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Silk, regional rivalry, and the impact of the port openings in nineteenth century Japan

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Abstract:

The centre of economic activities in Japan was once in western Japan. Since the mid-nineteenth century, however, economic activities within Japan have been continuously shifting towards the east side of the country including Tokyo. Conventional wisdom associates the end of the Tokugawa feudal regime with this eastward shift. By applying a new economic geography model to the silk economy of Japan in the nineteenth century, this paper explains why the majority of industrial activities located initially in western Japan, and offers an alternative economic explanation for the eastward shift as an impact of the port openings in 1859.

JEL classification: F12, L67, N95, R12

Keywords: international trade, economic geography, Japan, silk trade

1. Introduction

A distinct feature of the economic geography of Japan today is the persistent bias towards the east side of the country, particularly towards the Kanto region including Tokyo. It has not always been like this, however. The centre of industrial activities was once in western Japan, in the cities of Kyoto and Osaka in the Kansai region. Until the mid-nineteenth century, this region was the advanced industrial core of Japan. What represented the economy of Kyoto, in particular, was the silk fabric industry which was one of the earliest manufacturing activities and the first case of industrial agglomeration in Japan.[1] While these facts are well known, the origin of the eastward shift has received less attention. When and why did the eastward shift start? Why was western Japan more industrialized in the first place?

Looking into population data, drastic changes in the east-west population trends indicate that the origin of the eastward shift in Japan lies in the mid-nineteenth century, between 1846 and 1872. An important political change during this period is the end of the Tokugawa feudal regime and the start of modern Japan in 1867, resulting in the relocation of the Palace from Kyoto to Tokyo in 1869. Conventional wisdom then is that the corresponding reinforced status of Tokyo as the capital of Japan lead to the decline of the economies of Kyoto and Osaka.[2] But this neglects an important economic change that occurred in the same period – namely Japan's opening up to international trade in 1859. One hundred and fifty years ago, through its sudden and complete trade liberalization, Japan reengaged in world trade after nearly two and a half centuries of self-imposed economic isolation called the *Sakoku*.[3] What role, if any, might this have had in the subsequent reallocation of economic activity to the east? This paper uses new economic geography to investigate this question. We begin by providing an explanation for why western Japan had a larger industrial base represented by silk fabrics during the *Sakoku* era, and then move on to argue that the port openings provided an incentive to relocate the entrepreneurial resources related to this industry towards eastern Japan. The result suggests that the opening up to international trade triggered industrial development in eastern Japan, which contributed as one of the factors to the formation of the eastward biased geography of Japan today.

Following the opening-up in 1859, the main items for international trade were textiles, which at the time were the main products in manufacturing. Japan exported silk, mainly in

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[1] See for example Kakino (1999).
[2] See for example City of Kyoto (1973).
[3] See Bernhofen and Brown (2004, 2005) on the case of Japan as a natural experiment of international trade liberalization.

the form of raw silk, and imported woollen and cotton fabrics. Silk was not only the key product in Japan's trade and modern economic growth, but also one of the sources of economic rivalry between eastern and western Japan prior to the port openings. Due to the differences in natural conditions, raw silk was primarily produced in eastern Japan, but the production of silk fabrics took place in both eastern and western Japan. Using raw silk produced in eastern Japan, silk fabric manufacturers in each region produced various varieties and there was two-way trade of silk fabrics between the regions. Historical documents suggest the competition between the silk fabric producers was intense. Interestingly however, the majority of silk fabrics were produced in western Japan, in particular in the city of Kyoto. It is somewhat puzzling why the majority of silk fabric production should take place in western Japan, so far away from where raw silk was produced, in this era of high internal transport costs.

The first step of this paper is to explain this situation in the *Sakoku* era using a two-region model focusing on regional industrial distribution in the presence of agricultural raw materials. It builds on the footloose entrepreneur model by Forslid and Ottaviano (2003) in the new economic geography literature which is suitable for Japan in the nineteenth century when the interregional mobility of farmers/workers were still very limited. By introducing mobile or footloose entrepreneurs who run the monopolistically competitive manufacturing firms, the footloose entrepreneur model explains agglomeration of the firms and the entrepreneurs in one region. The regional distribution of manufacturing is determined by the relative strength of the 'market size' and the 'cost-of-living' effects of agglomeration, which work together in a cumulative way, and the 'local competition' effect which works against them. When interregional trade costs are sufficiently low, agglomeration forces outweigh the local competition effect and manufacturing agglomerates in one region. In the background is an agricultural sector that produces homogeneous final goods which incur no trade costs. To adapt this model to the silk economy of Japan in the nineteenth century, the model used in this paper gives a broader role to the agricultural sector. Here it produces both final goods (such as food or rice) and raw materials (raw silk) required in the production of manufactured goods (silk fabrics), thereby introducing an input-output structure between agriculture and manufacturing. In addition, the agricultural goods also incur trade costs. Due to the differences in natural conditions between the regions it is further assumed that raw materials (raw silk) can only be produced in eastern Japan while agriculture in western Japan produces other products such as food or rice.[4]

Given its advantage of lower raw material costs, the agglomeration of silk fabric firms through the cumulative mechanism typically occurs in eastern Japan if trade costs of silk fabrics are not too high. However, since agglomeration in eastern Japan raises local workers' wage and correspondingly the price of raw silk, there are two additional and opposing channels through which the regional distribution of the silk fabric firms are affected: first, agglomeration in the east raises the marginal cost of silk fabric production in eastern relative to western Japan, making eastern firms less competitive ('relative cost' effect); second, a rise in the eastern workers' wage implies a larger market size of eastern Japan ('indirect market size' effect). The relative cost effect works against agglomeration in eastern Japan while the indirect market size effect supports it.

Estimating feasible parameters from various historical studies of the *Sakoku* era and applying them to the model, I demonstrate that agglomeration in eastern Japan was not a feasible equilibrium, and instead the majority of silk fabric firms located in western Japan, which is consistent with historical evidence. This is because of the high interregional trade cost of silk fabrics which strengthened the local competition effect, working against agglomeration; and the low trade cost of raw silk which strengthened the relative cost effect, also working against agglomeration in eastern Japan. Furthermore, the size of the economy of western Japan was larger, due to the consumers' high expenditure share on food (or rice) produced in western Japan, which relatively favoured the silk fabric firms in western Japan.

The situation of regional rivalry between eastern and western Japan was overturned after the mid-nineteenth century. Various historical studies demonstrate the decline of the Kyoto economy and the manufacturing development of the Kanto region through silk fabric production. The second task of this paper is to examine whether this change can be explained as the impact of the opening up. To do so, international trade of textiles in which Japan exports raw silk and imports woollen and cotton fabrics is introduced into the model. The link between international trade and domestic economic geography has been studied by several authors, who extend the core-periphery model of Krugman (1991). Monfort and Nicolini (2000) and Paluzie (2001) suggest trade liberalization leads to agglomeration within countries, while Krugman and Livas-Elizondo (1996) suggests the opposite when

[4] The type of the input-output linkage studied in the model therefore is different from those by Krugman and Venables (1995) and Fujita et al. (1999) in which the two regions are assumed to be homogeneous and the upstream manufacturing sector supplies differentiated intermediate goods to the downstream sector.

there is a congestion cost of agglomeration.[5] But these studies have analysed the impact of international trade in differentiated manufactured goods on two homogeneous domestic regions. The present analysis differs in two respects; first, in that the two domestic regions are heterogeneous due to the differences in natural conditions, and second, in that the pattern of trade was such that Japan exporting raw materials and importing final goods. In the case of Japan, the impact of trade liberalization comes from two sources. One is from the import competition in fabrics and the other is from the rise of the price of raw silk due to its exports. The silk fabric firms in western Japan that operate at higher costs are more vulnerable to import competition. The rise of the raw silk price implies a larger market size of eastern Japan. When these two effects are combined, the model predicts that the majority of silk fabric firms and their associated entrepreneurs locate in eastern Japan after the opening up to international trade. In contrast to the existing studies, the result for Japan is that international trade liberalization lead to a movement of the silk fabric industry from western to eastern Japan where raw silk was produced.

The rest of the paper is organized as follows. The next section provides some historical background. Section 3 presents the set up of the model which takes into account the characteristics of the silk economy of Japan in the nineteenth century. Section 4 solves the model to analyse the regional industrial distribution in Japan during the *Sakoku* (or autarky). Section 5 analyses the impact of international trade on the regional industrial distribution of Japan, followed by concluding remarks.

2. Historical background

2.1. Eastward shift of economic activities after trade liberalization

While statistics are largely unavailable for Japan before the twentieth century, one exception is the regional population data from the mid-eighteenth century, which can be used as a proxy for the extent of regional economic activities. Figure 1 shows the population ratio of eastern and western Japan from the mid-nineteenth century.[6] It shows that it was largely static before the port openings in 1859, but has been rising continuously since then. Figure 2 presents data on the population growth rates of eastern and western Japan. The trends changed drastically after the port openings. In addition to both growth

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[5] According to Hanson (1998), the case of Mexico's trade liberalization seems consistent with the former, but a cross-country econometric study by Nitsch (2006) does not support the Krugman and Livas-Elizondo hypothesis.

