874 Meiji Prefectural production survey and other work, Settsu (2015) estimates that Japanese GDP was 728 million yen. Meiji customs officials tallied Japanese imports at about 23 million yen, or about 3.2 percent of GDP in 1874. The Ricardian endowment augmentation approach allows us to construct a theoretically-consistent counterfactual and illustrates how misleading a focus on trade shares of GDP can be if we are interested in understanding the impact of international integration on the periphery.

Our framework allows us to examine another key question that arises in the "de-industrialization" interpretation of the experience of the periphery during the Great Specialization. A country's position in the "resource lottery" could influence the time path of resource re-allocation, its ability to draw in labor and capital and the volatility of its net barter terms of trade. To the extent that a peripheral country was a price-taker, these influences could be viewed as potential costs (or benefits) of participation in the international economy. As already noted, some interpretations argue that shifts in a country's terms of trade could profoundly influence both the gains from trade and the pace of de-industrialization. If a peripheral country's comparative advantage was steered by Heckscher-Ohlin forces of relative resource scarcity, we would expect that it would be even more subject to the vagaries of participation in the resource lottery. Hanson (1980, Table 3.5) underscores the rising degree of export concentration among the peripheral countries, so that by 1900, the most important export of the median country in the periphery accounted for over one half of export revenue. This export concentration is also suggestive of Heckscher-Ohlin forces at work. In Japan's case, raw silk, silkworm eggs and other related products of the sericulture industry accounted for 55 percent of exports during the test period. Indeed, Bernhofen and Brown ((in press)) are unable to reject a general equilibrium test of the hypothesis that Japan's pattern of trade during the test period was consistent with the Heckscher-Ohlin theorem.

As noted above, the other side of the trading relationship—imports of manufactures produced using technologies of the industrial revolution—has received notice primarily as a passive outcome of specialization in a primary product. The final part of our analysis sheds new light on this side of the trade ledger in its examination of the relative contributions of specialization and technological differences to the gains from factor trade. As the discussion of our framework suggests, the factor endowment augmentation approach lends itself to disentangling the influence of relative resource scarcity (Hecksher-Ohlin) and absolute differences in technologies (Ricardo). Recall that the measure θ is derived from a comparison of foreign and Japanese technologies used in the production of similar products or close substitutes. A high value of θ reveals large differences in technologies. It is calculated as an import-weighted average of the autarky valuation of differences in technologies expressed as a share of the total gains from trade ($\mathbf{L}^{EV}$). The value of 1- θ compares the factor content of Japan's exports and the actual factor content of Japan's imports. A high value of 1-θ suggests that technological differences play a minor role in the gains from factor trade.

For ease of presenting the core result, we have included θ in the final row (10) of Table 4. The measure (θ) appears to increase in a discrete jump ca. 1872. From 1865 through 1871, it ranges from 0.64 to 0.75. Large imports of rice and soybeans from east Asian trading partners ended in 1871 as the impact of the harvest failures of 1869 faded away. From 1872 onwards we note the increasing concentration in its net factor imports of female labor and land in cotton yarn, cotton cloth and light worsteds; the measure θ now ranges between 0.86 and 0.91 through the conclusion of the study period. Or in brief, by the early- to mid-1870s, almost all of Japan's substantial gains from trade (relative to autarky) came about through substantial technological differences that existed between it and its trading partners. To assist the interpretation of this pattern of a change, consider the technological differences evident in producing three goods: rice, cotton yarn and cloth (grey shirtings) and light worsted cloth. Table 6 presents the results for these three traded goods.

The surge in rice imports peaked in 1871 at 14.6 million piculs, which would have been more than one quarter of production in 1874. Panel A of Table 6 details the comparison between Japanese and Cochin-Chinese factor usage for rice production. Japanese methods were more intensive in the use of all factors than the technologies of Cochin-China, which benefitted from plentiful rainfall and a longer growing season. Japanese rice was heavily fertilized, which accounts in part for the much higher requirements of female and unskilled labor (for applying the fertilizer, weeding and so forth) and skilled labor (for producing fish fertilizer). The difference in the autarky value of the endowment augmentation ($w^a\Delta\mathbf{L}$) of 0.41 ryō is striking.

Differences in technologies for import staple of cotton shirtings, the 20s yarn used in the manufacture of shirtings and the cotton used in the production of that yarn are found in Panel B. Shirtings used 20/20s yarn. 20s yarn was also the modal yarn import for Japan during the study period. It used about three-quarters short-staple Indian cotton and one-quarter longer staple American cotton. Japanese technology for growing cotton apparently substituted labor and capital for land, which was used much more intensively in India and the United States. The value in the lower right hand corner of Panel B indicates that each catty (1.33 lbs.) of shirtings essentially generated an additional 0.149 ryō in factor income. Most of this difference came from technological differences. The gain in factor income from the cotton used in the weaving of shirtings was 0.018 ryō, or about 12 percent of the added factor income. More added factor income came from differences in spinning technology. As Panel B illustrates, much of the British resource advantage came in the conversion of ginned cotton into yarn. The low productivity of Japanese methods meant that a catty of 1.33 lbs. required almost three days to be produced, when compared with about 0.03 days using British methods. Most of the labor differential was in the processes of preparing ginned cotton for spinning and spinning technology itself. Overall, British spinning technologies accounted for about 30 percent of the differential in the value of the endowment augmentation ($\frac{(0.069-0.018)}{0.149}$) from imported shirtings, and about three-quarters of the total addition to income from importing a catty of yarn. British processes for preparing winding the warp and weaving resulted in further savings of about 0.087 ryō, or almost 60 percent of the total for shirtings. Overall, technologica differences accounted for from three-quarters to 90 percent of the added factor income.

