Simulating early modern economic growth[1]

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Abstract

The paper discusses different attempts to measure economic growth in Europe before the Industrial Revolution. It is argued that the figures published by Angus Maddison probably overestimate growth between 1000 and 1820. Next, a method for simulating long-term patterns of growth is presented, and the results of this experiment, i.e. annual time series for the most important European countries, are discussed. It is concluded that growth was very slow between c 1450 and c 1800 – with the notable exceptions of England and the Netherlands – and that between c 1000 and 1450 GDP per capita increased probably faster than in the centuries before the Industrial Revolution.

1. Introduction.

The question how much growth there was – in Europe and elsewhere – in the centuries before the Industrial Revolution has become the subject of debate since the early 1990s. The debate began with a number of papers by Graeme Snooks (1990; 1994) about the long term evolution of the English economy, in which he argued that its GDP per capita had increased almost eightfold between the Domesday book of 1086 and 1800. In fact, in his view growth before the Industrial Revolution had been almost as rapid as after 1780. Next followed a series of papers – brought together by Angus Maddison and Herman van der Wee at the XIth World Economic History Congress in Milan in 1994 – which addressed the same issue for a number of European countries. Their conclusions were in general much more conservative; growth between 1500 and 1800 was substantially slower – if there was growth at all – than after 1800 (Blomme and Van der Wee 1994; Malanima 1994; Yun 1994; Van Zanden 1993). The outcome of this survey was that, apart from one or two growth spurts such as during Dutch Golden Age, per capita growth had been slow (Belgium) or non-existent (Italy, Spain). In an attempt to synthesize these results I concluded that on average GDP per capita in Western Europe may at best have increased by about 20% between ca 1500 and ca 1820; because labour input per capita probably increased substantially, labour productivity may have remained the same (Van Zanden 2001).

In his recent synthesis of thousand years of economic growth in the world economy, Angus Maddison (2001) came to different conclusions of the research carried out in the 1990s. In 'The world economy, a millennial perspective' he presented his own set of estimates of the economic growth in Europe between 1000 and 1820 (and

beyond): GDP per capita in Western Europe trebled between 1000 and 1820, the result of a near doubling of income levels between 1000 and 1500 and another 56% increase during the three centuries before the Industrial Revolution. Giovanni Federico (2002) in his detailed review of Maddison's 2001 book already pointed at a number of weaknesses in his estimates. They result, for example, in medieval levels of GDP per capita that are unrealistically low (only just above subsistence levels), and growth rates between 1500 and 1800 seem to be inconsistent with independent estimates of the growth of labour productivity in agriculture.

In this paper I will address the problem of early modern economic growth in a number of ways. First I will analyse the (changing) relationship between growth and structural transformation, leading to the conclusion that the Maddison (and by implication the Snooks) estimates are unrealistic. Next I will develop a new approach to estimate annual time series to chart the long-term development of European GDP. This approach is based upon the available benchmark estimates of GDP per capita and makes use of the data of the development of real wages and the structural transformation of the European economy before 1800. Finally I will discuss one of the problems faced by Maddison when he made his set of estimates of European GDP, his comparison with China. There is obviously a link with the debate about the relative performance and position of the Chinese and the European economies in the 18th century that was started by Ken Pomeranz (2000) and Roy Bin Wong (1997). Maddison's interpretation is that, whereas at about 1000 China had a higher GDP per capita than Europe, eight centuries later the order was radically reversed and GDP per capita in China was about half the European level (and about one-third of the British level). Since he argues that GDP per capita in China did not decline, he *has to assume* that growth in Europe was quite fast. This, in my view, helps to explain that Maddison tends to overestimate European

growth before 1820. To test the alternative interpretation of European growth presented in this paper, I will also address this problem, and therefore have to go into the debate about relative levels of GDP per capita before the Industrial Revolution. But we will first turn our attention to Europe.

2. Early modern growth and structural change

The relationship between economic growth and structural transformation – i.e. the relative decline of agriculture and the growth of industry and services as sources of employment and output – has been a familiar theme of inquiry since the seminal contributions by Colin Clark (1940) and Simon Kuznets (1966). They found patterns of change in 19th century industrializing countries and in 20th century developing nations that were quite similar. Next, Chenery and Syrquin (1975) modeled the relationships between levels of structural change and (other) macro-economic variables in a systematic way, and also distinguished different patterns of change, related to the size of countries and their specialization (oriented towards exports of primary commodities or towards industrial exports). The question, however, if these patterns change over time has not received much attention.