[6] There are no official definitions of eastern and western Japan. I follow the common view that the Kansai/Kinki regions and all prefectures to the west of them are in western Japan. The border is shown as the dotted lines in Figure 3.

rates turning positive, the east constantly recorded higher growth rates than the west, suggesting the eastward shift of economic activities.[7] Importantly, as the regional breakdown in Figure 3 shows, this change occurred not only in Tokyo but also in various prefectures in eastern Japan, in particular, in the Kanto region.

[Insert Figure 1 about here]

[Insert Figure 2 about here]

[Insert Figure 3 about here]

2.2. Geography of the silk industry in Japan

According to a survey by Akimoto (1987), clothing was the main non-food consumption expenditure in Japan in the late eighteenth century. In addition, as shown in Figure 4, international trade following the opening up was largely based on the two-way trade of textiles, suggesting the importance of the textile industry in this era. In particular, Japan exported silk products, mostly raw silk, and imported other types of textiles such as cotton and woollen fabrics. Around half of Japanese exports was raw silk and nearly 40% of imports consisted of cotton and woollen fabrics in the early years.

Raw silk was produced by farmers who raised silkworms which form cocoons.[8] The cocoons were then reeled into silk thread or raw silk. Silk fabric producers purchased raw silk from farmers and wove the thread into silk fabrics. The geography of agricultural production is more likely to be affected by natural conditions than in manufacturing. In the case of Japan, the difference in climate and landscape between the east and the west sides of the country determine the geography of agricultural production. The landscape of western Japan is relatively flat, and combined with a warmer climate, it is suitable for crops like rice. Eastern Japan, on the other hand, is disadvantaged for crops because of its mountainous landscape, colder climate and lower rainfalls. This lead to the introduction of sericulture in eastern Japan in the *Sakoku* era since raw silk import stopped. As is shown in Figure 5, silkworm cocoons were produced intensively in eastern Japan.[9] The earliest

[7] Before the port openings, population occasionally recorded negative growth, due partly to famine and diseases, and the level of population was stagnant. Data is not available for the years between 1846 and 1872.
[8] Raw silk production became more ‘industrialized’ from the late nineteenth century; the silk reeling industry developed and the reeling process was separated from the farmers who supplied the cocoons.
[9] Production statistics of silkworm cocoon is only available from 1887.

regional production data available for raw silk also indicates that raw silk production was highly concentrated in eastern Japan; 94% of raw silk output in quantity terms was concentrated in the east.[10]

In contrast, the historical literature suggests that production of silk fabrics originally evolved in western Japan before the *Sakoku*, namely in the cities including Hakata, Sakai and Kyoto, which had good access to the Asian continent to import raw silk. Production became somewhat more geographically dispersed during the late seventeenth to the eighteenth century between western and eastern Japan, but western Japan, in particular Kyoto, was still the main silk fabric production site (Figure 6).[11] According to the information in Yamawaki (2002) it can be estimated that in 1755, Kyoto alone produced more than 40% of silk fabrics and around 60% was produced in western Japan as a whole. The overall picture before the port openings, therefore, is that even though raw silk was produced in eastern Japan, production of silk fabrics was dispersed between eastern and western Japan, with the majority in western Japan.

Japan experienced a sudden and complete opening up to international trade in 1859, which is the only major change in the economy until the late nineteenth century when technological changes occurred in production and transportation. Soon after the port openings, western Japan's silk fabric production declined drastically; Sasaki (1932) reports that 5,174 looms existed in Kyoto in 1839, but it dropped to 3,819 in 1864. In addition, Hamano (2003) finds a net outflow of population from the Nishijin district of Kyoto where silk fabric production had been agglomerated, shortly after the port openings. In contrast, in the city of Kiryu in the northern Kanto region, which was the eastern rival of Kyoto in silk fabric production, later became the first to succeed in exporting silk fabrics, according to Okada (2005). This region still remains as one of the core manufacturing locations of Japan producing automobiles, automotive parts and electronic equipment.[12]

[Insert Figure 4 about here]

[Insert Figure 5 about here]

[10] This figure is that of 1876 based on the data in City of Yokohama (1965). Since natural conditions are not likely to change over a short period of time, we consider that silkworm cocoon and raw silk production had been concentrated in the east prior to the port openings.

[11] This is supported by various studies including Horie and Goto (1950), City of Kyoto (1973), Honjyo (1973), Nagahara (1983), Yamawaki (2002), and Okada (2003, 2005).

[12] For example, according to the Census of Manufactures, in Gunma prefecture which includes the city of Kiryu, the value of shipment of manufactured goods per capita is 1.65 times the national average in 2005.

[Insert Figure 6 about here]

3. A model of manufacturing location with agricultural raw materials

3.1. Assumptions

Goods, production technology and market structure

Silk fabric production in Japan was one of the earliest manufacturing industries in the nineteenth century, implying the division of labour into entrepreneurs (who offer workplaces) and workers. Studies by Kudo and Ichikawa (1955), Hayami and Uchida (1976), and Hayami (1983) suggest rural-urban migration of farmers/workers was present. However, their geographic area of migration was limited within regions, suggesting workers were employed locally. Turning to the products, according to Yamawaki (2002), there were numerous varieties of silk fabrics depending on the way they were woven. In contrast, raw silk, which was primarily produced in eastern Japan, was relatively homogeneous. To highlight such characteristics of the silk economy in nineteenth century Japan, the following production structure is introduced into the footloose entrepreneur model of Forslid and Ottaviano (2003). There are three goods in the economy: differentiated manufactured goods and two homogeneous agricultural goods – a raw material for manufactured goods production and food, a final good. Production of manufactured goods also requires two types of labour, entrepreneurs and workers. A firm producing a particular manufacturing variety requires a fixed number (α) of entrepreneurs, and one unit of raw materials and β workers per unit output. The firm thus faces increasing return to scale. Its total cost for producing a given amount q^M is then

$$c(q^M) = \alpha w^H + (\beta w^L + p^R)q^M, \qquad (1)$$

where w^H is the entrepreneurs' wage, w^L is the workers' wage, and p^R is the price of raw materials. Manufacturing firms are assumed to be monopolistically competitive.

Agriculture is a constant returns sector which uses only workers. The agricultural sector can produce either food or raw material for manufacturing. One worker produces a unit of food or a unit of raw material. Therefore, the total costs for producing given amounts of food (q^F) and raw materials (q^R) are $c(q^F) = w^L q^F$ and $c(q^R) = w^L q^R$, respectively. Perfect competition is assumed for the agricultural sector.

Geography and trade costs

There are two domestic regions, the east and the west. Interregional trade costs are expressed in iceberg form, and the trade cost for manufactured goods ($t^M > 1$) and agricultural goods ($t^A > 1$) can differ.

In addition, differences in natural geography are assumed to lead to regional specialization in agriculture. In Japan, the east and the west differ substantially in natural conditions so that eastern agriculture produces raw materials and western agriculture produces food. Manufacturing can locate in either region (Figure 7).

[Insert Figure 7 about here]

Labour endowment

Population of workers in the country is normalized at 1 and that of entrepreneurs is denoted by H. This implies that the total mass of firms in the country is fixed at H/α in equilibrium. The share of entrepreneurs in the east (λ) is the endogenous variable on which the analysis primarily focuses, and the mass of firms in the east will be $\lambda H/\alpha$ and $(1-\lambda)H/\alpha$ in the west. Based on the observation in Figure 1 that the population of eastern and western Japan was nearly equal before the port openings, the workers are assumed to be evenly distributed between the east and the west so each region has half a unit of workers.

Consumer preference

The assumptions for the consumers are standard. All consumers have the same preferences, which are described by a two-tier utility function. The upper tier is $U = M^{\mu}F^{1-\mu}$ ($0 < \mu < 1$), which implies that expenditure share of μ and $1-\mu$ is allocated for manufactured goods (M) and food (F), respectively. The second tier dictates the consumers' preferences over the differentiated manufactured varieties, which is defined as

$$M = \left[\int_0^n m(i)^{\rho} di\right]^{\frac{1}{\rho}} \quad (0 < \rho < 1), \tag{2}$$

where M is the composite of all the differentiated manufactured varieties, n is the mass of manufactured varieties, $m(i)$ is the consumption of variety i, and ρ is the substitution parameter. It is assumed that $0 < \rho < 1$ to ensure manufactured varieties are imperfect substitutes. $\sigma \equiv 1/(1-\rho) > 1$ represents the elasticity of substitution between any two varieties of manufactured goods.

