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JAPAN AND THE GREAT DIVERGENCE, 725-1874

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Abstract: Japanese GDP per capita grew at an annual rate of 0.04 per cent between 725 and 1874, but the growth was episodic, with the increase in per capita income concentrated in three periods, 1150-1280, 1450-1600 and after 1730, interspersed with periods of stable per capita income. There is a similarity here with the growth pattern of Britain. The first countries to achieve modern economic growth at opposite ends of Eurasia thus shared the experience of an early end to growth reversals. However, Japan started at a lower level than Britain and grew more slowly until the Meiji Restoration.

JEL classification: N10, N30, N35, O10, O57

Key words: Japan, Great Divergence, GDP per capita, growth reversals, Britain

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I. INTRODUCTION

The Great Divergence debate, which began with Pomeranz (2000), has revolved primarily around differences in living standards between Europe and China. However, this focus on China is dependent on a strongly revisionist interpretation of Chinese economic history, with Pomeranz arguing that China did not fall behind the West before 1800. Before this debate, the natural focus for a Europe-Asia comparison of living standards was Britain and Japan, as the first nations to achieve modern economic growth in Europe and Asia, respectively. Whilst it is interesting to note that Hanley (1983; 1986) preceded Pomeranz by nearly two decades in claiming that Japanese living standards were as high as in the West, her claims were quickly criticised and never had the same impact as Pomeranz's equally strong claims for China, or the similar claims for India made by Parthasarathi (1998; 2011).

One obvious piece of quantitative evidence which casts serious doubt on the revisionist claims is the comparison of real wages between Europe and Asia. Broadberry and Gupta (2006), Bassino and Ma (2005) and Allen *et al.* (2011) all present evidence to suggest that real wages were substantially lower in Asia than in Europe during the early modern period, even taking account of regional variations within both continents. Although the distributions overlapped, the richest parts of Asia were at best on a par with the peripheral parts of Europe. Bassino *et al.* (2010) extend the evidence on the real wage experience of Japan in international perspective back from 1600 to 1240. However, real wage evidence applies to only a part of the economy, typically the urban industrial sector. A comprehensive assessment of overall levels of economic development and an evaluation of the timing of the Great Divergence requires a historical national accounting approach, covering all economic activities.

Recently, there has been much progress in reconstructing the historical national accounts of a number of European countries during the early modern and medieval periods (Broadberry *et al.,* 2015a; van Zanden and van Leeuwen, 2012; Malanima, 2011; Álvarez-Nogal and Prados de la Escosura, 2013; Schön and Krantz, 2012). Broadberry *et al.* (2015b) have demonstrated that these methods can also be applied to Asia, and hence shed light on the origins of the Great Divergence of productivity and living standards between Europe and Asia. This paper applies these methods to the case of Japan, the first Asian country to achieve the transition to modern economic growth.

The results presented in this paper suggest that Japanese GDP per capita grew at an annual rate of 0.04 per cent between 725 and 1874. As in the North Sea Area of Europe, this growth was persistent, with periods of strong positive growth interspersed only with periods of stable per capita income. Without substantial growth reversals, or periods of negative per capita income growth, the Japanese economy was able to cumulate the gains of the growth spurts that occurred during 1150-1280, 1450-1600 and after 1730. These earlier growth spurts thus helped to lay the foundations of the transition to modern economic growth after the Meiji Restoration of 1868. Per capita income in Japan was over three quarters of the British level around 1280, but fell behind substantially following the Black Death of the mid-fourteenth century, which led to a roughly fifty percent increase of per capita incomes in Britain. By the mid-fifteenth century, Japanese per capita incomes were around half the British level. Between 1450 and 1600, per capita incomes grew substantially in Japan while stagnating in Britain, so that the gap narrowed. With accelerating British growth from the mid-seventeenth century, however, the gap widened, so that by the mid-nineteenth century per capita incomes in Japan were little more than a quarter of the British level. In 1874, Japan's GDP per capita was $860 in 1990 international dollars[1], substantially above Maddison's (2001) definition of bare bones subsistence at $400. This level is derived from the World Bank's poverty line of a dollar a day, and continues to be experienced by the world's poorest economies today. Japan's GDP per capita was slightly more than $500 in 725, but by the time of the Tokugawa period, Japan had already clearly emerged from bare bones subsistence, and was laying the foundations of the modern economic growth achieved after the Meiji Restoration of 1868.

How should we view the Great Divergence in the light of these patterns of growth? Just as Britain caught up with and overtook other European countries by spurts of growth interspersed with periods of stable per capita incomes, so Japan caught up with and overtook other Asian economies, including China, by a similar process of episodic growth and the avoidance of growth reversals. But since Japan started at a lower level than Britain and grew more slowly until the Meiji Restoration, the Great Divergence occurred as the most dynamic part of Asia fell behind the most dynamic part of Europe.

In order to derive a series of Japanese GDP, we adapt the recent work on reconstructing the historical national accounts of a number of European countries to the circumstances and data availability of Japan. The starting point is the estimation of population in section II. This is followed in section III by the estimation of agricultural output from the supply side, which is cross-checked against the demand for food based on real wage trends. Section IV then uses information on urbanisation and population density to estimate output in the secondary and tertiary industries. The sectoral estimates are combined in section

[1] This is higher than Maddison's (2010) figure of $756, because of Fukao *et al.*'s (2015) re-estimation of Japanese GDP for the period 1874-1890.

V to compute GDP and divided by population to obtain GDP per capita in Japan. This is then compared in section VI with GDP per capita in Britain, and the Anglo-Japanese comparison is placed in a wider Europe-Asia context to shed new light on the Great Divergence. Section VII concludes.

II. POPULATION GROWTH

Historical demographic data allow the estimation of total population for Japan back to around 725. The data in Table 1 are taken from a number of sources that have been cross-checked and made consistent. For the period 725-1600, the early benchmark years of 725 and 900 are taken from Kito (2000), while the later benchmark years of 1000, 1250, 1450 and 1600 are Saito's estimates quoted in Farris (2006). The data for other years before 1600 are obtained by linear interpolation. For the period 1600-1874, the benchmark years 1720, 1730, 1750, 1800 and 1850 are derived from the work of Kito (1996), but adjusted upwards so as to be consistent with the 1874 level established by Fukao *et al.* (2015). The years 1650 and 1700 were derived by linear interpolation, since Kito's estimates for the early Tokugawa period are based on an assumed growth pattern that was judged to be unrealistic.