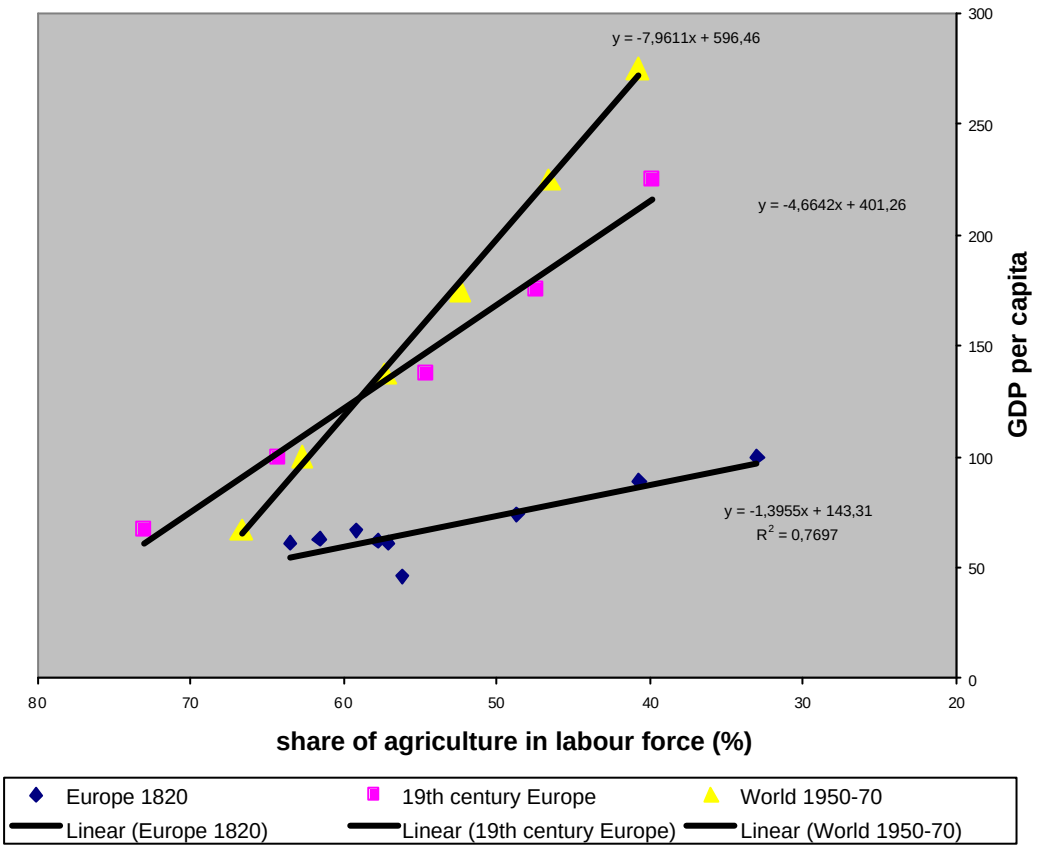
Nick Crafts (1985) applied this methodology to 19th century Europe in order to understand the special features of British industrialization. He found that Britain was exceptional because the level of structural transformation was much higher than was expected on the basis of the stylized 19th century pattern of European industrialization (the 'European norm'). On the basis of this comparison he identified as the main features of the British Industrial Revolution 'slow income growth and rapid structural

change', i.e. the share agriculture in employment and output declined much more rapidly than was expected on the basis of the 19th century European norm (Crafts, 1985, 61). In 1800, for example, GDP per capita was (according to Crafts) 427 dollars of 1970, which according to the European norm would be consistent a share of 62.3% of agriculture in the labour force, whereas this was in fact only 39.9% (Crafts, 1985, 62).

Crafts saw this pattern of fast structural transformation combined with slow growth as part of the British exceptionally in this period. However, similar experiments with data about the development of the Dutch economy in the 19th century by Ary Burger (1996) and by Van Zanden and Van Riel (2004) identified the same 'exceptionality'. The Dutch economy at the beginning of the 19th century too had a much smaller agriculture than was consistent with the European norm. Burger (1996) for example found that in 1810 the actual share of agriculture in GDP was 31%, whereas the European norm was 45%, a gap similar to that found by Crafts. Only after 1870 did this gap disappear and did the Netherlands converge to the European pattern.