By denoting the price of a manufactured variety and food as $p^M(i)$ and p^F, respectively, and introducing a price index of manufactured goods

$$G \equiv \left[\int_0^n p^M(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} \tag{3}$$

such that total expenditure on manufactured goods is GM, indirect utility (or the real wage, ω) can be expressed as

$$\omega^j = \frac{w^j}{G^\mu \left(p^F\right)^{1-\mu}} \quad (j = H, L). \tag{4}$$

Labour mobility

Given that the interregional mobility of farmers/workers was limited, it is assumed that the entrepreneurs are the only mobile factor between the regions, as in Forslid and Ottaviano (2003). They move toward the region that offers them the highest real wages. Workers can be employed in either sector within the region.

3.2. Firm behaviour in the presence of agricultural raw materials

Unlike the basic footloose entrepreneur model, here manufacturing requires raw materials which are only produced in the east, and so manufacturing firms in the east and in the west face different (marginal) costs. Let us denote the raw material price in the east as p_E^R. (Hereafter we use subscripts E and W to denote the regions, the east and the west, respectively.) Due to the competitive market structure of the agricultural sector and the inter-sectoral mobility of the workers in each region, the workers' wage in the east is also p_E^R in equilibrium. Then to maximize its profit, a monopolistically competitive firm in the east will set price so that marginal revenue equals marginal cost:

$$p_E^M \left(1 - \frac{1}{\sigma}\right) = (\beta + 1) p_E^R. \tag{5a}$$

Firms in the west, on the other hand, must bear trade costs of raw materials. Given the trade cost t^A, the delivered price of raw materials in the west is $p_E^R t^A$. Therefore a monopolistically competitive firm in the west will set price as

$$p_W^M \left(1 - \frac{1}{\sigma}\right) = \beta + p_E^R t^A, \tag{5b}$$

where the price of food (and equivalently the workers' wage in the west) has been chosen as the numeraire so that $p_W^F = w_W^L = 1$. There are simple but important relationships between p_E^M and p_W^M. First, other things equal, an increase in t^A raises p_W^M, because the delivered price of raw material rises in the west. Second, since

$$\frac{d}{dp_E^R}\left(\frac{p_E^M}{p_W^M}\right) = \frac{\beta(\beta+1)}{(\beta + p_E^R t^A)^2} > 0, \tag{6}$$

an increase in p_E^R raises the price of eastern relative to the western manufactured goods. This is because an increase in p_E^R also implies a rise in the eastern workers' wage. The effect is weaker with a higher t^A. This adds an endogenous regional asymmetry to the model through relative cost changes.[13]

4. Regional distribution of industry in Japan during the *Sakoku* era

4.1. Estimation of historical parameters of Japan

A spatial equilibrium of the model is defined as a situation in which all goods and factor markets clear, firm profits are driven down to zero due to free entry bidding up the entrepreneurial wages, and the entrepreneurs receive the same real wages in both regions and therefore have no incentive to move.[14] Because the regional manufacturing price indices are non-linear in p_E^R, we are prevented from obtaining a general analytical solution, including that for λ. The approach in this paper then is to focus on the case of Japan by solving the model numerically using appropriate parameters estimated from information in various historical studies of Japan from the mid-eighteenth and nineteenth centuries.

As seen above, the parameters required are μ, σ, β, t^M and t^A.[15] First, Akimoto (1987) estimates that the Engel coefficient (the ratio of food expenditure over total expenditure) was 75% in the mid-eighteenth century, so the share of manufacturing expenditure (μ) is set equal to 0.25. Second, β is estimated from studies providing technological information of silk-reeling and fabric production in the ninetennth century. From Minami and Makino (1995) it can be estimated that 232.08 man-days of labour is needed to produce 1 kan of raw silk.[16] From Yamawaki (2002) who presents information on various different varieties of silk fabrics, the median value of raw silk requirement

[13] If the manufactured goods were homogeneous, the firms will simply tend to locate in the lower cost region, which cannot explain the situation of the silk economy in nineteenth century Japan.

[14] The full description of the model is provided in Appendix 1.

[15] Parameters H and α do not affect geography. The numerical solutions are obtained by setting $H = \alpha = 1$.

[16] Kan is an old measurement unit. 1 kan is equal to 3.75 kilograms. Tan is also an old measurement unit for fabrics. 1 tan is roughly the amount of fabrics necessary to produce clothes for one person.

necessary to produce 1 tan of silk fabrics can be calculated to be 0.165 kan. This indicates that 1 kan of raw silk can be woven into 6.06 tan of silk fabrics. Kawaura (1965) shows that it requires 1 man-day to weave 1 tan of textiles. Therefore it can be estimated that 6.06 man-days of labour is needed to weave 1 kan of raw silk into silk fabrics. From these figures, we have $\beta = 6.06 / 232.08 \cong 0.03$. Third, the trade cost parameters are estimated as inferred trade costs from regional price differential data, that is, they are calculated as the ratio of the price at the destination over the price at the origin, based on the idea that persistent regional price differentials indicate interregional trade costs.[17] t^A is estimated from Yamazaki (1983) who presents local agricultural prices and their delivered prices in major cities including Kyoto. The ratio of the price of raw silk in Kyoto compared to the price in the Shindatsu area in eastern Japan ranged from 1.2 to 1.4 during the period 1818 to 1836, but was mostly in the range 1.2 to 1.3. The price of rice in Hachioiji in eastern Japan was on average 1.25 times higher than the price in Osaka in western Japan during the period 1856 to 1859. t^A therefore is set equal to 1.25. t^M is estimated based on Nakai and Shimada (1971) who studied the financial data from the Mitsui Echigoya department store including procurement prices of Kyoto-made silk fabrics and the Edo (current Tokyo) price of these products from 1777 to 1790. The destination-origin price ratios for the major varieties of silk fabrics were generally between 1.4 and 1.6. t^M therefore is set equal to 1.5. The elasticity of substitution $\sigma = 6.62$ is taken from Head and Mayer (2004).[18] These parameter values are summarized in Table 1.

[Insert Table 1 about here]

4.2. Regional industrial distribution in autarky

The numerical solutions for the endogenous variables of the model are shown in the first column of Table 2. The solution for λ is 0.33, which means that a third of the silk fabric firms and the associated entrepreneurs were located in eastern Japan and the rest were in western Japan.

This is in line with the historical references that the silk fabric industry was dispersed between eastern and western Japan, but with western Japan having the majority in autarky.

[17] Shinbo (1979) notes that national transportation networks were not developed and that they were an important factor affecting the regional price differentials in this era.
[18] This value is consistent with another estimate by Broda and Weinstein (2006), which is 6.7 for textiles at the SITC three digit level.

Furthermore, it can be calculated from the results in Table 2, taking into account the smaller firm sizes of the western silk fabric firms, that 58% of total silk fabric production took place in western Japan.[19] This is close to the estimate from the historical sources presented in Section 2 that 60% of silk fabrics were produced in western Japan.

Taking a look into the activities of the silk fabric firms using the results in Table 2, the delivered price of western Japan made silk fabrics in eastern Japan is 1.99, which is consistent with the result of the survey by Ono (1979) who finds that silk fabrics made in Kyoto were sold in Edo (Tokyo) at prices twice as high as eastern products.[20] Table 3 shows the sources of demand for typical silk fabric firms in eastern and western Japan calculated from the results in Table 2. The results in the first column of Table 3 suggest that the silk fabrics from western Japan were too expensive to compete in eastern Japan. In fact, the western Japanese firms almost totally rely on the local market; 98.6% of their output is sold locally, in contrast to the eastern Japanese firms that sell 53.7% locally and 42.7% in western Japan. It is well known in the historical literature that the silk fabric producers in Kyoto had asked the authority to restrict the inflow of silk fabrics from the eastern producers (Yamawaki (2002)). The result from the numerical solution explains the situation of the western silk fabric producers who faced competition from the eastern firms in their local market, and clarifies why the producers in Kyoto demanded such protection.

4.3. The forces at work and the stability of the equilibrium

In the basic footloose entrepreneur model, regional industrial distribution is determined by the balance between the two agglomeration forces (the market size effect and the cost-of-living effect), versus the dispersion force (the local competition effect). The agglomeration forces outweigh the dispersion force when the trade costs of manufactured goods are low, leading to the agglomeration of manufacturing in one region. In the present model with trade costs of agricultural raw materials which are only produced in the east, agglomeration is likely to occur in eastern Japan when the trade cost of silk fabrics (t^M) is sufficiently low. This can be seen in panel (a) of Figure 8, which shows the solution of λ for various levels of t^M fixing the level of t^A at 1.25.[21] However, since a larger share of

[19] The result of the numerical solution that the western silk fabric firms operate at smaller scales than their rivals in eastern Japan is also in line with the observation by Kuromatsu (1965).

[20] $0.4238 \times 1.5 / 0.3201 \cong 1.99$.