The figure for 725 is derived by multiplying the average number of persons in each *go* (the smallest administrative unit in the ancient period, consisting of 50 *ko*, or household units) and the total number of *go* in Japan. In addition, an allowance is made for the number of slaves, estimated at 4.4 per cent of the free people, and the number of people living in Heijokyo, also called *Nara no miyako* (Nara the capital), which served as the imperial capital in 710-740 and 745-784, and had around 74,000 residents in 725 (Kishi, 1984). The figure for 900 is based on the total paddy field area from data in *Wamyosho* (an ancient Japanese encyclopaedia compiled in the first half of the tenth century), multiplied by the estimated population per unit of paddy field, which is derived from the system of rules for the distribution of paddy fields. Kito also made an allowance in 900 for the urban population in Heiankyo, currently Kyoto, the imperial capital almost continuously from 794 to 1868, which was estimated to have 120,000 and 300,000 residents in 1150 and 1600 by Kito (2000) and Takao et al. (1968), respectively.

Population estimates for 1750 and 1850 are based on the Tokugawa Government's population surveys, which started in 1721, and which have been adjusted for under-enumeration. For years before 1721, Kito (2000) follows Hayami (1973) in subdividing Japan into three regions (the developed, less developed and least developed regions), and assuming that the population growth pattern in each region can be approximated by a logistic curve. The shape of the logistic curve is derived from the population growth pattern estimated from data in *shumon-aratame-cho* (temple registry books) for certain regions. By using regional benchmark data for the eighteenth century, and by assuming the starting year of population growth for each region (with population growth in the developed region assumed to have started earlier), Hayami (1973) and Kito (2000) are able to obtain estimates of population in the years between 1600 and 1721.

In his work on famines, Saito (2010) found that in the second half of the sixteenth century there was a sudden drop in the frequency of famines in spite of disadvantageous climatic conditions. Based on this finding, he concludes that population growth must have started earlier and been faster in the developed region than Kito (2000) had assumed. Saito produces revised estimates based on these revised assumptions.

Over the entire period 725-1874, Japanese population grew at a relatively modest annual rate of 0.18 per cent. However, there was a long period of stagnation between 900 and 1250, with growth averaging the higher rate of 0.24 per cent per annum in the 1250-1450 period. It should be noted that in contrast to European countries, there was no major population decline in the mid-fourteenth century, as Japan completely avoided the Black Death that ravaged Europe in 1348-1349. Population growth increased after 1450, reaching 0.47 per cent per annum between 1600 and 1730, before slowing down sharply during the later years of the Tokugawa shogunate. There was an absolute fall in the population level between 1730 and 1800, before a recovery during the nineteenth century. The population decline was driven by trends in eastern Japan, which fell behind the proto-industrialising western parts of the country and was hit by famines as a result of cold weather and economic stagnation. Population continued to increase in western Japan, where proto-industry and agriculture continued to prosper.

III. AGRICULTURAL PRODUCTION

1. Agricultural output from the supply side

Agricultural output can be estimated directly from the supply side, using data on crops harvested or the amount of land used for crop production multiplied by crop yields.[2] This can then be cross-checked against estimates of the demand for food derived indirectly from data on population, wages and prices. Starting with the supply-side estimates, the precise method of estimation varies by period. For the ancient and medieval periods, agricultural output is

[2] The returns from staple food consumption surveys undertaken in the second half of the 19th century at the regional level (quoted in Umemura et al., 1983: 246-251) indicate that rice accounted for around half of total output at the national level, while wheat and barley accounted for around one quarter, and millet, buckwheat, maize, sweet potatoes, and other roots and tubers for the rest. Available evidence suggests that shares remained rather stable between the 8th and the 19th century, with the notable exceptions of maize and sweet potatoes introduced in Japan in the 16th century, and white potatoes in the 18th century that probably expanded at the expense of staples other than rice, wheat and barley.

derived from data on the amount of arable land in use, multiplied by estimates of the productivity of land. For the period 1600-1874, by contrast, the most reliable data are for total production and land use, with land productivity derived from these two series.

For the ancient (725-1150) and medieval (1150-1450) periods, data must first be assembled on the amount of cultivated land. This involves both rice paddies and dry fields. The data for the ancient period are collected from primary sources as explained in Takashima (2012). Dealing first with rice paddies, for the year 725, the area is derived from estimates of the amount of paddy field per *go*, multiplied by the number of *go*. The number of *go*, or administrative units consisting of 50 households, is reported in *Rissho Zanpen* (an ancient penal code) and *Wamyosho*. For the year 900, we use *Wamyosho* data on the total area of rice paddies. For 1150, we use the total area of rice paddies reported in *Shugaisho* (an old Japanese encyclopedia compiled in the early medieval period). Data on rice yields are obtained from the same primary sources, based on a legal formula which regulated the proportions of land between high-grade, medium-grade, low-grade and very low-grade paddies.

Since these estimates are apparently restricted to rice paddies, it is necessary to also make an allowance for dry fields. This is done by collecting data on the ratio of dry fields to total arable land from primary sources. For the year 725 the ratio is taken from the inventory list of assets and properties of *Horyuji* temple and *Gufukuji* temple[3], which include the total number of *shoen* (private estates managed by the temples and aristocrats) with detailed separate records for rice paddies and dry fields. A wider range of temple records is available

[3] *Horyuji* and *Gufukuji* are two important Buddhist temple complexes established in the 7th century close to Nara.

to calculate the ratio of dry fields to total arable land in 900 and 1150. These same primary sources are also used to obtain data on crop yields in dry fields, which were 64 per cent of the level of land productivity in paddies.

For 1280 and 1450, we follow Farris (2006) in deriving total arable land by multiplying the population older than 6 years by estimates of arable land per head of the population (older than 6 years) obtained from primary sources. These estimates are then multiplied by grain yields from the same sources to yield agricultural output. However, it should be noted that the 1280 figure for arable land per capita is derived from the 1450 figure by assuming that arable output per capita was the same in both years, so that arable land per capita declined as land productivity increased. Agricultural output for these years should therefore be regarded as tentative, awaiting more research to identify archives with more dependable sources relating to acreage and land productivity between the thirteenth and fifteenth centuries.