The final example explores the sources of the gains to the Japanese economy as French and German manufactures of *mousseline de laine* (woolen muslin) learned to finish the cloth according to Japanese preferences so that it became a substitute for domestically-produced chirimen, or silk crepe. Panel B suggests that one pound of *mousseline de laine* resulted in almost one ryō of added factor income. Evidence from the late 1860s suggests that the French wool industry still contributed to domestic consumption, although merino wool from the southern hemisphere (including Argentina and Australia) was making rapid inroads. French methods of wool production were particularly intensive in the use of cropland, since most sheep were fed in stalls year-round. Argentinian methods relied entirely on pastureland. The labor and particularly the capital intensity of raw silk production account for most of the autarky valuation of the resource augmentation due to the substitution of wool for raw silk. The fact that

Japan’s imports of this worsted cloth implicitly included substantial “subtractions” of land from its endowment. The land “subtractions” almost compensated for the substantial savings in labor realized when the imported worsted cloth was substituted for the domestically-produced silk. The value of 0.08 ryō, the value of the addition to Japan’s resources accounted for by raw materials, suggests that factor exchange played a minor role in the import of worsted cloth. Instead, the technological efficiency of production methods in France, both the efficiency of preparation processes (combing wool and spinning worsted yarn) and the even the efficiency of French handlooms, accounted for over 90 percent of the gain to factor income. While classic forces of Heckscher-Ohlin may not matter so much here, we do note that these gains would not have been possible without the prerequisites for trade in a consumer good subject to the vagaries of fashion: communication by telegraph between production sites on the continent and markets in Japan and fast steamship service via the Suez Canal.

Conclusions

This case study of the benefits that Japan experienced as it was forcibly incorporated into the international trading system applies a static framework to the issue of whether it was better off as a primary product producer of the periphery compared with autarky. We employ the factor endowment augmentation approach to assessing the amount and sources of Japan’s gains from trade. Although our framework cannot speak directly to a dynamic account of how the Great Specialization influenced the path of growth of a peripheral country such as Japan, it does allow for a general equilibrium assessment of the gains within the context of a well-defined autarkic counterfactual. We find that Japan would have experienced an efficiency loss of five to seven percent relative to the gains to its endowment that it experienced with open trade. Viewed within the context of the anemic growth that it—and other parts of the periphery—experienced during the century prior to opening up, the benefits conferred by open trade were substantial.

Our closer look at the importance of technological differences found that they became increasingly important during the second decade of open trade. The direct benefits of the industrial revolution in terms of high productivity technologies for processing cotton (and wool) conferred gains to Japan, but so did the innovations in ocean-born transport and international communications that facilitated trade in specialized consumer goods as well as bulk commodities. The flows of capital to emerging centers of resource supply such as the southern cone, Australia and the southern United States also redounded to the benefit of millions of Japanese consumers. Our case study of Japan with a well-defined counterfactual suggests to us that the contribution of the Great Specialization to the Great Divergence remains an open question.

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Figure 1: The trading equilibrium