[21] Agglomeration of silk fabric firms in eastern Japan is not sustainable beyond the sustain point. See Appendix 2 for the derivation and the analysis of the sustain point curve. Note that agglomeration is unlikely to occur in standard models when trade costs for the agricultural goods are introduced. See Davis (1998) and Fujita et al. (1999, ch. 7).

the silk fabric firms locating in eastern Japan means that they employ more eastern workers, it reduces the supply of raw silk, driving up its price (p_E^R) and equivalently the eastern workers' wage (w_E^L). A rise in p_E^R has two opposite effects; on the one hand, it raises the marginal cost of silk fabric production in eastern relative to western Japan, making eastern firms less competitive ('relative cost' effect).[22] This leads to lower demand and decreased profits for the eastern Japanese firms. On the other hand, a rise in p_E^R means a larger market size of eastern Japan (Y_E), which relatively favours eastern firms through increased demand, leading to higher profits ('indirect market size' effect). These are the two additional channels through which the regional distribution of industry is affected; the former works as an additional dispersion force while the latter supports industrial agglomeration in eastern Japan.

In the autarkic spatial equilibrium of Japan, indicated as E_0 in Figure 8, agglomeration of silk fabric firms in eastern Japan does not occur. This is because 1) t^M was sufficiently high which relatively strengthened the local competition effect, working against agglomeration, 2) t^A was sufficiently low which strengthened the relative cost effect, also working against agglomeration in eastern Japan, and furthermore, 3) the size of the economy of western Japan was larger, due to the consumers' higher expenditure share on food (or rice) produced in western Japan, which relatively favoured the silk fabric firms in western Japan.

The stability of equilibrium can be examined by perturbing λ. Let us use panel (b) of Figure 8 which shows the solution of λ for various levels of t^A fixing the level of t^M at 1.5. Starting from the autarkic spatial equilibrium $\lambda = 0.33$ (E_0), suppose we moved a fraction of firms and entrepreneurs from western to eastern Japan so that $\lambda = 0.5$ (E_1).[23] The relative cost effect combined with the local competition effect in eastern Japan is so strong that demand or output (q_E) is reduced for eastern firms, and hence their profits turn negative. Firms and the entrepreneurs, therefore, will relocate back to western Japan to restore the equilibrium at E_0 . An opposite process that restores E_0 can be confirmed if a fraction of firms and entrepreneurs were moved from eastern to western Japan so that $\lambda = 0.1$ (E_2). An increase of t^A from 1.25 to 1.30 as in E_3 raises the cost of raw silk in western Japan which works to the disadvantage of western firms and the entrepreneurs. The

[22] See equation (6).

[23] The solution of the endogenous variables of E_0 , E_1 and E_2 are shown in the second, third and the fourth column of Table 2, respectively.

western firms and the entrepreneurs will then move to eastern Japan (i.e., λ increases), until intensified local competition and the rising relative cost of production in eastern Japan put a brake on further relocation. The higher t^A, the weaker the relative cost effect, which supports agglomeration in eastern Japan.

[Insert Figure 8 about here]

5. The impact of Japan's trade liberalization on its internal geography

5.1. Additional assumptions and parameter settings

In order to examine the impact of the trade liberalization on the economy of nineteenth century Japan, in particular, on the regional industrial distribution (λ), a foreign economy is introduced into the model with the trade pattern that Japan exports raw silk and imports cotton/woollen fabrics. For simplicity and to focus on the impact on the internal geography of Japan without adding too many parameters, the foreign economy is modelled simply as an exporting sector that produces fabrics and their raw materials, and exports all the fabrics to Japan and only imports raw silk from Japan.[24] The imported fabrics are assumed to be substitutable to home (silk) fabrics.[25] Eastern and western Japan are assumed to have equal access to foreign, that is, international trade costs from eastern Japan and from western Japan are the same.[26] Factors are not mobile internationally.

In addition to the parameters in Table 1, international trade cost (T) and the size of the foreign exporting sector represented by its endowment of entrepreneurs (H_f) and workers (L_f) are needed to solve the model numerically. First, concerning international trade cost, the f.o.b. price of Japanese raw silk and its prices in Lyon and London from 1861 to 1867 reported in City of Yokohama (1999) can be used. Taking the ratio of the two prices, T can be inferred to be around 1.8. However, Sugiyama (1979) reports Yokohama price was around 80% of the price of Japanese silk in European markets, which leads to a much lower iceberg trade cost of 1.25. Therefore, an intermediate value of 1.5 is used in the following analysis. Second, the size of the foreign exporting sector is chosen so that half of Japanese raw silk produced is exported. This is based on the estimate by Nakamura (1985) that 47% of domestic production was exported between 1874 and 1900, although there were

[24] The details of how the model is modified to introduce international trade are given in Appendix 3.
[25] Tamura (2001) finds that imported woollen fabrics particularly became popular among the general public and imposed competitive pressure on domestic silk fabric producers.
[26] This can be interpreted as both regions having ports for international trade. In fact, multiple ports throughout Japan were opened.

variances by year.[27] Given the variances in the levels of T and the export share of raw silk, sensitivity of the result to these foreign variables is reported in Appendix 4. It is shown that the impact is strengthened with a lower international trade cost and/or a larger foreign economic size.

5.2. Comparison of the regional industrial distribution in autarky and in the trading equilibrium

By numerically solving the model with international trade, λ is found to increase from 0.33 in autarky to 0.89 with international trade, as shown in Figure 9.[28]

Let us take a look into the results to investigate the underlying mechanism that overturns the situation in autarky and brings the majority of silk fabric firms and entrepreneurs to eastern Japan. From the domestic firms' point of view, the opening up to international trade has two aspects: one is the competition that comes with imported fabrics, and the other is the rise in the price of raw silk (p_E^R) due to it now being exported. As was shown in the previous section, in autarky, the majority of silk fabric firms operate in western Japan even though it is a high cost location by relying almost totally on the local market. But this implied that the consumers in western Japan faced higher silk fabric prices and hence they shift a larger share of their fabric expenditures on to imported varieties compared to the consumers in eastern Japan. Table 4 shows the consumers' expenditure shares on eastern, western and foreign fabrics, calculated from the results in Table 2. As shown in the second column of Table 4, immediately after trade liberalization (if the regional distribution of the firms remains unchanged in the short run) western consumers spend 81.2% of their fabric expenditures on imported varieties while eastern consumers spend 71.2% on them. Therefore, firms in western Japan were more vulnerable to import competition after the opening up compared to those in eastern Japan. Next, the rise in p_E^R had two opposite implications: one was the rise in the relative production cost of firms in eastern Japan which worked against agglomeration in eastern Japan, and the other was the enlarged market size of eastern Japan which supported agglomeration in eastern Japan.

In the case of Japan, it can be interpreted that import competition which relatively affects the firms in western Japan and the enlarged market size of eastern Japan outweighed the effect of the rise in the relative cost of silk fabric production in eastern Japan. Allowing

[27] Export share of raw silk ranged from 30 to 80% by year. This is consistent with the figures in City of Yokohama (1965).

[28] The full solution of the trading equilibrium is shown in the final column of Table 2.

for firm migration, western firms and entrepreneurs relocate to eastern Japan, until intensified local competition and the further rise in the relative cost in eastern Japan stop further relocation at a new spatial equilibrium of $\lambda = 0.89$.[29]

The impact on the welfare of the three factors of production can be examined by comparing their real wages in autarky and in the trading equilibrium. The eastern farmers, who raised silkworms to supply raw silk, gain most from increased raw silk prices. This is consistent with the historical observations emphasizing that the port openings brought huge gains to the raw silk farmers in eastern Japan.[30] Western farmers/workers gain slightly. The present spatial general equilibrium analysis adds to the historical literature that domestic entrepreneurs involved in silk fabrics may well have lost considerably due to foreign competition and increased raw silk prices.[31]

[Insert Figure 9 about here]

[Insert Table 2 about here]

[Insert Table 3 about here]

[Insert Table 4 about here]

6. Concluding remarks

Since the mid-nineteenth century, eastern Japan has been growing as the centre of the economic activities of modern Japan for the last one and a half centuries. This is usually attributed to the change in the political regime which lead to the relocation of the Palace and the corresponding reinforced status of Tokyo. This paper presented an alternative hypothesis that Japan's trade liberalization in 1859 may well have triggered this process, suggesting that the eastward shift may have happened anyway.

The period from 1846 to 1872 is labelled as 'the missing quarter century' in Japanese economic history, because of the lack of social and economic indicators (Hayami (1983)).

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29 However, it must be noted that, as shown in Figure 9, if t^A was lower than 1.12 the net impact of trade liberalization could be the opposite. This is because the relative cost increase in eastern Japan due to the rise in p_E^R is so strong that it outweighs the import competition and the indirect market size effects.

30 For example, see Saito and Tanimoto (2003).

31 It was not until the late nineteenth century that silk fabrics were exported. It can be confirmed that if Japan exported silk fabrics, the negative impact on the entrepreneurs are weaker.