To link up with the estimates for later years, it is necessary to make a number of adjustments to the raw data. First, all figures for the period 725-1450 are computed on the basis of Nara units. Accordingly, we have converted the original land productivity data in Nara units to Tokugawa units.[4] Second, we take account of considerable areas of land that were fallowed and abandoned before 1450. The scale of this adjustment is 12.5 per cent in 725 and 900, rising to 25 per cent in 1150 because the land system of the ancient government had almost collapsed at that time. The adjustment factor then fell back to 12.5 per cent in 1280 and 1450, as a double-cropping system and iron farming equipment diffused. The third

[4] The conversion is based on the assumption that 1 Nara *cho* = 1.088 Tokugawa *cho* (1 Tokugawa *cho* = 0.991736 hectares, and therefore 1 Nara *cho* = 1.079 hectares) and 1 Tokugawa *koku* = 2.5 Nara *koku* (1 Tokugawa *koku* = 180 litres, and therefore 1 Nara *koku* = 72 litres.

adjustment, for the ancient period only, is to allow for output not captured in the public records that have been relied upon to obtain the data on arable land and yields. This is the same ratio (1.56) that has been used to adjust output during the Tokugawa period to ensure consistency with the 1874 benchmark.

For the period 1600-1874, data on arable land and harvested output are used to derive estimates of land yields and combined with data on population to derive estimates of output per capita. For arable land, we establish benchmark estimates for 1721 and 1874, and use linear interpolation for other years. The data for 1721 are taken from a survey of the Tokugawa shogunate, while the 1874 data are from a report of the Agency for the Promotion of Industry of the Ministry of Home Affairs. A comparison of the Ministry of Home Affairs figure for 1874 with the estimates of arable land area in Umemura *et al.* (1966) suggests the need to increase the unadjusted series by a factor of 1.1 to correct for under-recording in the public statistics of the time. For harvested output, a similar estimating procedure to that proposed by Nakamura (1968) has been followed, but implemented by Fukao *et al.* (2015) at the level of 14 regions rather than at the national level. Nakamura's approach was to estimate the changes in agricultural production using data on engineering projects to improve land, rather than to rely simply on the *kokudaka* (yield quantity assessed by the feudal government) data. He used two benchmark years, relating to a cadastral survey in 1645 and agricultural production in the last year of the Tokugawa regime, 1867, as established by the incoming Meiji government. In these years, it seemed that the government had taken greater trouble to assess the output harvested, which grew substantially faster than the land area, in line with the engineering projects. For other years, however, reported output grew only in line with the arable land area, which produced a large jump between 1850 and 1867. Nakamura assumed that the output data for 1645 and 1867 were correct and established the relationship between the change in output between these years and the number of land improvement projects.[5] He then adjusted the *kokudaka* data for other years in line with the number of projects. Fukao *et al.* (2015) apply Nakamura's procedure to estimates of regional *kokudaka*, by altering the final benchmark year to 1874. As noted earlier, the 1874 data have been used to provide a correction factor for the under-recording of output in the historical sources, by comparing with the estimates of value added in Fukao *et al.* (2015). The calculations have been done at a regional level, but for the agricultural sector as a whole, this results in a correction factor of 1.56.

The agricultural production data are set out in Table 2. The arable land area is given in the first column, while the second column shows agricultural land productivity in Tokugawa units. The third column gives agricultural production in 1,000 *koku*, while the fourth column gives the series for agricultural production per head, obtained by dividing agricultural production by the population series from Table 1. Agricultural production grew at an annual rate of 0.22 per cent between 725 and 1874, with nearly three quarters of the growth coming from an extension of the arable area, and the other quarter from rising land productivity. Most of the output growth was needed merely to keep up with the increasing population, but over the period as a whole agricultural production per head increased by 0.04 per cent per annum. Most of the per capita growth occurred in three phases, 1150-1280, 1450-1600 and after 1730, which does not suggest any simple Malthusian link to population growth.

2. Real wages and the demand for food

[5] Strictly speaking, Nakamura used average annual agricultural output during 1877-1879 as the figure for 1867.

One way of cross-checking our agricultural output data is to estimate a demand function for food, using known trends in wages and prices. This approach can be traced back at least as far as the work of Crafts (1985), who calculated the path of agricultural output in Britain during the Industrial Revolution with income and price elasticities derived from the experience of later developing countries. The approach was developed further by Allen (2000) using consumer theory. Allen (2000: 13-14) starts with the identity:

$$Q^A = rcN \qquad (1)$$

where Q^A is real agricultural output, r is the ratio of production to consumption, c is consumption per head and N is population. Real agricultural consumption per head is assumed to be a function of its own price in real terms (P^A/P), the price of non-agricultural goods and services in real terms (P^{NA}/P), and real income per head (y). Assuming a log-linear specification, we have:

$$\ln c = \alpha_0 + \alpha_1 \ln(P^A / P) + \alpha_2 \ln(P^{NA} / P) + \beta \ln y \qquad (2)$$

where α_1 and α_2 are the own-price and cross-price elasticities of demand, β is the income elasticity of demand and α_0 is a constant. Consumer theory requires that the own-price, cross-price and income elasticities should sum to zero, which sets tight constraints on the plausible values, particularly given the accumulated evidence on elasticities in developing countries (Deaton and Muellbauer, 1980: 15-16, 60-82).

For early modern Europe, Allen (2000: 14) works with an own-price elasticity of -0.6 and a cross-price elasticity of 0.1, which constrains the income elasticity to be 0.5. Allen also assumes that agricultural consumption is equal to agricultural production. For the case of Japan, where more limited information is available, we implement a restricted version using the rice wage (the daily wage divided by the price of rice) for unskilled labourers and an assumed income elasticity of 0.5.[6] The rice wage is taken from Bassino *et al.* (2010) and Bassino and Ma (2005), and plotted on an annual basis in Figure 1. Table 3 sets out the trend in the rice wage using decadal averages and uses it to derive the demand for food.

For the period 1260-1600, rice wages in Kyoto were constructed using information on rice prices in copper coins reported in Momose (1959), Rekihaku (2009), and KKB (1962) while series of nominal wages in copper coins (or directly paid in rice) were generated on the basis of wage rates for benchmark years collected by Endo (1956) and Tanaka (2007) and on individual contracts reported by Rekihaku (2009). Although wages are also available for highly skilled carpenters, attention has been restricted here to the unskilled helpers of craftsmen and transporters. Skilled wages were paid to a much smaller share of the population, so that unskilled wages are likely to provide a better indicator of average incomes. Throughout the entire period, the nominal wage rates for unskilled workers remained fairly stable at around 10 copper coins, so that most of the rice wage variation resulted from changes in rice prices. For the post-1743 period, rice wages are also available for Kyoto, based on a collection of retail prices of rice sold and labour compensation paid by the Kyoto branch of the trading house Mitsui (Mitsui Bunko 1981).