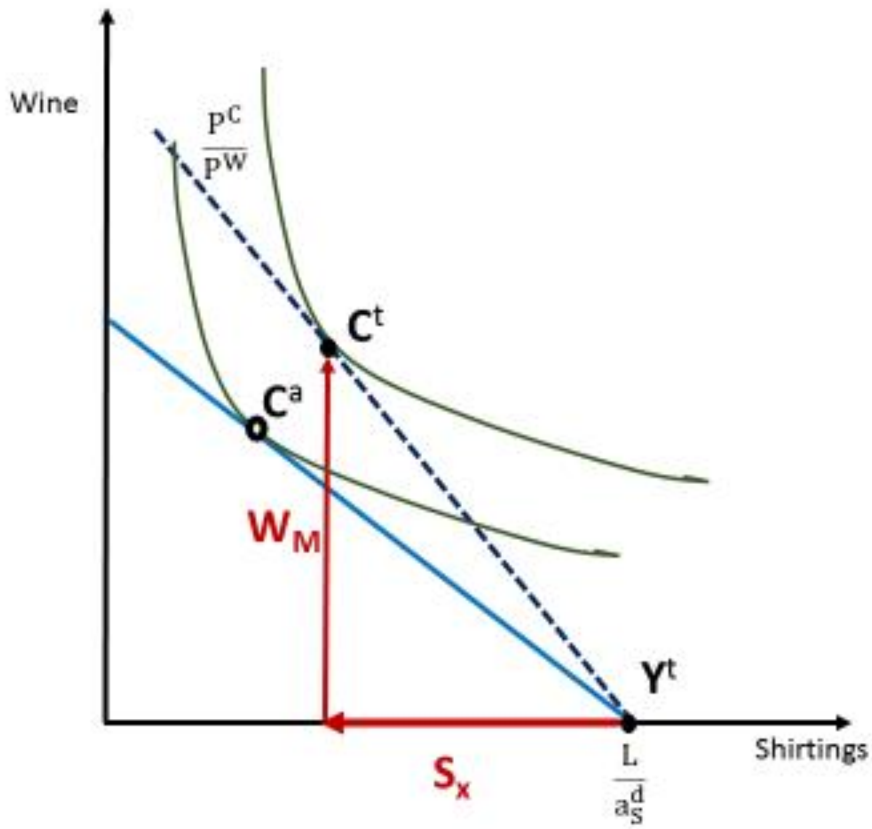


Figure 2: Endowment augmentation and measured real gains

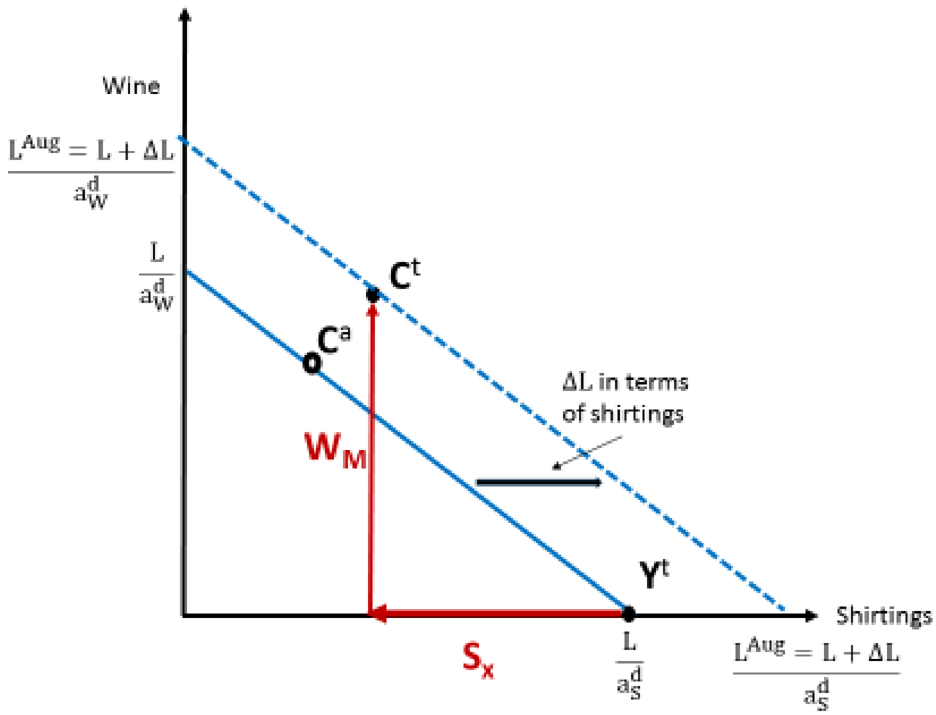


Figure 3: Endowment Augmentation with Two Factors and measured gains to income

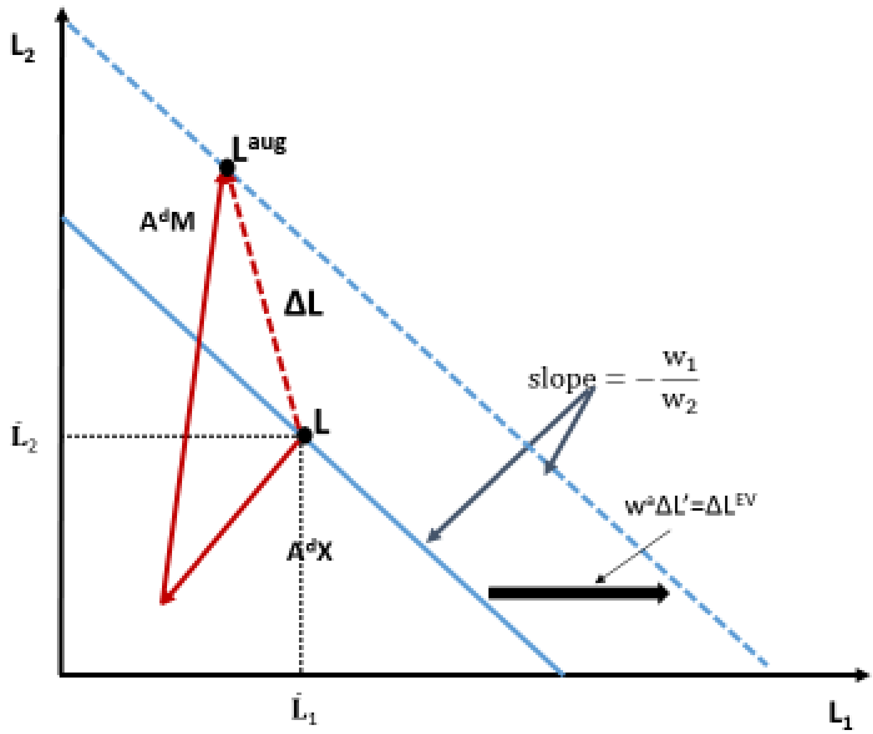
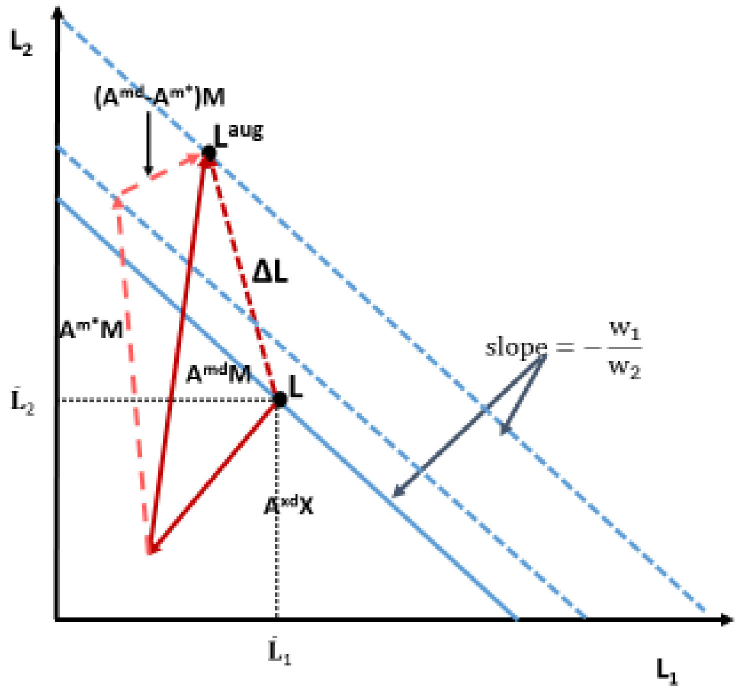