Little is therefore known about what happened during this period when Japan opened up to international trade. This paper aimed to shed light on this period by considering the link between international trade and the domestic economic geography in a spatial general equilibrium framework. In addition to the well known fact that the farmers growing silkworms in eastern Japan enjoyed huge gains after the opening up, the analysis predicts asymmetric impacts on regional firm performance and the resulting geographic reallocation of entrepreneurial resources. This may be considered as one of the impacts of Japan's opening up during the 'missing quarter century' that contributed to the making of the eastward-biased economic geography of Japan today.

Appendices:

Appendix 1. Full description of the model (autarky)

The solution of the model requires the following market clearing conditions and the zero profit conditions to be satisfied. Supply of manufactured goods from the east and the west, respectively, are to meet their demands:

$$q_E^M = \left(p_E^M\right)^{-\sigma}\left(G_E\right)^{\sigma-1}\mu Y_E + \left(p_E^M t^M\right)^{-\sigma}\left(G_W\right)^{\sigma-1}\mu Y_W t^M , \tag{A1a}$$

and

$$q_W^M = \left(p_W^M\right)^{-\sigma}\left(G_W\right)^{\sigma-1}\mu Y_W + \left(p_W^M t^M\right)^{-\sigma}\left(G_E\right)^{\sigma-1}\mu Y_E t^M , \tag{A1b}$$

where Y_r ($r = E, W$) are the regional aggregate incomes, and G_r are the price indices of manufactured goods

$$G_E = \left\{ n_E\left[\frac{\sigma}{\sigma-1}(\beta+1)p_E^R\right]^{1-\sigma} + n_W\left[\frac{\sigma}{\sigma-1}(\beta+p_E^R t^A)t^M\right]^{1-\sigma}\right\}^{\frac{1}{1-\sigma}} \tag{A2a}$$

and

$$G_W = \left\{ n_E\left[\frac{\sigma}{\sigma-1}(\beta+1)p_E^R t^M\right]^{1-\sigma} + n_W\left[\frac{\sigma}{\sigma-1}(\beta+p_E^R t^A)\right]^{1-\sigma}\right\}^{\frac{1}{1-\sigma}} , \tag{A2b}$$

with

$$Y_E = \lambda H w_E^H + \frac{1}{2}p_E^R \text{ and } Y_W = (1-\lambda)H w_W^H + \frac{1}{2}. \tag{A3}$$

Supply of food from the west is to meet its demand:

$$\frac{\theta_W}{2}\mu = \frac{(1-\mu)H(1-\lambda)w_W^H}{p_W^F} + \frac{(1-\mu)(1-\theta_W)w_W^L}{2p_W^F} + \frac{(1-\mu)Y_E}{p_W^F t^A}t^A , \tag{A4}$$

where θ_r ($r = E, W$ and $0 < \theta_r \le 1$) is the share of workers employed in the agricultural sector in each region. Supply of raw materials from the east is to meet the demand for raw materials from the manufacturing sector:

$$\frac{\theta_E}{2} = n_E q_E + n_W q_W t^A . \tag{A5}$$

Full employment of entrepreneurs implies $n_E = \lambda H/\alpha$ and $n_W = (1-\lambda)H/\alpha$. Full employment of workers requires that the supply of workers for manufacturing in each region meets the demand from manufacturing firms:

$$\frac{1-\theta_r}{2} = n_r \beta q_r \ (r = E, W). \tag{A6}$$

In the manufacturing sector, assuming free entry and exit, equilibrium entrepreneurial wage corresponding to their full employment is determined by a bidding process for entrepreneurs, which continues until no firm can earn a positive profit at the equilibrium prices. This implies that in equilibrium a firm's size is such that the operating profit exactly matches the fixed cost which is the wage paid to the entrepreneurs. That is,

$$\alpha w_E^H = p_E^M q_E - (\beta+1) p_E^R q_E \quad \text{and} \quad \alpha w_W^H = p_W^M q_W - (\beta + p_E^R t^A) q_W , \tag{A7}$$

for the eastern and western firms, respectively.

Appendix 2. Sustain point analysis

Figure A1 illustrates the solutions for λ under various combinations of t^M and t^A, where the 'cliff' corresponds to the sustain points of agglomeration in eastern Japan. Assuming that manufacturing firms and the entrepreneurs are located in the east ($\lambda = 1$), the potential function of relocation to the west is defined as

$$\Omega_W \equiv \frac{\tilde{\pi}_W}{\alpha \tilde{w}_W^H}, \tag{A8}$$

where $\tilde{\pi}_W$ is the hypothetical operating profit in the west and $\tilde{w}_W^H$ is the hypothetical wage of entrepreneurs in the west. As long as $\Omega_W < 1$ agglomeration of firms in the east is sustainable since there is no incentive for a firm to relocate to the west. When $\Omega_W > 1$ firms defect from the east since the west is profitable, hence agglomeration will no longer be sustainable. $\Omega_W = 1$ implicitly defines the sustain point of agglomeration in the east. The $\lambda = 1$ case can be solved with

$$w_E^H = \frac{\mu}{2H\sigma(1-\mu)} \quad \text{and} \quad p_E^R (= w_E^L) = \frac{(\sigma-1)\mu}{\sigma(1-\mu)}, \tag{A9}$$

therefore, $\tilde{\pi}_W$ can be expressed as

$$\begin{aligned} \tilde{\pi}_W &\equiv \frac{\mu\alpha}{\sigma H}\left[\frac{p_E^M}{\tilde{p}_W^M}\right]^{\sigma-1}\left[(t^M)^{1-\sigma} Y_E + (t^M)^{\sigma-1} Y_W\right] \\ &= \frac{\mu\alpha}{2\sigma H}\left[\frac{(\beta+1)\mu}{\sigma\beta(1-\mu)/(\sigma-1)+\mu t^A}\right]^{\sigma-1}\left[(t^M)^{1-\sigma}\frac{\mu}{1-\mu} + (t^M)^{\sigma-1}\right] \end{aligned} . \tag{A10}$$

The hypothetical entrepreneurial wage in the west is

$$\tilde{w}_W^H = w_E^H \frac{(G_E t^M)^\mu}{(G_E)^\mu (t^A)^{1-\mu}} = \frac{\mu (t^M)^\mu}{2\sigma H(1-\mu)(t^A)^{1-\mu}} . \tag{A11}$$

The parameter values in Table 1 gives $\Omega_W = 1.67$, meaning that agglomeration of silk fabric production in eastern Japan was not sustainable. The sustain point curve that satisfy $\Omega_W = 1$ is upward sloping because $d\Omega_W / dt^M > 0$ and $d\Omega_W / dt^A < 0$, which is shown in Figure A2. The $\Omega_W = 1$ curve corresponds to the 'cliff' in Figure A1. As can be expected from the standard results of the new economic geography models, a high t^M leads to dispersion. In the present analysis, a low t^A also leads to dispersion by raising the relative cost of manufacturing in the west, leaving a large area of dispersion in the bottom-right corner in Figure A2. Given the combination of a relatively high t^M and low t^A, the case of Japan at the coordinate $(t^M, t^A) = (1.5, 1.25)$ is confirmed to be in the dispersion area ($0 < \lambda < 1$).

[Insert Figure A1 about here]

[Insert Figure A2 about here]

Appendix 3. Modifications of the model with international trade

The foreign economy is modelled as an exporting sector only producing fabrics and their raw materials with the same technology as home. The fixed number of entrepreneurs (H_f) and workers (L_f), implies that the mass of foreign firms and their outputs are fixed. The foreign aggregate wage income is written as

$$Y_f = H_f w_f^H + (1-\gamma) w_f^L L_f + \gamma p_f^R L_f \, , \tag{A12}$$

where γ is the share of foreign workers producing raw materials, and subscript f is used to denote the foreign variables. Then the additional demand for home produced raw materials from foreign, including trade costs, is

$$\frac{Y_f}{p_E^R T} T \, , \tag{A13}$$

and demand for foreign manufactured goods, including trade costs, is expressed as

$$q_f^M = \left(p_f^M T\right)^{-\sigma} \left(G_E\right)^{\sigma-1} \mu Y_E T + \left(p_f^M T\right)^{-\sigma} \left(G_W\right)^{\sigma-1} \mu Y_W T \, , \tag{A14}$$

where the regional price indices are now

$$G_E = \left\{ \begin{array}{l} n_E \left[\frac{\sigma}{\sigma-1} (\beta+1) p_E^R \right]^{1-\sigma} + n_W \left[\frac{\sigma}{\sigma-1} (\beta + p_E^R t^A) t^M \right]^{1-\sigma} \\ + n_f \left[\frac{\sigma}{\sigma-1} (\beta+1) w_f^L T \right]^{1-\sigma} \end{array} \right\}^{\frac{1}{1-\sigma}} \qquad \text{(A15a)}$$

and

$$G_W = \left\{ \begin{array}{l} n_E \left[\frac{\sigma}{\sigma-1} (\beta+1) p_E^R t^M \right]^{1-\sigma} + n_W \left[\frac{\sigma}{\sigma-1} (\beta + p_E^R t^A) \right]^{1-\sigma} \\ + n_f \left[\frac{\sigma}{\sigma-1} (\beta+1) w_f^L T \right]^{1-\sigma} \end{array} \right\}^{\frac{1}{1-\sigma}}. \qquad \text{(A15b)}$$

The value of home imports of manufactured goods ($p_f^M q_f^M$) and home exports of raw materials (A13) are equalized in the trading equilibrium.