For the period 1600-1743, unskilled wage rates in copper coins are obtained from a data series for Osaka, which is available for the whole period 1600-1870 (Miyamoto, 1963). The stability of the rate over long periods indicates that an in-kind component of rice was not included. The Osaka wages were substantially lower than in Kyoto, but were adjusted upwards to the Kyoto level by assuming that the in-kind component in Osaka was 0.8 *sho*

[6] One way to justify this would be if the cross-price elasticity is zero and real income is the wage divided by the overall price level. The own-price elasticity must then equal the negative of the real wage elasticity. But then the overall price level used to deflate the wage cancels out with the overall price level used to deflate the grain price, leaving a single term in the grain wage.

(1.8 litres per *sho*, and 1.5 kg in the case of husked rice). This adjustment factor is obtained by comparing the Osaka wage series for the period 1743-1870 with the series for Kyoto covering the period 1743-1762 and 1791-1870. Pre-1720 rice price series were generated by projecting backwards the Kyoto Mitsui series, assuming the same yearly variation as for wholesale prices in Osaka for 1700-1742 and 1763-1790, Hiroshima 1620-1700 (Iwahashi 1981) and Osaka 1600-1650 (Kimura 1987).

The unskilled rice wage remained relatively stable between 1260/69 and 1450/59, before roughly doubling to 1550/59 and then slipping back, but remaining on a higher plateau than before 1450/59. An index of agricultural demand per head has been derived in Table 3 from the unskilled rice wage on the assumption of an income elasticity of demand of 0.5. This pattern of agricultural demand per head is consistent with the estimates of agricultural output per head derived from the supply side, once allowance is made for an "industrious revolution" during the Tokugawa period (Hayami, 1967). As daily grain wages first declined and then stagnated during the Tokugawa period, households increased the number of days worked per year and were thus able to increase food consumption per head in line with agricultural output per head.

The plausibility of food supply data can be gauged by converting the rice equivalent output estimates into kilocalories available. Although a *koku* was intended to be sufficient rice to feed one person for a year, the traditional volume measure of 180.391 litres implies a daily amount of 0.5 litres, which provides just 1,448 kilocalories. Since around 2,000 kilocalories per day are needed to work and reproduce[7], the estimated agricultural output per

[7] Average caloric requirements per head depend on body height, which was relatively low in medieval and early modern Japan, but also on claim related to basal metabolism, disease exposure and physical activities, which were quite demanding in Japanese agriculture and industry.

head of around 1.4 *koku* throughout the period 725-1450 suggests that Japan was producing just enough food, with little margin for loss of kilocalories through either wastage or food processing.[8] The higher figures for later years would be consistent with a rise in food processing activities (sake and noodles, but also soy bean paste and soy sauce), reflecting a rise in living standards. Adjusting for losses in storage and processing would result in kilocalorie figures broadly comparable to estimates for Britain, in a range between 2,000 and 2,400 from the thirteenth to the nineteenth century (Broadberry *et al.*, 2015), but with a much lower intake of animal proteins in Japan.

IV. SECONDARY AND TERTIARY OUTPUT

1. Urbanisation and non-agricultural production

A number of authors have used the share of the population living in towns as a measure of the growth of the non-agricultural sector. This approach began with Wrigley (1985), and has recently been combined with the demand approach to agriculture to provide indirect estimates of GDP in a number of European countries during the early modern period (Malanima, 2011; 2011; Álvarez-Nogal and Prados de la Escosura, 2013; Schön and Krantz, 2012). With the path of agricultural output (Q^A) derived using equations (1) and (2), overall output (Q) is derived as:

$$Q = \frac{Q^A}{1-\left(Q^{NA}/Q\right)} \qquad (3)$$

where the share of non-agricultural output in total output (Q^{NA}/Q) is proxied by the urbanisation rate. The approach can be made less crude by making an allowance for higher

[8] However, it should be borne in mind that non-rice output has been converted to rice equivalent output at market prices, and that the price of a kilocalorie from wheat, barley, millet, buckwheat and other non-rice staples was significantly lower than the price of a kilocalorie from rice. Gross availability of kilocalories would therefore have been significantly higher than 2,000, leaving more scope for losses through wastage and food processing.

productivity in the non-agricultural sector, so that (Q^{NA}/Q) increases more than proportionally with the urbanisation rate.

However, as Saito and Takashima (2014) point out, there is a major problem with applying this method to Japan, because the urbanisation rate declined during the Tokugawa period, which is widely seen as the key period of proto-industrial growth. Data on the Japanese urban population are shown in Table 4. The definition of urbanisation chosen here is the number of people living in settlements of at least 10,000, in line with the work of de Vries (1984) on Europe. The data on the size of individual towns were derived from historical sources compiled by local governments in Japan. The urban population share remained relatively stable at around 3 per cent until the mid-fifteenth century, when it increased substantially, particularly at the beginning of the Tokugawa shogunate. However, the urbanisation rate then remained on a plateau during the seventeenth and eighteenth centuries before declining during the nineteenth century. The sharp increase in the level of urbanisation at the beginning of the Tokugawa period was the result of the introduction of the *Bakuhan* system, which was based on a principle of separation between peasants in the countryside and warriors in towns, with merchants and artisans also being required to reside in towns (Iwahashi, 2004: 88-89). However, the separation between peasants and the commercial classes was less strictly enforced than that between peasants and the warriors, allowing the growth of proto-industry in the countryside (Shimbo and Hasegawa, 2004).

2. Allowing for proto-industry

Under the circumstances outlined above, a crude estimation of non-agricultural production using the urbanisation rate would miss the expansion of cottage industry in the rural industrious revolution highlighted by Hayami (1967). The solution proposed by Saito and

Takashima (2014) is to allow secondary and tertiary output to vary with population density as well as the urbanisation rate, with the weights for these two factors derived from pooled regional data for the years 1874, 1890 and 1909. Using data from Fukao et al. (2015), they run separate regressions for the secondary and tertiary sectors, with the same right hand side variables allowed to have different effects on the secondary and tertiary sector shares. The secondary sector share variable (*Sshare*) is defined as the proportion of secondary sector output in the sum of primary and secondary sector output, and the regression is run with the dependent variable in logit form to deal with the skewness of the distribution:

$$ln\left(\frac{Sshare}{1-Sshare}\right) = \alpha_0 + \alpha_1 lnD + \alpha_2 ln\left(\frac{U}{1-U}\right) + \alpha_3 M + \alpha_4 YR1 + \alpha_5 YR2 + \varepsilon \qquad (4)$$

Here, *D* is population density, *U* is the urbanisation rate (also entered in logit form), *M* is a dummy variable for modernised prefectures (confined to Tokyo and Osaka in 1874 and 1890, but with the addition of Aichi and Fukuoka in 1909), *YR1* and *YR2* are year dummies for 1890 and 1909 respectively, and ε is a stochastic error term. The tertiary sector share variable (*Tshare*) is defined as the proportion of tertiary sector output in the sum of primary and tertiary sector output, and the regression is again run with the dependent variable in logit form to deal with the skewness of the distribution:

$$ln\left(\frac{Tshare}{1-Tshare}\right) = \alpha_0 + \alpha_1 lnD + \alpha_2 ln\left(\frac{U}{1-U}\right) + \alpha_3 M + \alpha_4 YR1 + \alpha_5 YR2 + \varepsilon \qquad (5)$$

The right hand side variables are the same as in equation (4), but the coefficients are allowed to take different values in the two sectors. The results for the OLS estimation of equations (4) and (5), presented in Table 5 taken from Saito and Takashima (2014), yield a number of interesting findings. First, both population density and urbanisation were significant determinants of both secondary and tertiary sector activity. Second, however, the population density effect was comparatively more important for the secondary sector, while the urbanisation effect was comparatively more important for the tertiary sector.