It is probably no coincidence that these 'exceptional' patterns are found in these two countries. Both are examples of successful early modern economic development, and had the highest levels of GDP per capita at the start of the 19th century. The price that was paid for this precocious growth was an even more radical transformation of the structure of the economy. This suggests that the relationship between GDP growth and structural change before about 1820 was a different one than in the centuries after the Industrial Revolution.

Figure 1 The relationship between GDP per capita and the share of agriculture in the labour force (GDP per capita of Britian in 1820=100)



This idea can be tested easily by comparing different patterns of structural change. Figure 1 combines the two 'norms' used by Crafts – the European 19th century norm and the world 1950-1970 norm (derived from Chenery and Syrquin (1975)) - with the actual observations for Europe at the beginning of the 19th century.[2] The differences are immediately clear. The 1820 curve is much less steep, showing that a decline of the share of the labour force in agriculture before 1820 is consistent with a much smaller increase in GDP per capita. Whereas a halving of the labour force in agriculture (from 66 to 33%) before 1820 correlates with an increase of GDP per capita of about 90%,

[2] GDP levels for 1820 are derived from Maddison 1995, which I prefer to the 1820-estimates of Maddison 2001 because in the latter dataset GDP per capita of the Netherlands in 1820 is higher than in the UK, which I find unlikely; shares of agriculture in total employment from Allen 2000a.

during the 19th century such a change would be consistent with an increase of 165%; in 1950-1970 the growth of GDP would be even larger: 369%.[3]

This shifting relationship between structural change and per capita growth is a significant finding. It is beyond the scope of this paper, however, to discuss and analyze the causes for the shift. Here it is used – in combination with a set of estimates of the long term evolution of the structure of the labour force in European countries between 1500 and 1800 - to assess the plausibility of the estimates made by Maddison and by others. Therefore I compare three sets of estimates of GDP per capita: the 1820 sample of 9 European countries (from Maddison 1995), the Maddison estimates for the same countries in 1500-1820 (Maddison 2001), and finally my own set of estimates, published in 2001 (Van Zanden 2001). The latter data set is a synthesis of the work of a number of economic historians (Malanima, Blomme and Van der Wee, Yun, and Van Zanden), to which I added estimates for Poland based on the work of Topolski and Wyczanski (1982) and estimates of English GDP based on the work of Overton and Campbell (1997). All estimates are standardized by setting Great Britain in 1820 at 100. The estimated relationships between GDP per capita and share of agriculture (Agr) are:[4]

- for the 1820 point estimates: 143 – 1.40 * Agr. (R^2 = .770)

  (15.53) (.288)

- for the Maddison 1500-1820 dataset: 173 – 1.95 * Agr (R^2 = .703)

  (18.31) (.294)

- for the Van Zanden 1500-1820 dataset: 136 – 1.24 * Agr (R^2 = .573)

  (10.80) (.151)

(standard errors)

[3] The results are slightly different when not a linear nut a logarithmic trend is used, but the picture obviously remains the same.

[4] Structure labour force from Allen 2000a; Again, estimating logarithmic trends leads to the same results; I prefer the linear trends because their transparency and the ease with which the effect of a halving of the share of the labour force in agriculture on GDP per capita can be estimated.

It is evident that Maddison assumes a relationship between structural change and GDP growth that is steeper than is implied by the 1820 cross section; his coefficient of 1.95 still falls within the confidence interval of two times the standard error of the coefficient of the 1820 cross section, but only just (1.95 < 1.968). The coefficient of the Van Zanden dataset is much more similar to the 1820 cross section, and even somewhat lower, which is perhaps what may be expected given the fact that this measure of the relationship between growth and structural change appears to be moving up in time (Figure 1). According to the Maddison estimates a decline of the share of agriculture in labour force from 66 to 33% is consistent with a 144% increase in GDP per head, against 90% in the 1820 cross section and 77% according to the Van Zanden data. Clearly, the Van Zanden dataset is much closer to the 1820 cross section.