Appendix 4. Sensitivity of the result to the international trade cost parameter (T) and the size of the foreign exporting sector

Table A1 shows the solutions for λ for various levels of international trade costs (T) and foreign sizes (H_f and L_f) in the trading equilibrium. The impact of international trade liberalization on λ is strengthened with a lower international trade cost and/or a larger foreign economic size.

[Insert Table A1 about here]

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Tables:

Table 1: Parameter values for the case of Japan

μ	0.25
σ	6.62
β	0.03
t^M	1.50
t^A	1.25

Table 2: Numerical solutions

	E_0 Autarkic spatial equilibrium	E_1 (fixing $\lambda = 0.5$)		E_2 (fixing $\lambda = 0.1$)		E_3 $t^A = 1.3$ (fixing $\lambda = 0.33$)		E_4 Spatial equilibrium with trade	
w_E^H	0.02714	0.02629	-3.1%	0.02925	7.8%	0.02757	1.6%	0.006921	-74.5%
w_W^H	0.02366	0.02345	-0.9%	0.02421	2.3%	0.02350	-0.7%	0.006050	-74.4%
$w_E^L = p_E^R$	0.2638	0.2675	1.4%	0.2592	-1.7%	0.2654	0.6%	0.3190	20.9%
$w_W^L = P_W^F$	1.0000	1.0000	-	1.0000	-	1.0000	-	1.0000	0.0%
Y_E	0.1408	0.1469	4.3%	0.1325	-5.9%	0.1417	0.6%	0.1657	17.7%
Y_W	0.5159	0.5117	-0.8%	0.5218	1.1%	0.5158	0.0%	0.5007	-2.9%
p_E^M	0.3201	0.3245	1.4%	0.3145	-1.7%	0.3220	0.6%	0.3870	20.9%
p_W^M	0.4238	0.4292	1.3%	0.4170	-1.6%	0.4418	4.2%	0.5050	19.2%
p_E^M / p_W^M	0.7553	0.7562	0.1%	0.7542	-0.1%	0.7289	-3.5%	0.7663	-
G_E	0.3875	0.3657	-5.6%	0.4594	18.6%	0.3904	0.7%	0.3605	-7.0%
G_W	0.4376	0.4521	3.3%	0.4208	-3.8%	0.4528	3.5%	0.4112	-6.0%
n_E	0.3274	0.5000	-	0.1000	-	0.3274	-	0.8910	-
n_W	0.6726	0.5000	-	0.9000	-	0.6726	-	0.1090	-
θ_E	0.9890	0.9855	-	0.9934	-	0.9882	-	0.9937	-
θ_W	0.9851	0.9879	-	0.9815	-	0.9863	-	0.9995	-
q_E	0.5612	0.4818	-14.1%	1.1045	96.8%	0.6030	7.4%	0.1184	-78.9%
q_W	0.3696	0.4030	9.0%	0.3433	-7.1%	0.3393	-8.2%	0.07930	-78.5%
$\omega_E^H = \omega_W^H$	0.02909	0.02860	-1.7%	0.03005	3.3%	0.02865	-1.5%	0.007555	-74.0%
ω_E^L	0.2829	0.2909	2.8%	0.2663	-5.9%	0.2758	-2.5%	0.3482	23.1%
ω_W^L	1.2295	1.2195	-0.8%	1.2416	1.0%	1.2191	-0.8%	1.2488	1.6%
π_E	0.0000	-0.002673	-	0.02322	-	0.001762	-	0.0000	-
π_W	0.0000	0.002673	-	-0.002580	-	-0.0008577	-	0.0000	-
λ	0.3274	0.5 (fixed)	-	0.1 (fixed)	-	0.3274 (fixed)	-	0.8895	-

Note: Y_r, θ_r and π_r are the aggregate income, the share of workers employed in the agricultural sector, and the profit of a typical manufacturing (silk fabric) firm in region r, respectively. See Appendix 1 for the full description of the model. The foreign variables for the solution of E_4 in the final column are omitted. Percent changes are calculated in comparison to the autarky equilibrium in the first column.

Table 3: Source of demand of typical eastern and western silk fabric firms

Location of production	Source of demand	Autarkic spatial equilibrium E_0 ($\lambda = 0.33$)	Introducing international trade fixing $\lambda = 0.33$, short run	Spatial equilibrium with trade E_4 ($\lambda = 0.89$)
East	East	57.3%	71.8%	60.6%
	West	42.7%	28.2%	39.4%
West	East	1.4%	2.6%	1.6%
	West	98.6%	97.4%	98.4%

Note: Includes trade costs.

Table 4: Fabric expenditure shares of eastern and western consumers

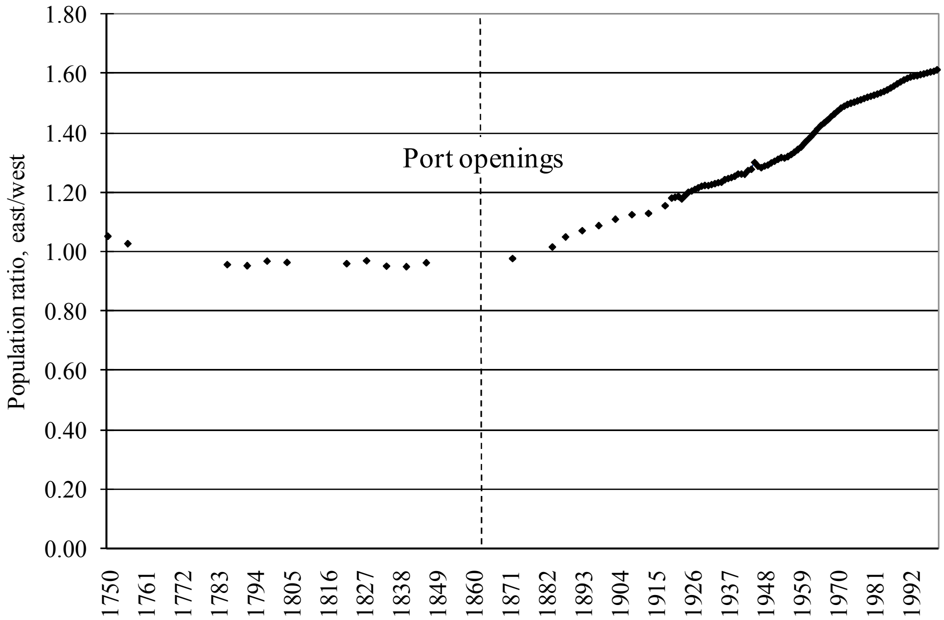
Location of consumers	Origin of product	Autarkic spatial equilibrium ($\lambda = 0.33$)	Introducing international trade fixing $\lambda = 0.33$	Spatial equilibrium with trade ($\lambda = 0.89$)
East	East	93.8%	26.9%	49.7%
	West	6.2%	1.9%	0.2%
	Foreign	-	71.2%	50.1%
West	East	26.7%	4.7%	13.0%
	West	73.3%	14.1%	2.3%
	Foreign	-	81.2%	84.7%

Note: Includes trade costs.

Table A1: Solutions for λ in the trading equilibrium

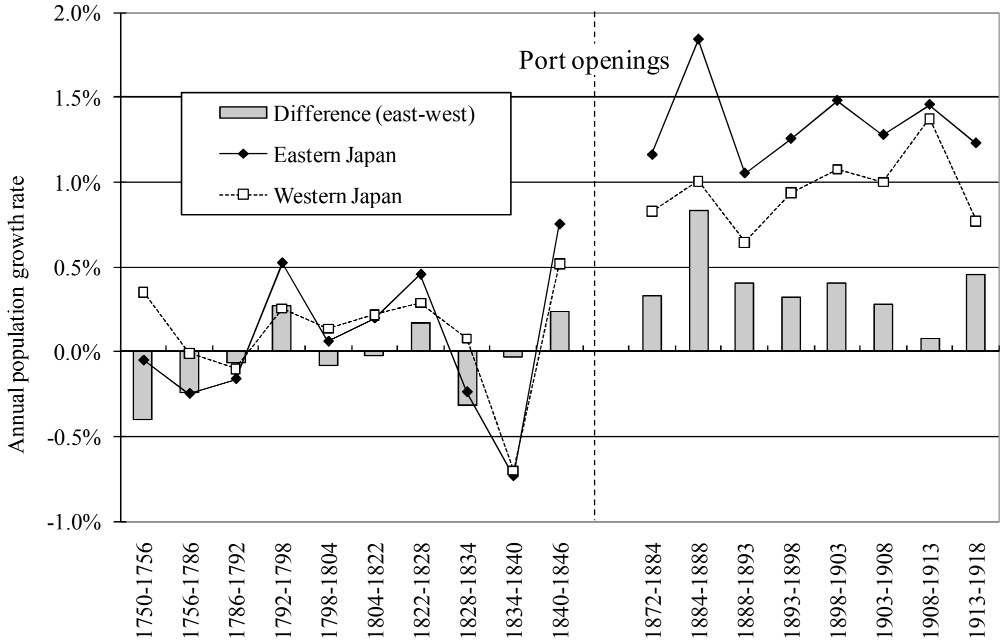
	$T = 1.2$	$T = 1.5$ (base)	$T = 1.8$
$(H_f, L_f) = (0.3, 0.3)$	0.58	0.50	0.46
$(H_f, L_f) = (0.5, 0.5)$ (base)	1	0.89	0.70
$(H_f, L_f) = (0.7, 0.7)$	1	1	1