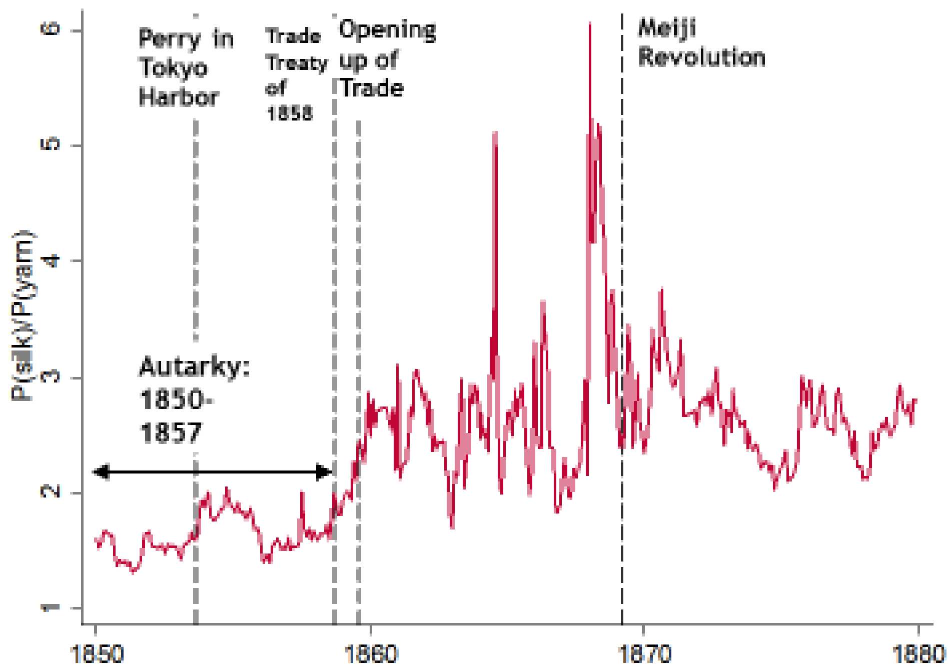
Figure 4: Endowment Augmentation and Sources of Gains to Trade



Notes: The vector $\mathbf{A}^{md}\mathbf{M}$ shows the augmentation to the endowment resulting from resource exchange.

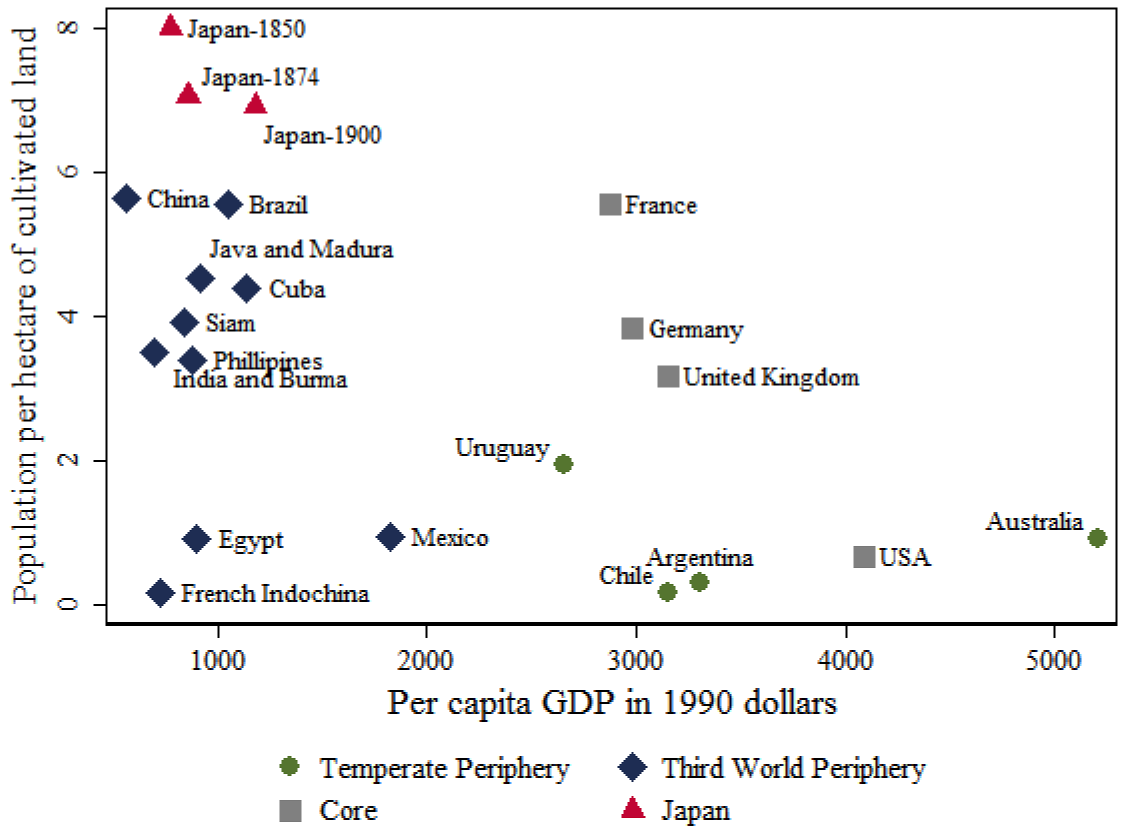
The vector $(\mathbf{A}^{md}\text{-}\mathbf{A}^{m*})\mathbf{M}$ shows the gains to the endowment resulting from technological differences.