Figure 2 The relationship between GDP per capita and the share of agriculture in the labour force, Europe 1500-1800

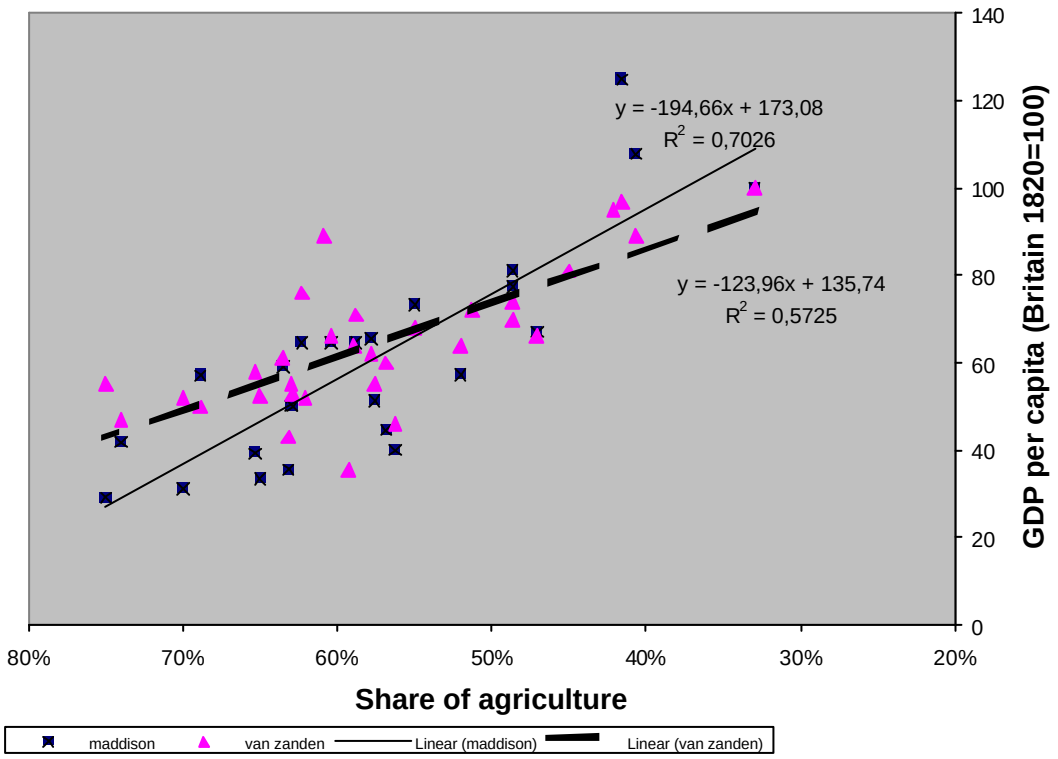


Figure 2 presents the two datasets that are under review. The overall impression of the Maddison estimates is that they overestimate growth. This can also be illustrated on the basis of a comparison with the different country studies. Yun (1994) estimated that GDP per capita in Spain (in fact in Castile) at the beginning of the 19th century was not higher and probably somewhat lower than in the final quarter of the 16th century. Maddison's estimates for Spain are a respectable growth of GDP per capita of more than 50% between 1500 and 1820 (and still 18% between 1600 and 1820).[5] Similar problems arise when Malanima's estimates for Northern Italy or my estimates (Van Zanden 1987; 1993, 1994) for the Netherlands are compared with the Maddison 2001 series. Whereas I concluded that GDP per capita in the Netherlands increased by at most 50% between 1500 and 1820, Maddison assumes that it increased by in total 141% in the same period; almost all the divergence is due to his different appreciation of the period before 1580. Moreover, after publishing the 2001 paper I have reconstructed the national accounts of Holland at the beginning of the 16th century, an experiment which again points to the limited degree of growth between 1500 and 1800; the best estimate I could make to Holland is that GDP per capita increased by 34 to 57%; growth outside Holland may have been more rapid, however (Van Zanden 2002).

The United Kingdom estimates are a different story. Maddison rejects the Snooks estimates that have been severely criticized by a number of scholars. Perhaps the most devastating criticism was by Bruce Campbell, who on the basis of a detailed reconstruction of agricultural (arable) output in the Middle Ages (in 1086 and 1300) showed that Snooks' estimates are much too low. GDP per capita according Snooks would have been lower than the agricultural output necessary to feed the English population (Campbell, 2000, 406-10). In a previous study I have used the Overton and

[5] In a recent synthesis of the work on Spanish economic growth before the Industrial Revolution, Carreras (2003) came to the same conclusion.