The coefficients from Table 5 can be used together with national level data on population density and the urbanisation rate to estimate secondary and tertiary sector output from the data on primary sector output in Table 6. Primary sector output is first derived from agricultural output in Table 2 by making an allowance for forestry and fisheries during the period 725-1450. The agricultural output data for the period 1600-1874 already include forestry and fisheries, so do not need further adjustment. For the period 725-1450, however, the agricultural output data have been increased by 18.5 per cent, in line with the ratio of forestry and fisheries to agriculture in 1874.

For the period 1720-1874, Saito and Takashima (2014) and Fukao *et al.* (2015) calculated secondary and tertiary sector output shares applying the coefficients from Table 5 to equations (4) and (5), using data for the urbanisation rate, population density and primary sector output. However, they argue that the age of proto-industrialisation and de-urbanisation began only after 1720, following the policies of the eighth Shogun, Yoshimune, who lifted some of the restrictions on the import of foreign books. These measures facilitated the spread of information needed for effective import substitution, particularly in raw silk, thus stimulating rural proto-industry. Also in 1720, the population density rose above 1.0 per *cho* for the first time at the national level. For the period before 1720, they thus turn off the population density effect. This means that before 1720, they have effectively adopted the Malanima (2011) model, where non-agricultural output grows in line with the urbanisation rate, but with separate coefficients for the secondary and tertiary sectors.

Secondary and tertiary sector real output in 1,000 *koku* are shown in Table 6A, together with primary sector output. Primary output is derived from the agricultural output estimates in Table 2, but with an adjustment for the omission of forestry and fishing in the pre-1600 data. This involves increasing the agricultural output estimates by 18.5 per cent, in line with the 1874 ratio. Table 6B provides the growth rates of GDP and its sectoral components over a number of sub-periods. Over the period 725-1874, and also in the Tokugawa period, agriculture was the slowest growing sector, and the secondary sector grew a little bit faster than the tertiary sector. As a result, the primary sector's share of output in rice equivalent terms declined from a peak of 74.3 per cent in 900 to 58.6 per cent by 1874. Over the same period, the secondary sector increased its share from 8.8 to 10.9 per cent and the tertiary sector share nearly doubled from 16.9 to 30.5 per cent.

V. JAPANESE GDP PER CAPITA

The GDP per capita series is shown in level form in Table 7A, and in annual growth rate form in Table 7B. Japanese GDP per capita grew at an annual rate of 0.04 per cent between 725 and 1874. As in the North Sea Area economies of Britain and Holland, this growth was persistent, with periods of strong positive growth that were not followed by substantial growth reversals (Broadberry *et al.*, 2015a; van Zanden and van Leeuwen, 2012). The major periods of positive per capita GDP growth occurred during 1150-1280, 1450-1600 and again after 1730. This latter period of growth during the late Tokugawa period led on to a further acceleration of the rate of growth as Japan made the transition to modern economic growth during the Meiji period. It is interesting to note that the first economies to make the transition to modern economic growth at the two ends of Eurasia, Britain and Japan, both built on earlier gains reaching back to the medieval period. This suggests that the key to understanding modern economic growth lies in identifying the forces which dampened growth reversals rather than the forces responsible for the initiation of a growth phase (Broadberry, 2014).

VI. IMPLICATIONS FOR THE GREAT DIVERGENCE

1. An Anglo-Japanese comparison

To pin down the timing and extent of the Great Divergence, we need to compare GDP per capita in Japan with Britain, where the transition to modern economic growth first occurred, and place the Anglo-Japanese comparison within its wider Europe-Asia context. Here, we project back from Maddison's (2010) estimates of GDP per capita in the late nineteenth century, expressed in 1990 international dollars, but with some important adjustments. First, whereas Maddison worked with the territory of the United Kingdom, Broadberry *et al.* (2015a) provide a series for Great Britain covering the period 1700-1870 and England for the period 1270-1700. They note that even in the Middle Ages, British levels of GDP per capita were well above $400 in 1990 international prices. The figure of $400, or a little more than a dollar a day, is usually taken as the measure of bare bones subsistence, and is observed for many poor countries in the twentieth century. Broadberry *et al.* (2015a) note that GDP per capita figures of well above $400 have been found for a number of west European countries in the late Middle Ages (van Zanden and van Leeuwen, 2012; Malanima, 2011; Alvarez-Nogal and Prados de la Escosura, 2013). Broadberry *et al.* (2015b) also find early modern India well above bare bones subsistence, while Broadberry *et al.* (2014) present estimates showing Chinese GDP per capita as the highest in the world during the eleventh century. It is therefore of great interest to establish Japan's position in the Great Divergence.

Table 8 shows that GDP per capita in Japan in 1280 was more than three quarters of the British level. However, following the Black Death of the mid-fourteenth century, which wiped out around a third of the British population immediately and more than half by the mid-fifteenth century, British GDP per capita increased sharply. A similar increase in GDP per capita and in the real wage occurred across much of Europe, where the Black Death also sharply reduced the population. However, the Black Death did not reach Japan and there was accordingly no similar increase in GDP per capita. Hence by 1450, Japanese GDP per capita was only around half the British level. The gap narrowed in the sixteenth and early seventeenth centuries, with Japan at around 57 per cent of the British level in 1650. However, a surge of economic growth in Britain from the middle of the seventeenth century further widened the gap and Japan's per capita GDP was only around a quarter of the British level by the mid-nineteenth century.