Figure 5: The ratio of the price of raw silk to cotton yarn in Japan: 1850-1880



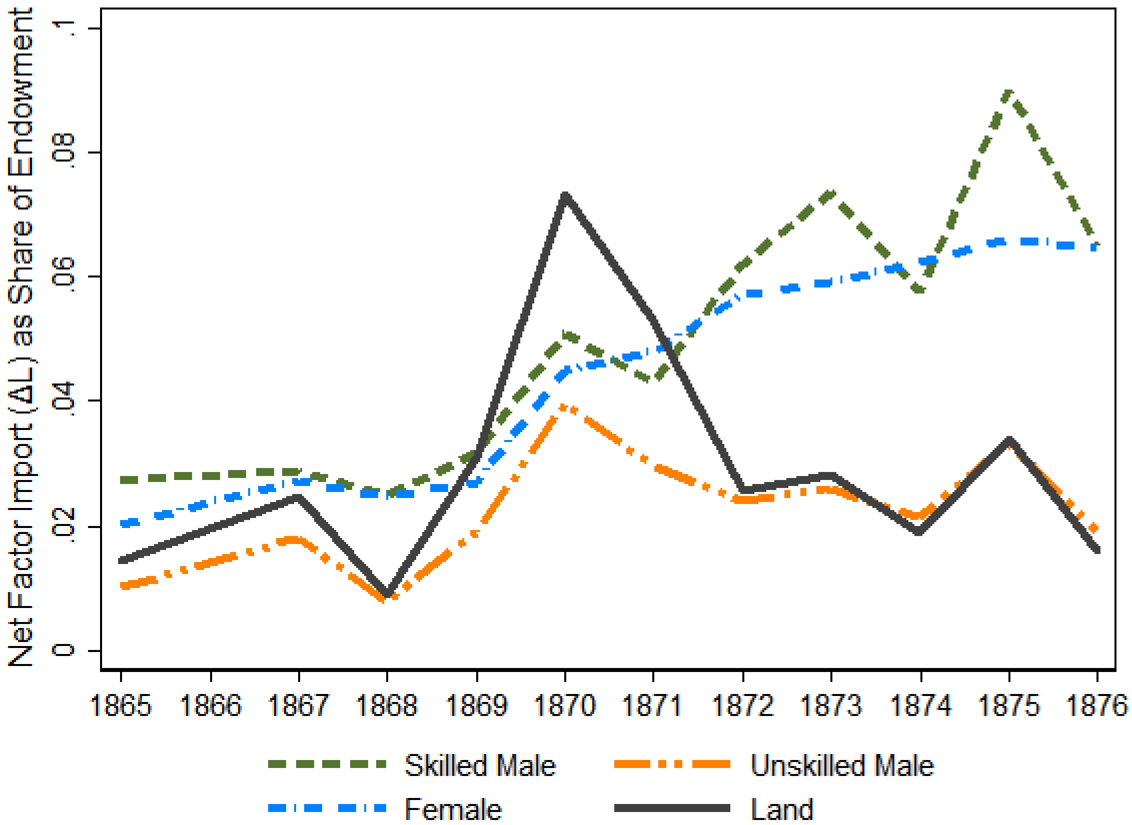
Source: Miyamoto and Ōsaka Daigaku Kinsei Bukkashi Kenkyūkai (1963) for monthly observations on raw silk and yarn prices.

Figure 6: Access to cultivated land and real GDP ca. 1900.



Source: Germany. Statistisches Reichsamt (1928), United States War Department Cuban census office (1900), Germany. Statistisches Reichsamt (1903) for 1900 and Broadberry, Fukao et al. (2015).

Figure 7: Net factor trade as a share of the endowment: 1865-1876

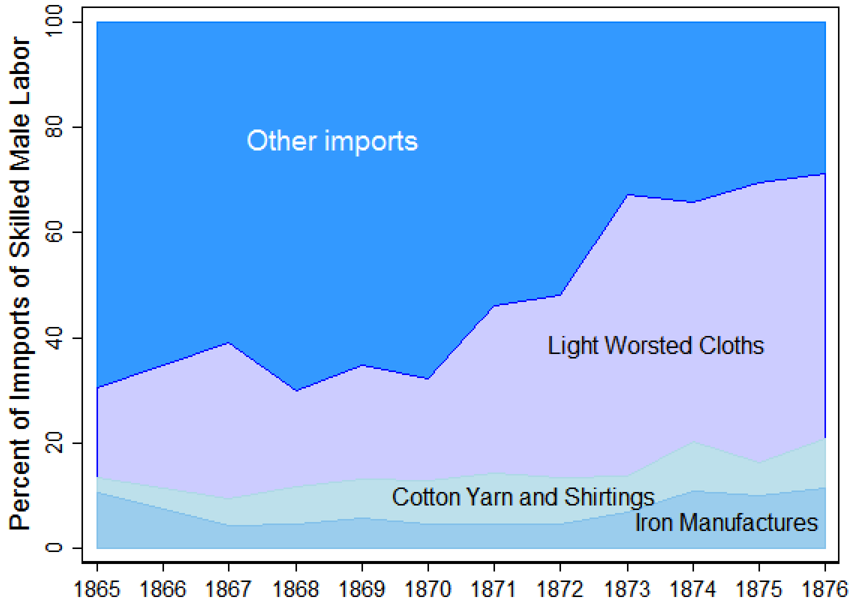


Notes: The graph shows the ratio of counterfactual each net factor import to the factor endowment ($\frac{\Delta L_k}{\bar{L}_k}$).