Campbell (1997) estimates of the development of agricultural output between 1086 and 1871 to extend the Crafts series of GDP per capita (starting in 1688) back in time (Van Zanden, 2001, 74-5). Maddison, after discussing the different interpretations of growth before 1700, assumes however that 'the Crafts-Harley rate of per capita income for 1700-1801 was valid for 1500-1700'(Maddison, 2001, 246).

For Eastern Europe Maddison assumes that GDP per capita increased by 37% between 1500 and 1800. In my dataset I have only included Poland, and used the series of estimates by Topolski and Wyczanski (1982) showing that agricultural output per capita fell by one third between 1570 and 1800 (and made a number of additional assumptions about what happened to non-agricultural output); the end result was long term stagnation in GDP per capita in Poland. Finally, new research by Olle Krantz (2004) on the long-term evolution of Swedish GDP in the early modern period also seems to corroborate the more pessimistic interpretation. He concludes his detailed reconstruction of GDP in 1571 as follows: "Despite the margins of uncertainty, it could be inferred that GDP per capita was about the same in the 16th century as around 1800. Thus, Sweden, like other peripheral countries was characterised by stagnation during the period between the 16th and the 19th centuries." (Krantz, 2004). This again contradicts the Maddison (2001) estimates showing that GDP per capita in Sweden increased by 45% between 1600 and 1820 (and 73% between 1500 and 1820).

Summing up, there are two reasons for not using the Maddison estimates of early modern growth in Europe: they appear to be inconsistent with the relationship between growth and structural change that seems to have existed before the 19th century, and they are not consistent with much of the recent work done in the field. For these reasons I prefer the Van Zanden dataset, which is based on the recent research reviewed here and does not have the weaknesses of the Maddison estimates.

3. Simulating growth before 1800

Figure 2 shows that there existed a relationship between structural change and economic growth in early modern Europe, but also that the spread around the estimated trend was quite large; an estimated R^2 of .57 or slightly higher (.60) when the relationship is estimated logarithmically is not very impressive. One way to improve the fit of the model is to incorporate other indices of the level of development of the economy into the 'model'. Thanks to the research by Robert Allen (2001) a database is available with internationally comparable estimates of real wages for about a dozen European cities in the early modern period. Most data relate to the capital cities (or another very important city) of the countries under study. For a few cities (London, Florence) the real wage series go back to the early 14th century, most series begin in the 15th or the 16th century. It is obvious that there exists a link between the real wage and GDP per capita, although this relationship may change over time (with changes in the distribution of income and/or the structure of the economy) and may be different in different parts of Europe (Van Zanden 2002).

The eclectic approach chosen here is to explain the variation in GDP per capita in Europe between 1500 and 1800 as measured by the Van Zanden dataset[6] by two independent variables, real wages of unskilled labourers (in capital cities) and the level

[6] The dataset has been modified in the following ways: 1/ Spain in 1500 has been included following Carreras 2003, and the other estimates for Spain have been adapted consistent with Carreras review of evidence; 2/ the 1820 benchmark from Maddison 2001 is projected backwards to 1800 using the average rates of growth in the 1700-1820 period (this leads to marginal corrections in the relative ranking of countries, however; 3/ the Maddison 2001 UK estimates have been transformed into estimates for England and Wales on the basis of Maddison 2001: 247.; the dataset includes two estimates for the period before 1500: Italy in 1450 and England in 1380; the panel data analysis is therefore unbalanced. Note also that almost all estimates from the Van Zanden dataset are based on the output approach, and therefore independent from the real wages used in the regression; the exception is the series of estimates by Malanima 1994, who does use real wage estimates in combination with output indicators.

of structural transformation of the economies involved. The intuition is that these two sets of data represent two parts of the economy: real wages obviously represent labour income, but are also linked to the productivity of labour in agriculture (Allen 2000a). The share of agriculture in the labour force is an index of structural change, and is inversely linked to industrialization and urbanization. I have shown elsewhere (Van Zanden 1995) that in the early modern period there existed a strong link between structural transformation of the economy and income inequality; urbanization and industrialization resulted, in particular in the case of Holland, in a strong increase of capital income concentrated in the cities. The assumption is, therefore, that the share of the labour force in agriculture is an invers measure of non-wage income.[7] One would, therefore, expect a positive link between real wages and per capita GDP, and a negative relationship between the share of agriculture in the labour force and per capita GDP.