The finding that Japanese GDP per capita in 1280 was already below the British level is extremely interesting, since the two countries had similar levels of urbanisation at this time. One way of understanding this is to see two counterbalancing forces at work. First, it seems likely that Japan had a more sophisticated urban culture than Britain (Farris, 2006: 81, 151-153; Rozman, 1973, 13-58; Astill, 2000: 46-49). Second, however, offsetting this first effect was the fact that Britain had an unusually large share of its agricultural sector devoted to high value added livestock farming (Broadberry et al., 2015: 118). Although this did not produce more kilocalories than the minimum required for the population to work and reproduce, it did allow a varied diet, including meat, dairy produce and ale as well as the more basic grain products such as bread and oatmeal. Given the importance of agriculture at the time, it is this effect which dominated, making per capita GDP higher in Britain than in Japan.

2. Japan in the Great Divergence

So far, we have compared Japan only with Britain. However, Britain was a relatively poor part of Europe in the eleventh century and a relatively rich part by the nineteenth century, as can be seen in the estimates of GDP per capita for a sample of European and Asian countries presented in Table 9. Before the Black Death struck in 1348, per capita incomes were substantially higher in Italy and Spain than in England and Holland (Broadberry *et al.*, 2015a; van Zanden and van Leeuwen, 2012; Malanima, 2011; Álvarez-Nogal and Prados de la Escosura, 2013). There then followed a substantial reversal of fortunes between the North Sea Area and Mediterranean Europe, so that by 1800, per capita incomes were substantially higher in Britain and the Netherlands than in Italy and Spain. This "Little Divergence" occurred alongside the "Great Divergence" between Europe and Asia.

The reversal of fortunes within Europe was accompanied by a "Little Divergence" within Asia. In contrast to Japan's persistent growth path which avoided significant growth reversals, Chinese per capita GDP was on a downward trajectory from its high point during the Northern Song dynasty (Broadberry *et al.*, 2014). On these estimates, Japan overtook China only during the eighteenth century. Like China, India experienced declining GDP per capita from the Mughal peak under Akbar, circa 1600 (Broadberry *et al.*, 2015b). Again, Japan only pulled decisively ahead of India during the eighteenth century.

The Great Divergence between Europe and Asia occurred at the same time as the reversals of fortune that were occurring within both Europe and Asia. Like Britain and Holland, Japan was following an upward trajectory as other parts of Europe and Asia experienced stagnation or decline of per capita GDP. However, compared to Britain and Holland, Japan started at a lower level of GDP per capita and grew more slowly than the North Sea Area economies. The transition to modern economic growth thus occurred first in the North Sea Area in the form of the British Industrial Revolution, which then spread fairly quickly to other high income parts of Europe. As Japan was overtaking China and India, however, it was also falling further behind Britain until the Meiji restoration of 1868 and the institutional reforms which ushered in Japan's transition to modern economic growth.

VII. CONCLUSIONS

This paper provides estimates of Japanese GDP per capita for the period 725-1874, constructed from the output side, using methods developed for the estimation of GDP per capita in medieval and early modern Europe, but amended to suit Japanese circumstances and data. Our estimates for the agricultural sector are built up from direct estimates of arable land use and land productivity, and checked against trends in agricultural demand derived from the grain wages of unskilled labourers. Activity in the secondary and tertiary sectors is quantified using techniques developed originally in the context of Europe, but again amended to suit Japanese circumstances and data availability. As well as linking the growth of non-agricultural output to the urbanisation ratio, a role is identified for population density during the proto-industrial phase of the Tokugawa period.

The results suggest that Japanese GDP per capita grew at an annual rate of 0.04 per cent between 725 and 1874. The upward trend was persistent, if not consistent, as in Holland and Britain. A comparison with Britain and other European countries and also with other Asian countries can be used to establish the main contours of the Great Divergence. Just as Britain caught up with and overtook other European countries in a process known as the European Little Divergence, so Japan caught up with and overtook China and India in an Asian Little Divergence. However, since Japan started at a lower level than Britain and grew more slowly until the Meiji Restoration, the Great Divergence occurred as the most dynamic parts of Asia fell behind the most dynamic parts of Europe.

TABLE 1: Total population of Japan, 725-1874

A. Level in millions

Year	Population	Year	Population
725	4.5	1500	12.3
800	5.5	1550	14.5
900	6.4	1600	17.0
1000	6.0	1650	21.8
1150	6.3	1700	28.1
1200	6.4	1720	31.0
1250	6.5	1730	31.2
1280	7.0	1750	30.9
1300	7.3	1800	30.6
1350	8.3	1850	32.5
1400	9.3	1874	34.8
1450	10.5		

B. Annual growth rates

Years	% per annum
725-900	0.20
900-1250	0.00
1250-1450	0.24
1450-1600	0.32
1600-1730	0.47
1730-1800	-0.03
1800-1874	0.18
725-1874	0.18
1600-1874	0.26

Sources and notes: Period 725-1600: years 725, 900 from Kito (2000); years 1000, 1250, 1450, 1600, from Saito's estimates quoted in Farris (2006: 99, 169-170), with the other years 800, 1150, 1200, 1280, 1300, 1350, 1400, 1500 and 1550 derived by linear interpolation. Period 1600-1874: Years 1720, 1730, 1750, 1800, 1850, derived from Kito (1996), adjusted to 1874 level from Fukao *et al.* (2015), with years 1650 and 1700 derived by linear interpolation. Year 1874 includes Hokkaido and Okinawa prefecture.

TABLE 2: Japanese agricultural production, 725-1874

A. Levels

	Arable land (1000 *cho*)	Land productivity (Tokugawa *koku*/*cho*)	Agricultural production (1000 *koku*)	Agricultural production per head (*koku*)
725	725	8.59	6,222	1.38
900	1,125	7.99	8,986	1.39
1150	1,061	7.82	8,300	1.32
1280	961	10.71	10,290	1.47
1450	1,188	12.99	15,434	1.47
1600	2,488	12.31	30,173	1.77
1650	2,782	13.32	37,256	1.71
1700	3,110	14.97	47,592	1.70
1720	3,252	14.98	49,882	1.61
1730	3,325	14.98	51,073	1.64
1750	3,477	15.00	53,550	1.73
1800	3,889	15.03	60,308	1.97
1850	4,349	15.74	69,826	2.15
1874	4,594	16.78	77,103	2.21