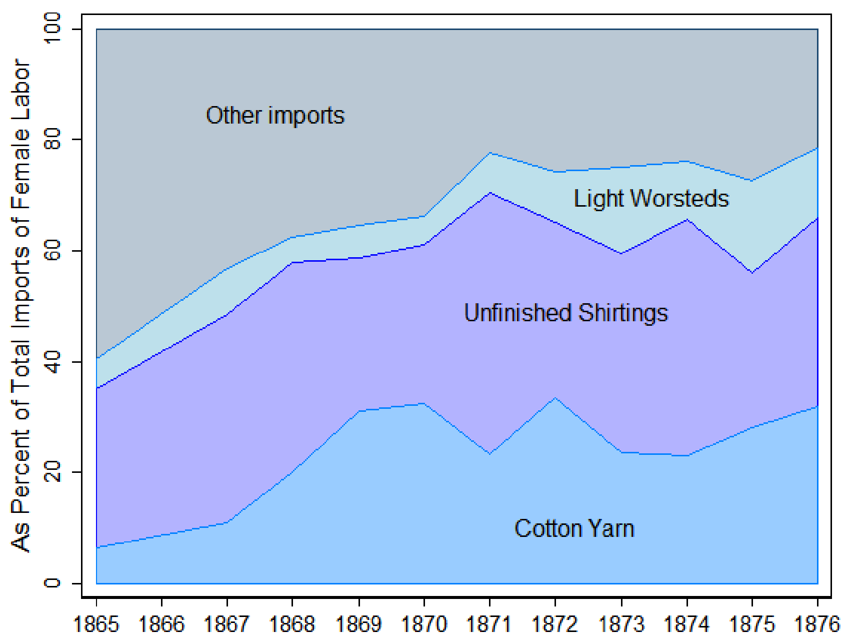
Source: The endowment data are from Saito and Takashima (2015, Table 1) for population ca. 1846, Broadberry, Fukao et al. (2015) for the land endowment in 1850 and Van Buren (1880) for the report of the distribution of the population by age and employment sector in 1873. The net factor imports are from Table 3.

Figure 8: The contributions of key imports to imports of skilled and female labor

Panel A: Skilled Male Labor



Panel B: Female Labor



Source: Results in Table 3 and authors' calculations.

Table 1: The Pattern of World Trade ca. 1900 for Core Economies

Panel A: Composition of Trade

Country	Imports as Share of Total		Export Composition: Raw Materials and Food			
	Share Textiles	Share Raw Materials	Animal	Plant	Mineral	Total
Germany	0.039	0.590	0.029	0.064	0.062	0.155
France	0.028	0.650	0.117	0.148	0.008	0.273
United Kingdom	0.072	0.640	0.002	0.056	0.110	0.168
USA	0.020	0.430	0.125	0.330	0.096	0.551

Panel B: Direction of Trade

	Sources of Imports as Share of Total				Destinations of Exports as Shares of Total			
Country	Asia	Africa	South/ Central America	Total Non-Core	Asia	Africa	South/ Central America	Total Non-Core
Germany	0.080	0.017	0.073	0.170	0.060	0.012	0.048	0.120
France	0.119	0.068	0.138	0.325	0.030	0.100	0.049	0.179
United Kingdom	0.204	0.061	0.091	0.356	0.338	0.099	0.096	0.533
USA	0.205	0.013	0.180	0.398	0.078	0.014	0.115	0.207

Source: *Annuaire Statistique de la France, Statistisches Jahrbuch des Deutschen Reiches, Germany. Statistisches Reichsamt (1928).*

Table 2: The Pattern of World Trade for Non-Core Economies ca. 1900

Panel A: Composition of Trade

Country	Imports as Share of Total		Export Composition: Raw Materials and Food			
	Share Textiles	Share Raw Materials	Animal	Plant	Mineral	Total
Argentina	0.331	0.093	0.460	0.462	0.000	0.922
Brazil	0.140	0.430	0.049	0.927	0.024	1.000
Chile	0.233	0.141	0.043	0.063	0.836	0.942
Cuba	0.162	0.236	0.005	0.580	0.099	0.684
Mexico	0.120	0.270	0.010	0.120	0.850	0.980
Peru	0.262	0.172	0.047	0.447	0.239	0.733
Uruguay	0.250	0.278	0.921	0.057	0.000	0.978
Australia	0.284	0.379	0.430	0.101	0.021	0.552
China	0.347	0.291	0.306	0.129	0.043	0.478
Dutch East Indies	0.275	0.152	0.000	0.650	0.346	0.996
French Indochina	0.290	0.155	0.067	0.745	0.040	0.852
India	0.397	0.105	0.103	0.604	0.000	0.707
Japan 1874	0.581	0.155	0.410	0.450	0.057	0.917
Japan 1900	0.063	0.630	0.210	0.119	0.067	0.396
Siam	0.220	0.145	0.023	0.762	0.088	0.873
Egypt	0.286	0.190	0.006	0.929	0.000	0.935
South Africa	0.270	0.264	0.220	0.000	0.750	0.970

Sudan	0.239	0.160	0.169	0.619	0.000	0.788
Average	0.276	0.213	0.192	0.450	0.200	0.842

Panel B: Direction of Trade

Country	Sources of Imports as Share of Total: Asia	Africa	South/Central America	Total Non-Core	Destinations of Exports as Shares of Total: Asia	Africa	South/Central America	Total Non-Core
Argentina	0.000	0.000	0.069	0.069	0.002	0.000	0.053	0.055
Brazil	0.003	0.013	0.040	0.056	0.063	0.000	0.145	0.208
Chile	0.009	0.003	0.028	0.040	0.055	0.000	0.075	0.130
Cuba	0.005	0.000	0.011	0.016	0.003	0.000	0.125	0.128
Mexico	0.000	0.000	0.050	0.050	0.011	0.000	0.005	0.016
Peru	0.000	0.000	0.032	0.032	0.030	0.000	0.039	0.069
Uruguay	0.000	0.000	0.368	0.368	0.000	0.016	0.171	0.187
Australia	0.186	0.060	0.000	0.246	0.116	0.000	0.000	0.116
China	0.208	0.018	0.000	0.226	0.223	0.000	0.000	0.223
Dutch East Indies	0.343	0.010	0.000	0.353	0.170	0.000	0.000	0.170
French Indochina	0.184	0.014	0.000	0.198	0.173	0.142	0.000	0.315
India	0.312	0.070	0.020	0.402	0.117	0.030	0.000	0.147
Japan 1874	0.189	0.000	0.000	0.189	0.369	0.000	0.000	0.369
Japan 1900	0.500	0.015	0.010	0.525	0.313	0.014	0.002	0.329
Siam	0.752	0.016	0.000	0.768	0.597	0.000	0.001	0.598
Egypt	0.047	0.000	0.000	0.047	0.149	0.000	0.019	0.168
South Africa	0.077	0.000	0.000	0.077	0.003	0.009	0.000	0.012
Sudan	0.000	0.429	0.000	0.429	0.082	0.610	0.000	0.692

Source: *Germany. Statistisches Reichsamt (1928)* and United States. Department of Commerce and Labor Bureau of Statistics (1909).