Table 1 gives the results of a panel data regression analysis to explain the log of GDP per capita, with the independent variables Lshare, the log of the share of agriculture in the labour force, Lrealwages, the log of real wages, and G2 …. G6 being dummies for countries other than England (G1 is England which is the standard). The results are rather satisfactory: the variables have the expected signs (positive for real wages, negative for the share of agriculture), the country dummies have a much smaller impact, with the exception of that of Italy which indicates that Italian GDP per capita is significantly higher than can be expected on the basis of the rest of the model, and the overall fit is quite good (although the number of observations is rather limited).[8]

[7] For the Netherlands the correlation between share in agriculture and income inequality (Gini coefficient of income distribution from Van Zanden 1995) was very strong: R^2 = . 965 (but this is based on 5 observations only).

[8] An alternative model with time dummies is presented in the appendix.

Table 1 Explanation of the variation in GDP per capita in Europe 1500-1800 (Van Zanden dataset)

	Coefficient	Std. Error	t-value	t-prob
Lshare	- .857	.121	- 7.10	0.000
Lreal wage	.219	.081	2.71	0.012
Constant	3.224	.177	18.3	0.000
G2	.189	.045	4.17	0.000
G3	-.100	.055	-1.84	0.078
G4	.294	.082	3.60	0.001
G5	- .092	.054	-1.72	0.097
G6	-.127	.109	-1.17	0.252

G2 = the Netherlands

G3 = Belgium

G4 = Italy

G5 = Spain

G6 = Poland

R^2 0.846

RSS 0.440 TSS 2.86

no. of observations 33 no. of parameters 8

The next step is to use this model to estimate annual series of the long-term evolution of GDP per capita in a number of European countries on the basis of the following datasets:

- The annual estimates of real wages of labourers in the capital cities of the countries involved;[9]
- The benchmark estimates of the share of agriculture in the labour force for 1300 (England and Italy only), 1400, 1500, 1600, 1700, 1750 and 1800 from Allen (2000a) were transformed into annual estimates of this share by simple interpolation; in a few cases, where the De Vries (1984, 39) estimates of the development of the urbanization ratio between 1500 and 1800 indicate that this process was relatively discontinuous between those years (much faster in the first half of the century than in the second half, or vice versa) I adapted the intrapolation accordingly.

This makes it possible to use the equation of table 1 to estimate GDP per capita on an annual basis. The annual changes of GDP should, however not be taken too seriously;[10] we are primarily interested in the long-term patterns of economic change, and the annual fluctuations are to a large extent a by-product of the method used here. In the discussion of the results of the model I will therefore concentrate on long-term changes.[11]

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[9] Austria: Vienna; England: London; Netherlands: Amsterdam; Germany: Augsburg (Strasbourg for a few years); Belgium: Antwerp; Italy: Florence (and Milan); Spain: Madrid (Seville for a few years); Poland: Cracow.

[10] Although there may be a grain of truth in them, because they are caused by annual fluctuations in real wages, which reflect (given the rigid nature of nominal wages) price fluctuations, which in their turn are caused by good and bad harvests; because European GDP is dominated by the agricultural sector, these variations in the yield of the harvest may have a large impact on GDP per capita.

[11] For the countries covered by the Van Zanden dataset, the country-dummies of table 1 have also been used. For the countries outside the dataset (Germany, France, Austria) but for which we do have estimates of the other variables, GDP per capita was also estimated, but in those cases without country-dummies.