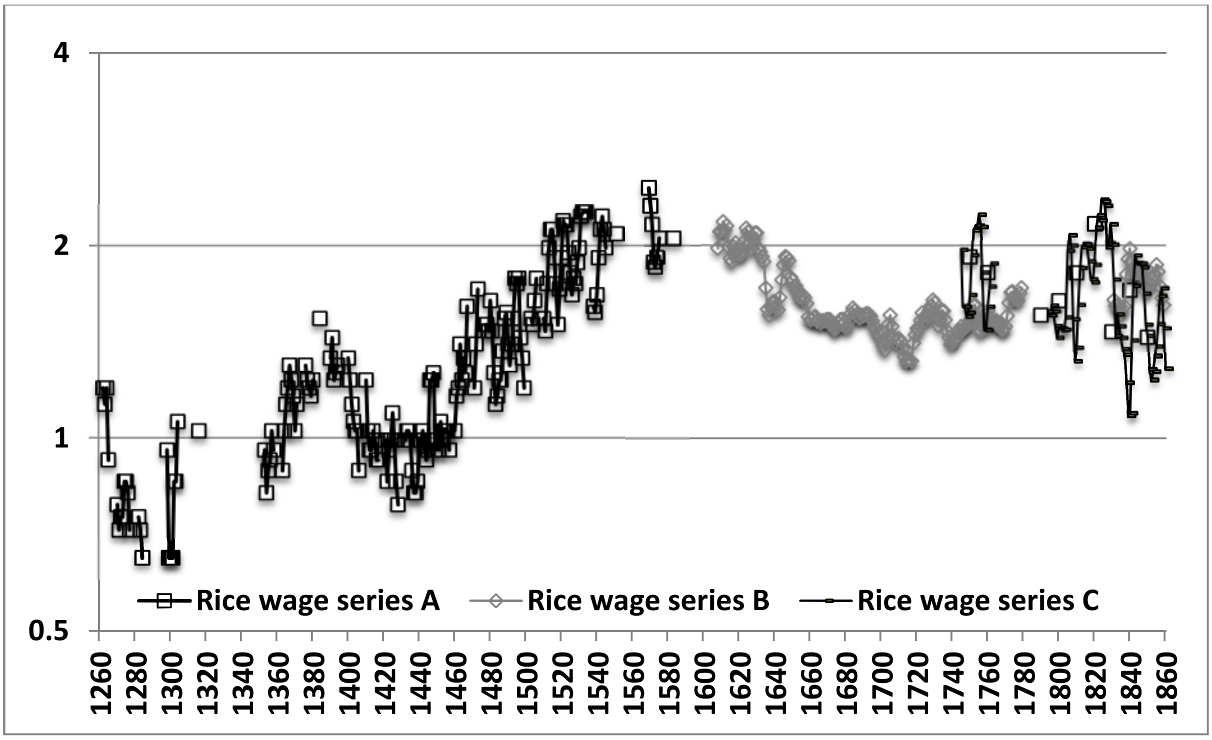
B. Annual growth rates

	Arable land	Land productivity	Agricultural production	Agricultural production per head
725-1150	0.09	-0.02	0.07	-0.01
1150-1280	-0.08	0.24	0.17	0.08
1280-1450	0.13	0.11	0.24	0.00
1450-1600	0.49	-0.05	0.45	0.13
1600-1730	0.22	0.18	0.41	-0.06
1730-1800	0.22	0.01	0.24	0.26
1800-1874	0.23	0.11	0.33	0.16
725-1874	0.16	0.06	0.22	0.04
1600-1874	0.22	0.12	0.34	0.08

Sources and notes: (1) Ancient and medieval period: output derived from data on arable land and land productivity. Years 725-1150 derived from Takashima (2012). Separate calculations were made for rice paddies and dry fields. Years 1280 and 1450 from Farris (2006). As described in the text, an adjustment factor was applied to the land area in the period 725-1450 to take account of abandoned and fallowed land. The same adjustment factor as in the Tokugawa period was applied to the land yields during the period 725-1150, to bring the agricultural production into line with the output for later years. All these figures were computed in Nara units and converted into Tokugawa units assuming 1 Nara *cho* =1.088 Tokugawa *cho* and 1 Tokugawa *koku* = 2.5 Nara *koku*.
(2) Tokugawa period: land productivity derived from data on arable land harvested output. Output obtained from Fukao *et al.* (2015). The approach of Nakamura (1968) has been applied at the level of 14 regions. An adjustment factor was applied to output of each region for consistency with Fukao *et al.* (2015) data for 1874. Similarly, an adjustment factor of 1.1 was applied to the land data for consistency with the data of Umemura *et al.* (1966) for 1874. All these figures were computed in

Tokugawa units: 1 Tokugawa *cho* = 10 Tokugawa *tan* = 2.4506 acres; 1 Tokugawa *koku* = 150 kg. Year 1874 includes Hokkaido and Okinawa prefecture.

FIGURE 1: Japanese unskilled rice wage, 1261-1860 (kg per day, 3-year moving average, log scale)



Sources: series A constructed using information reported in Momose (1959), Rekihaku (2009), and KKB (1962), Endo (1956) and Tanaka (2007). Series B generated using information in Miyamoto, 1963), Iwahashi (1981) and (Kimura 1987). Series C derived from Mitsui (Mitsui Bunko 1981). See text for details.

TABLE 3: Japanese unskilled rice wage and agricultural demand, 1260-1860

	Unskilled rice wage (kg/day)	Agricultural demand per head (1850=100)
1260/69	1.0	79.4
1300/09	0.8	73.5
1350/59	0.9	76.5
1400/49	1.0	79.4
1450/59	1.0	79.4
1500/09	1.6	97.1
1550/59	1.9	105.9
1600/09	2.0	108.8
1650/59	1.7	100.0
1750/59	1.5	94.1
1850/59	1.7	100.0

Sources: Unskilled rice wage: Bassino *et al.* (2010), Bassino and Ma (2005). Agricultural demand per head derived from the unskilled rice wage with an assumed income elasticity of demand of 0.5.

TABLE 4: Urban population in Japan, 725-1874

	Urban population (1,000)	Total population (millions)	Urban share (%)
725	124	4.5	2.7
800	120	5.5	2.2
900	120	6.4	1.9
1000	120	6.0	2.0
1150	120	6.3	1.9
1200	213	6.4	3.3
1250	210	6.5	3.2
1280	208	7.0	3.0
1300	207	7.3	2.8
1350	121	8.3	1.5
1400	229	9.3	2.5
1450	326	10.5	3.1
1500	435	12.3	3.5
1550	643	14.5	4.4
1600	1,032	17.0	6.1
1650	2,954	21.8	13.5
1700	3,380	28.1	12.0
1720	3,615	31.0	11.6
1730	3,772	31.2	12.1
1750	4,129	30.9	13.4
1800	4,055	30.6	13.3
1850	4,028	32.5	12.4
1874	3,654	34.8	10.5

Sources and notes: Urban population includes persons living in settlements of at least 10,000. Year 1874 includes Hokkaido and Okinawa prefecture. Data derived from Farris (2006; 2009), Harada (1942), Ishii and Omiwa (1989), Kito (1996, 2000), Nimusho Chirikyoku (1875), Ono (1934), Rikugun Sanbo Honbu (1878-1880), Saito (1984), Sasaki (1975), Takao *et al.* (1968) and histories compiled by local governments in Japan.