Notes: A significant share of Siam's imports and exports were routed through either Hong Kong or Singapore. Most of these imports were re-exports of goods from other countries.

Table 3: Japan's counterfactual factor trade: 1865-1876

	1865	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876
Counterfactual Imports of Factors: $\mathbf{A}^{md}\mathbf{M}$											
Skilled male (millions of days)	20.39	21.02	18.39	20.81	31.89	30.95	40.56	46.46	38.73	56.20	44.85
Unskilled male (millions of days)	55.88	64.37	46.49	66.25	119.41	108.49	88.86	98.71	87.37	119.21	99.22
Female (millions of days)	61.36	74.29	71.04	73.51	119.17	131.55	151.18	157.21	167.45	178.63	178.01
Capital (ryō of 1851-55)	1.71	2.24	1.74	1.96	3.29	3.45	3.30	3.70	3.59	4.51	3.90
Land (millions of *tan*)	1.29	1.51	0.98	1.78	3.69	3.11	1.79	2.02	1.68	2.37	1.92
Factors Exports: $\mathbf{A}^{xd}\mathbf{X}$											
Skilled male (millions of days)	6.06	5.95	5.37	4.25	5.22	8.44	8.00	7.96	8.58	9.02	10.78
Unskilled male (millions of days)	31.09	19.77	27.30	19.32	21.61	35.50	29.79	34.85	34.71	36.62	52.04
Female (millions of days)	12.67	9.09	11.43	8.70	11.18	16.07	13.87	15.34	17.57	19.48	22.95
Capital (ryō of 1851-55)	0.81	0.50	0.71	0.50	0.55	0.91	0.73	0.86	0.85	0.92	1.25
Land (millions of *tan*)	0.67	0.44	0.59	0.42	0.51	0.80	0.68	0.80	0.87	0.89	1.23
Net Imports of Factors: $\Delta\mathbf{L}$											
Skilled male (millions of days)	14.33	15.08	13.02	16.56	26.66	22.52	32.56	38.50	30.15	47.17	34.06
Unskilled male (millions of days)	24.79	44.60	19.19	46.93	97.80	72.99	59.07	63.86	52.65	82.59	47.18

Female (millions of days)	48.69	65.20	59.61	64.82	107.99	115.48	137.31	141.86	149.88	159.15	155.06
Capital (ryō of 1851-55)	0.90	1.73	1.03	1.46	2.75	2.54	2.57	2.83	2.74	3.59	2.65
Land (millions of *tan*)	0.62	1.07	0.39	1.35	3.18	2.31	1.11	1.22	0.82	1.48	0.70
Net Imports of Factors under Balanced Trade: $\Delta\mathbf{L}^{\text{balanced}}$											
Adjustment for Trade Imbalance†	1.41	0.89	1.85	0.70	0.47	0.98	0.77	0.81	0.89	0.79	1.38
Skilled male (millions of days)	22.79	12.76	28.71	10.30	9.80	21.85	23.17	29.84	25.99	35.56	51.00
Unskilled male (millions of days)	47.96	37.50	58.88	26.98	34.65	70.65	38.49	45.46	43.28	57.95	84.65
Female (millions of days)	74.14	57.00	120.27	42.68	44.97	112.64	102.29	112.56	131.92	122.22	222.29
Capital (ryō of 1851-55)	1.61	1.49	2.51	0.87	1.00	2.47	1.80	2.14	2.36	2.66	4.12
Land (millions of *tan*)	1.16	0.91	1.23	0.82	1.23	2.24	0.70	0.85	0.64	0.99	1.43

†Ratio of exports to imports

Notes: The ryō is the currency of Japan prior to the introduction of the gold yen in 1871 at a ratio of 1:1. Capital is expressed in terms of the buying power of the ryō in 1851-1855. The *tan* is a measure of area and is equal to about 0.1 hectares. Under the assumption of balanced trade, the import vector **M** is multiplied by the Adjustment to ensure balanced trade for each year.

Source: For a discussion of the calculations, please see the text.

Table 4: The value of the factor augmentation (L^{EV}), the efficiency of autarky (ρ) and the contribution of technological differences(θ)

Row	Measure	1865	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	Average
(1)	$\boldsymbol{\Delta L}^{ev}$	3.59	5.68	3.36	5.92	11.81	9.79	8.64	9.51	8.32	11.65	8.21	7.86
(2)	I^{ev}†			1.20	3.30	7.80	6.60	7.80	11.10	8.40	9.90		7.01
(3)	$\Delta\mathbf{L}^{ev}$balanced‡	6.25	4.85	8.34	3.60	4.46	9.50	5.98	7.13	7.07	8.50	13.13	7.52
(4)	Real GDP: Chōshū	87.37	88.07	88.43	88.78	89.14	89.49	89.85	90.21	90.57	90.93	91.30	89.86
(5)	ρ (Chōshū) Growth rate 1800-1850	0.93	0.95	0.91	0.96	0.95	0.90	0.93	0.92	0.92	0.91	0.86	0.93
(6)	ρ (Chōshū) Growth rate 1850-1874	0.93	0.95	0.91	0.96	0.95	0.90	0.94	0.92	0.93	0.91	0.87	0.93
(7)	Real GDP : S&T	125.02	126.03	126.53	127.04	127.54	128.06	128.57	129.08	129.60	130.12	130.64	128.57
(8)	ρ (S&T) Growth rate 1800-1850	0.95	0.96	0.93	0.97	0.96	0.93	0.95	0.94	0.94	0.93	0.90	0.94
(9)	ρ (S&T) Growth rate 1850-1874	0.95	0.96	0.94	0.97	0.97	0.93	0.96	0.95	0.95	0.94	0.91	0.95
(10)	Technological differences as a share of gains (θ)	0.64	0.72	0.75	0.75	0.75	0.73	0.91	0.93	0.94	0.91	0.86	0.81

†Gains from trade (Equivalent variation in income)

‡Assuming balanced trade in every year.