Figure 3 GDP per capita of England, Italy, the Netherlands and Poland, 1500-1800 (England & Wales in 1800=100)

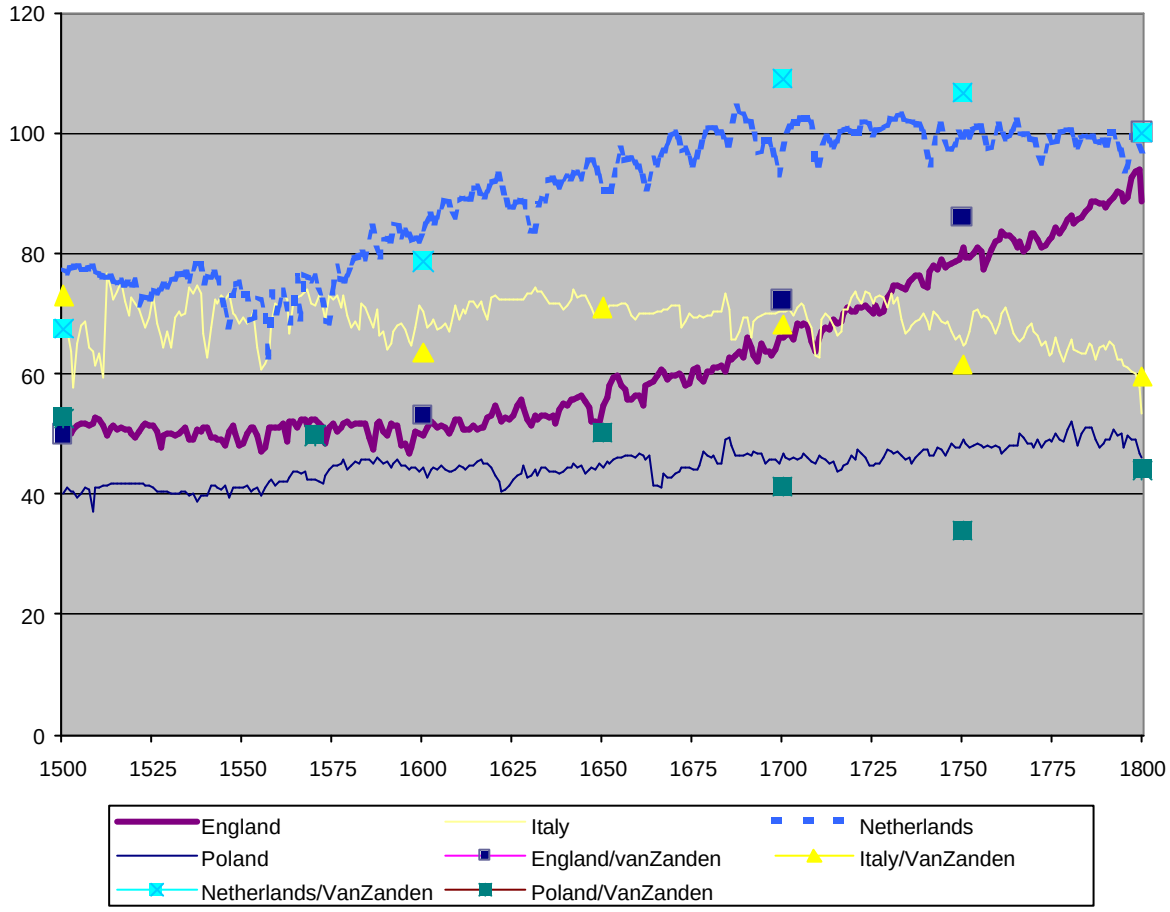


Figure 3 presents the estimates of the perhaps most interesting countries for the 1500-1800 period; the continuous series are the result of the application of the model, whereas the dots in Figure 3 are the original point estimates on which the model is based.