TABLE 5: OLS regressions for the determinants of the shares of the secondary and tertiary sectors in aggregate GDP, 1874-1909

	Secondary sector	Tertiary sector
Population density	0.434	0.454
	(5.83)	(7.74)
Urbanisation rate	0.098	0.331
	(1.79)	(7.84)
Prefectural dummy	1.052	0.579
(modernised = 1)	(5.21)	(3.72)
Year 1890 dummy	0.474	0.287
	(5.38)	(4.23)
Year 1909 dummy	0.827	0.310
	(8.69)	(4.23)
Constant	-1.741	-0.173
	(-10.95)	(-1.41)
Adjusted R^2	0.741	0.826

Sources and notes: Saito and Takashima (2014). For the secondary sector, the dependent variable is the proportion of secondary sector output in the sum of primary and secondary sector output, converted into a logit value. For the tertiary sector, the dependent variable is the proportion of tertiary sector output in the sum of primary and tertiary sector output, converted into a logit value. The regressions are run on a cross-sectional dataset which includes prefectural output and population figures for the three benchmark years, 1874, 1890 and 1909.

TABLE 6: Japanese GDP by main output categories, 725-1874 (1,000 *koku*)

A. Levels of GDP

	Primary output	Secondary output	Tertiary output	GDP
725	7,376	912	1,909	10,196
900	10,652	1,266	2,417	14,335
1150	9,839	1,172	2,249	13,260
1280	12,198	1,519	3,241	16,959
1450	18,296	2,289	4,934	25,519
1600	30,173	4,044	10,263	44,481
1650	37,256	5,445	16,970	59,671
1700	47,592	6,866	20,745	75,202
1720	49,882	7,556	22,176	79,614
1730	51,073	7,789	23,115	81,976
1750	53,550	8,233	25,123	86,905
1800	60,308	9,307	28,614	98,228
1850	69,826	11,002	33,281	114,109
1874	77,103	14,343	40,093	131,539

B. Growth rates of GDP

	Primary output	Secondary output	Tertiary output
725-1150	0.07	0.06	0.04
1150-1280	0.17	0.20	0.28
1280-1450	0.24	0.24	0.25
1450-1600	0.33	0.38	0.49
1600-1730	0.41	0.51	0.63
1730-1800	0.24	0.25	0.31
1800-1874	0.33	0.59	0.46
725-1874	0.20	0.24	0.27
1600-1874	0.34	0.46	0.50

Sources: Primary output is derived from agricultural output in Table 2, adjusted to include forestry and fishing output in the period 725-1450. The ratio of forestry and fishing to agriculture during this period is assumed to be 18.5 per cent, the same as in 1874. Secondary and tertiary output before 1874 are derived using data on the urbanisation rate and population density together with the regression coefficient from Table 5, as described in the text. Outputs of all sectors and GDP for 1600-1874 are derived from Fukao *et al.* (2015).

TABLE 7: Japanese GDP per capita, 725-1874

A. Level of GDP per capita

	GDP (*koku*)	Population (1,000)	GDP per capita (*koku*)	GDP per capita (1874=100)
725	10,196	4.5	2.26	59.9
900	14,335	6.4	2.23	58.9
1150	13,260	6.3	2.10	55.7
1280	16,959	7.0	2.42	64.2
1450	25,519	10.5	2.43	64.4
1600	44,481	17.0	2.62	69.3
1650	59,671	21.8	2.73	72.3
1700	75,202	28.1	2.68	71.0
1720	79,614	31.0	2.57	67.9
1730	81,976	31.2	2.63	69.7
1750	86,905	30.9	2.81	74.5
1800	98,228	30.6	3.21	85.1
1850	114,109	32.5	3.51	93.0
1874	131,539	34.8	3.78	100.0

B. Annual growth rates of per capita GDP

	Growth rate (%)
725-1150	-0.02
1150-1280	0.11
1280-1450	0.00
1450-1600	0.05
1600-1730	0.00
1730-1800	0.29
1800-1874	0.22
725-1874	0.04
1600-1874	0.13

Sources: GDP from Table 6, population from Table 1.

TABLE 8: An Anglo-Japanese comparison of per capita GDP, 725-1874

	Japan p.c. GDP ($1990)	GB p.c. GDP ($1990)	Japan/GB p.c. GDP (GB=100)
725	515		
900	507		
1150	479		
1280	552	679	81.3
1450	554	1,055	52.5
1600	596	1,123	53.1
1650	622	1,100	56.6
1700	610	1,563	39.0
1720	584	1,605	36.4
1730	599	1,641	36.5
1750	640	1,710	37.5
1800	732	2,080	35.2
1850	800	2,997	26.7
1874	860	4,191	20.5

Sources: Japanese GDP per capita from Table 7, based on Saito and Takashima (2014) and benchmarked at 1874 from Fukao *et al.* (2015) using Maddison (2010). GB GDP per capita from Broadberry *et al.* (2015a), benchmarked at 1850 using Maddison (2010), but adjusted from the territory of the United Kingdom to a Great Britain basis.

TABLE 9: GDP per capita levels in Europe and Asia, 725-1850 (1990 international dollars)

	England/ GB	Holland/ NL	Italy	Spain	Japan	China	India
725					515		
900					507		
980						1,247	
1020						1,518	
1050						1,458	
1086	754					1,204	
1120						1,063	
1150					479		
1280	679			957	552		
1300	755		1,482	957			
1348	777	876	1,376	1,030			
1400	1,090	1,245	1,601	885		960	
1450	1,055	1,432	1,668	889	554	983	
1500	1,114	1,483	1,403	889		1,127	
1570	1,143	1,783	1,337	990		968	
1600	1,123	2,372	1,244	944	596	977	682
1650	1,110	2,171	1,271	820	622		638
1700	1,563	2,403	1,350	880	610	841	622
1750	1,710	2,440	1,403	910	640	685	573
1800	2,080	1,752	1,244	962	732	597	569
1850	2,997	2,397	1,350	1,144	800	594	556

Sources: GB: Broadberry *et al.* (2015a); Broadberry and van Leeuwen (2011); Walker (2014); Holland/Netherlands: van Zanden and van Leuwen (2012); Italy: Malanima (2011); Spain: Álvarez-Nogal and Prados de la Escosura (2013); Japan: Table 8; China: Broadberry *et al.* (2014); India: Broadberry *et al.* (2015b).

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