Figure 1: population ratio of eastern and western Japan (east/west)



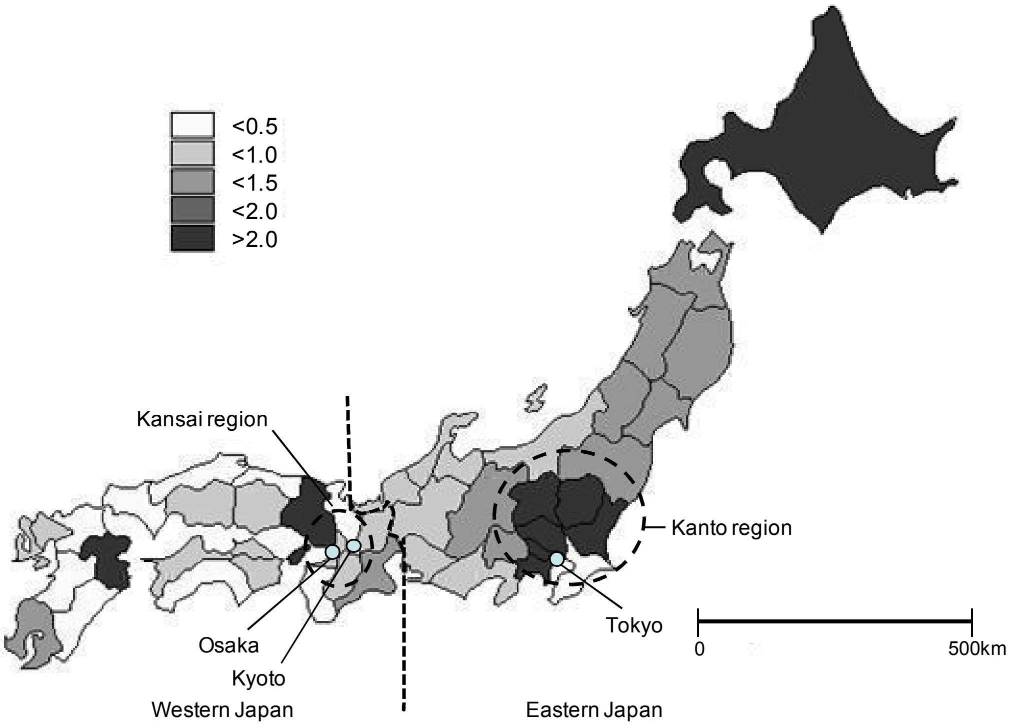
Note: See Figure 3 for the definition of eastern and western Japan.
Source: Complied and calculated by author. Original data from Ministry of Internal Affairs (1993a, 1993b) and Ministry of Internal Affairs and Communications (2006).

Figure 2: Average annual population growth rates of eastern and western Japan



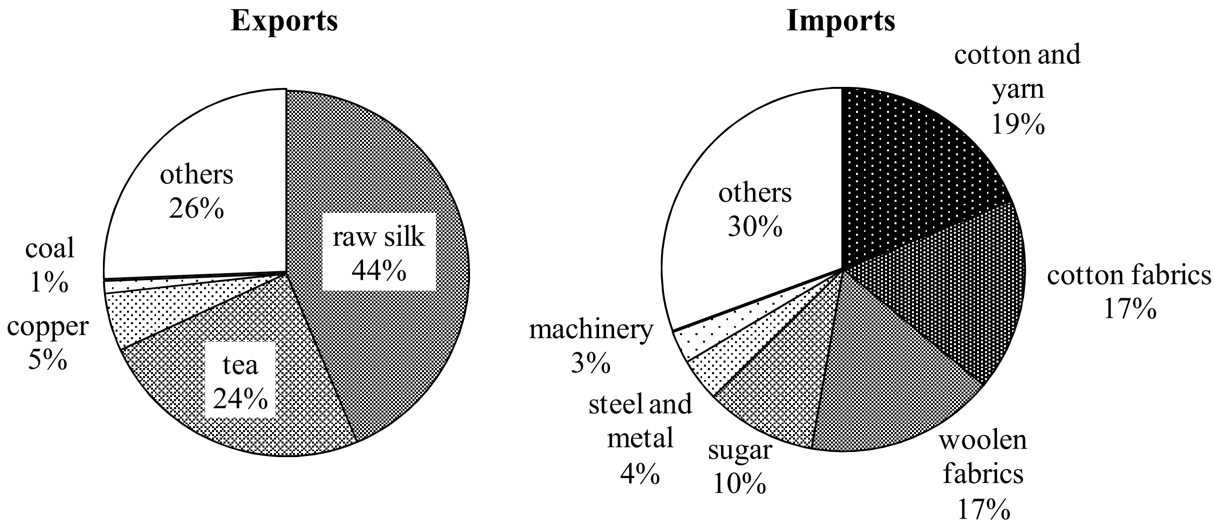
Note: Lengths of the periods differ due to data availability.
Source: Complied and calculated by author. Original data from Ministry of Internal Affairs (1993a, 1993b) and Ministry of Internal Affairs and Communications (2006).

Figure 3: Comparison of regional population growth rates, before and after the port openings



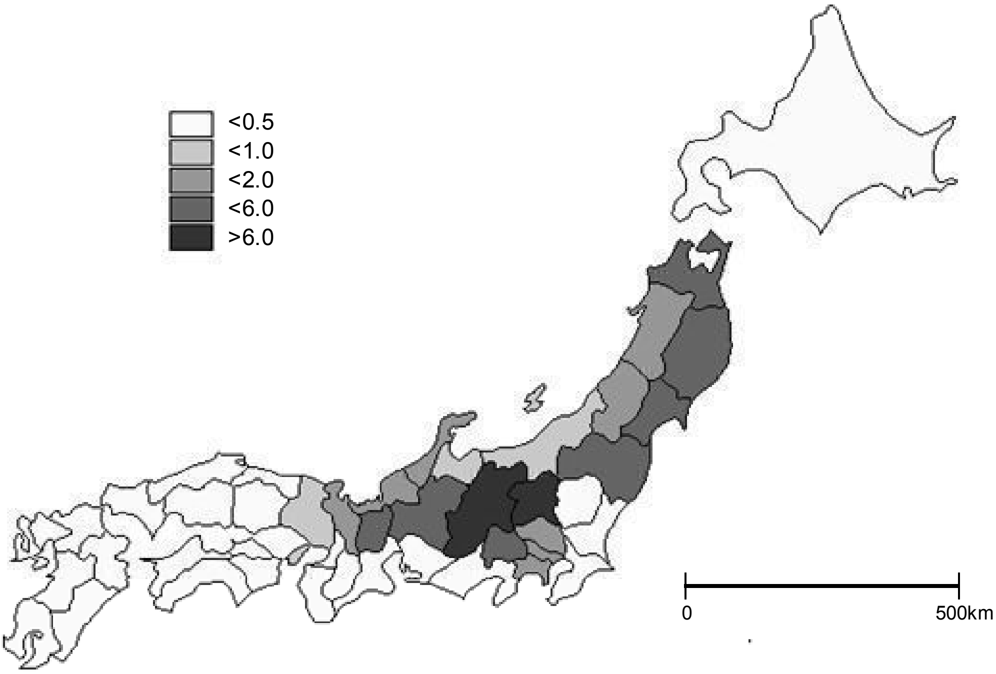
Source: Compiled and calculated by author. Original data from Ministry of Internal Affairs (1993a, 1993b) and Ministry of Internal Affairs and Communications (2006).
Note: The figure shows the differences in average annual growth rates between the period 1872 to 1888 and the period 1750 to 1846 for each region, in % points.