Notes: L^{ev} is the inner product of the autarky factor price vector ($\mathbf{w}^a$) and the vector of net factor imports for each year. I^{ev} is the estimate of the equivalent variation gains from trade reported in Bernhofen and Brown (2005). L^{ev}balanced is the inner product assuming balanced trade in each year ($\Delta\mathbf{L}^{balanced}$). The measure of the efficiency of resource utilization under autarky (ρ) is $\mathbf{w^a L} / \mathbf{w^a L}^{aug}$.

Source: Results from Table 3 (for balanced trade). Real GDP Chōshū is a forecast of real GDP using the real GDP per capita from the Chōshū domain for the early 1840s presented in Nishikawa (1987) in ryō of 1851-1855. The assumed growth rate is 0.4 percent in subsequent years up through the study period based upon Saito and Takashima (2014, Table 4) for 1850-1874. Population estimates for the early 1870s are from Saito and Takashima (2015, Table 1A). Real GDP S&T is based upon the estimates of total Japanese real GDP expressed in *koku* (volume rice units) from Saito and Takashima (2014, Table 4) expressed as a ratio to the *koku* estimates of Nishikawa for Chōshū and multiplied by Nishikawa's (lower) estimates for the Chōshū domain . An annual growth rate of 0.4 percent is also assumed.

Table 5: Comparative technologies for rice, yarn and worsted cloth

Panel A: Rice (per picul of 133 lbs.)

	Japan	Cochin-China	Difference ΔL_j
Skilled Male	0.7	0	0.7
Unskilled Male	9.69	0.99	8.7
Female	1.93	0.54	1.39
Capital	0.08	0.01	0.07
Land	0.47	0.39	0.09
$\mathbf{w^a A} / \boldsymbol{w^a \Delta L}$ in ryō	0.99	0.58	***0.41***

Panel B: Cotton, 20s Yarn and Unfinished Shirtings

Factor	Ginned Cotton for 20s Yarn (per catty of 1.33 lbs.)					20s Yarn (per catty of 1.33 lbs.)			Shirtings from one catty of yarn		Difference
	Japan	India	USA	Total	ΔL_j (raw material)	Japan	Britain	ΔL_j (raw material and spinning)	Japan	Britain	ΔL_j (total augmentation)
Skilled Male	0.105	0.000	0.018	0.004	0.101	0.179	0.011	0.168	0.189	0.029	0.160
Unskilled Male	0.751	0.370	0.182	0.323	0.428	0.782	0.327	0.455	0.826	0.170	0.655
Female	0.641	0.335	0.047	0.263	0.378	3.868	0.283	3.585	7.569	0.138	7.431
Capital	0.058	0.009	0.011	0.010	0.048	0.066	0.019	0.046	0.073	0.011	0.062

Land	0.015	0.052	0.041	0.049	-0.034	0.015	0.049	-0.034	0.016	0.037	-0.021
w^{a}A /*w^{a}ΔL* in ryō	0.106			0.088	***0.018***	0.161	0.099	***0.062***	0.218	0.069	***0.149***

Panel C: Worsted Cloth (*Chirimen*/ *Mousseline de Laine)* and Raw Material (Silk/Merino Wool)

Factor	Raw Silk (per lb.)	Wool (per lb.)					*Chirimen* (per lb.)	*Mousseline de Laine* (per lb.)	Difference
	Japan	France	Argentina	Australia	Total Wool (per lb. of cloth)	**ΔL$_j$** (due to raw material)	Japan	France	**ΔL$_j$** (total augmentation)
Skilled Male	0.490	0.043	0.000	0.000	0.061	0.429	6.958	0.415	6.543
Unskilled Male	3.170	0.101	0.048	0.109	0.233	2.937	13.375	0.369	13.006
Female	1.010	0.005	0.000	0.000	0.007	1.003	6.792	0.439	6.353
Capital	0.350	0.015	0.005	0.008	0.030	0.320	0.486	0.079	0.407
Land	0.060	0.160	0.034	0.087	0.297	-0.237	0.250	0.297	-0.047
w^{a}A /*w^{a}ΔL* in ryō	0.533				0.453	***0.080***	1.527	0.528	***0.999***

Sources: **A**^{md} and **A**^{m*} matrices and autarky factor prices.

Notes: 20s cotton was spun with one quarter American and three-quarters Indian yarn. The waste in spinning British yarn was about 17 percent and the waste in converting Japanese cotton to cloth was about five percent. One catty of shirtings made 20s/20s yarn would have been about 5.5 square yards. The calculations assume that shirtings contained about 20 percent sizing by weight. The factor usage for the silk (*chirimen*) and worsted (mousseline de laine) cloths is in terms of factors per pound of cloth. Mousseline de laine is assumed to be composed of one-half French, one-quarter Argentinian and one-quarter Australian wool. The loss of weight from washing and cleaning accounts for the difference between the factor usage per pound of wool and the factor usage per pound of cloth. The cloth is assumed to weigh about 0.24 lbs. per square yard, or the weight of *chirimen*.