Figure 4: Product share of Japan's trade, 1868-1881



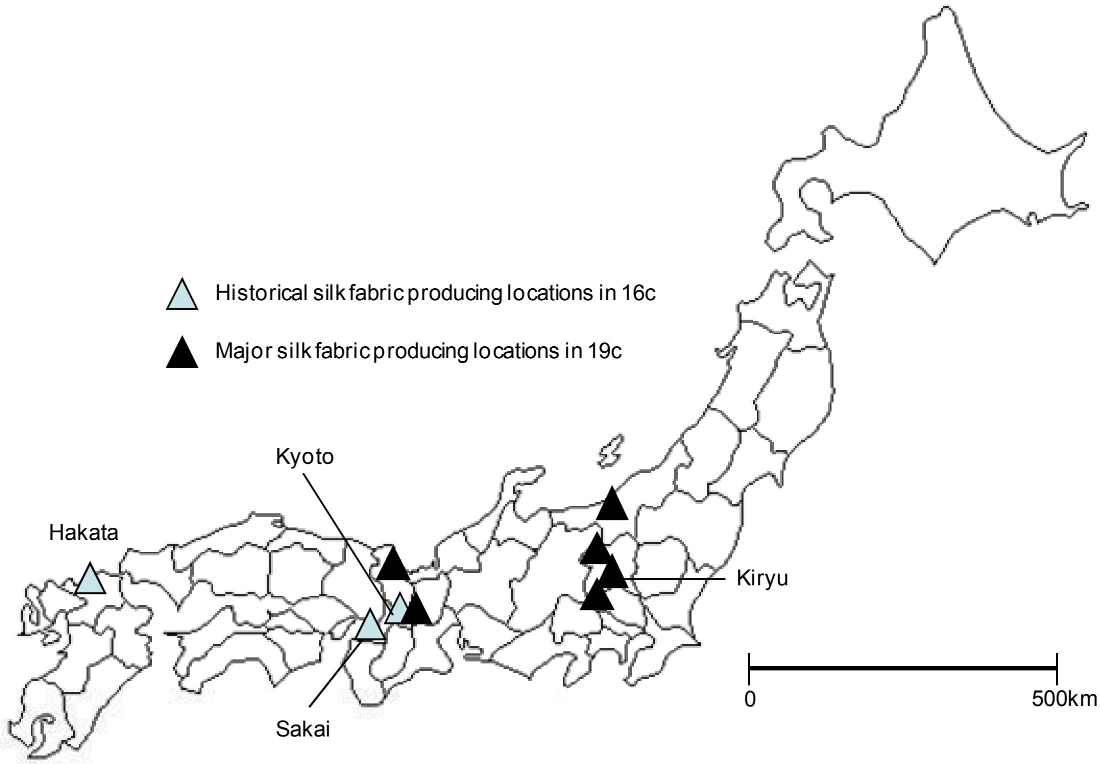
Note: Raw silk includes silkworm eggs and cocoons.
Source: Toyo keizai shinpo sha (1975)

Figure 5: Regional silkworm cocoon production intensity, 1887



Note: Cocoon production intensity is calculated as cocoon output (kg)/population. Population data is that of 1888 since that of 1887 is not available.
Source: Compiled and calculated by author. Original data from Ministry of Internal Affairs and Communications (2006) and Ministry of Agriculture, Forestry and Fisheries (2004)

Figure 6: Location of silk fabric production



Source: Drawn from information in Nagahara (1983)

Figure 7: The two regions, industrial location and trade costs

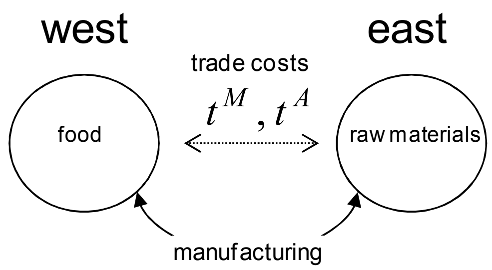


Figure 8: Regional industrial distribution in autarkic Japan

a. holding t^A at 1.25 **b. holding t^M at 1.5**

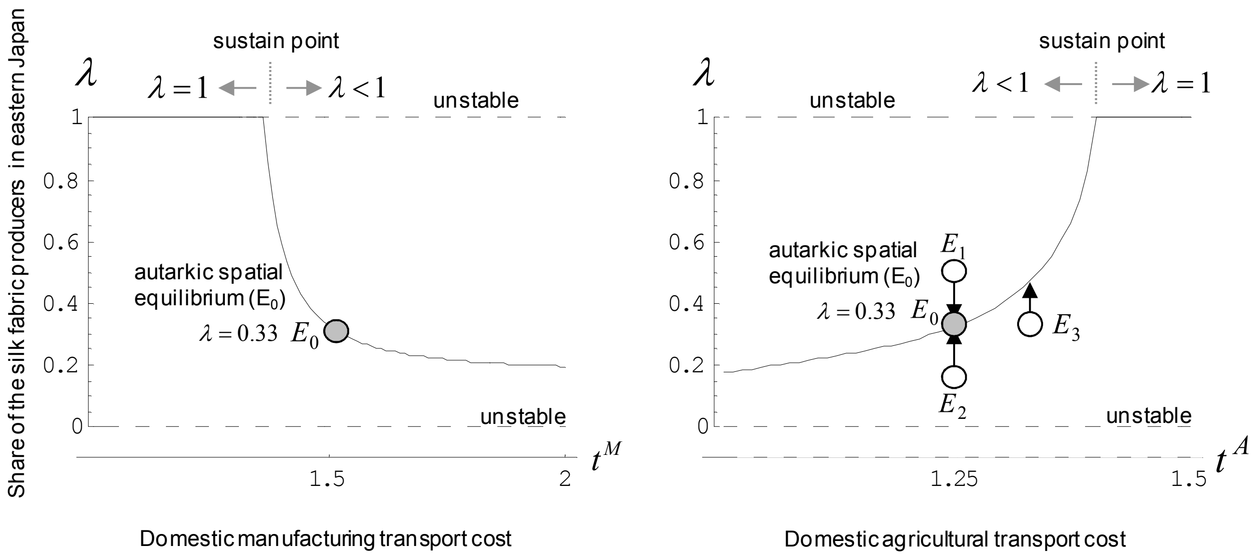


Figure 9: Regional industrial distribution in Japan after the port openings

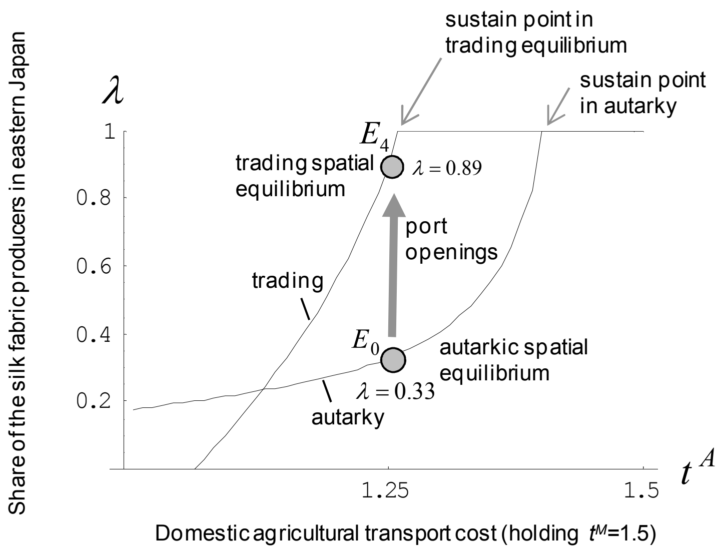


Figure A1: Regional industrial distribution in autarkic Japan

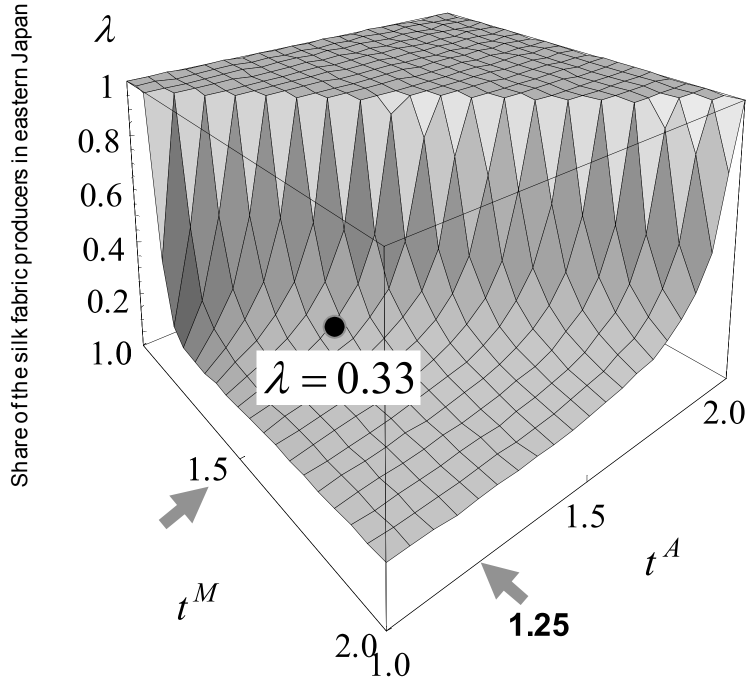


Figure A2: Sustain point of the case of Japan in autarky