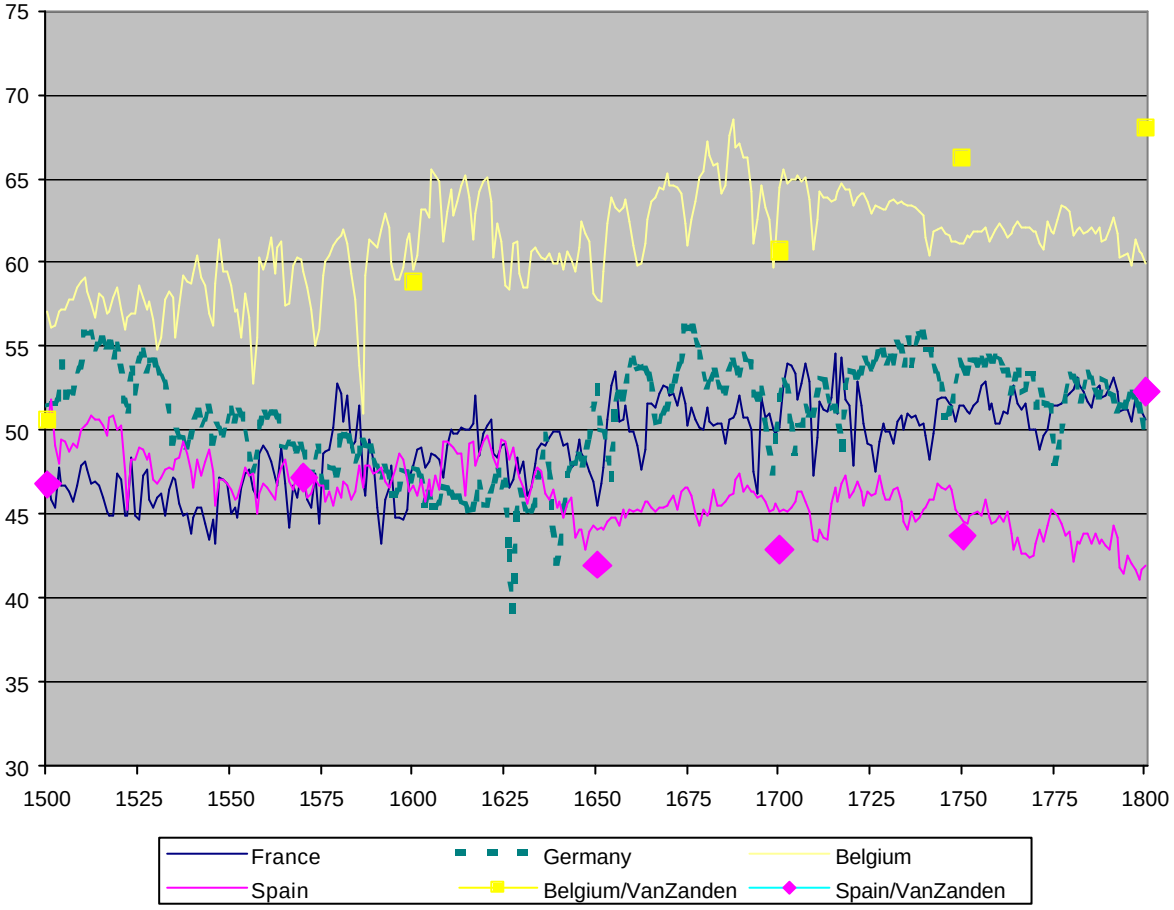
According to these simulations, Poland in the long run grew only very slightly during these three centuries; the growth that occurred was completely due to the fact that Allen assumes that some structural transformation of the economy did take place in the long run (resulting in a decline of the share of agriculture in the labour force from 75% in 1500 to 56% in 1800). The original point estimates were more pessimistic: these

implied that GDP per capita actually declined by 10 to 20 percent during these three centuries.

Both approaches give very similar results for (northern) Italy, which stagnates on a relatively high level, only to show some decline during the 18th century (as a result of falling real wage levels). The Dutch pattern is one of a relatively high level in 1500, followed by slow but persistent decline during the first three quarter of the 16th century Between the 1580s and 1670s – during its 'Golden Age' - Dutch GDP per capita grows rapidly; then follows long-term stability at a high level. The pattern is consistent with the available literature (De Vries and Van der Woude 1997), but it is significant that the simulations do not completely capture the supposedly very strong growth of Dutch GDP during the first stage of growth between 1580 and 1650 (after 1650 the two series of estimates converge again).

Perhaps the most interesting pattern can be found in England. Both sets of estimates agree that stability at a not impressively high level between 1500 and the 1620s is followed by a 'take off' into 'sustained economic growth' from the 1620s and 1630s onwards, a process which continued until the end of the period (and, of course, beyond). Between the 1620s and 1800 GDP per capita almost doubles, which is even more impressive than the growth of Dutch GDP per capita during the 17th century, which was 'only' about 40% (when 1500 is taken as starting point). Again, this is consistent with the available estimates and the most recent literature. Wrigley (2000) in a recent survey dated the start of the 'divergence' of the English economy in the 17th century, without being able to be more specific about the timing of the process (see also Allen 2001 and 2003).

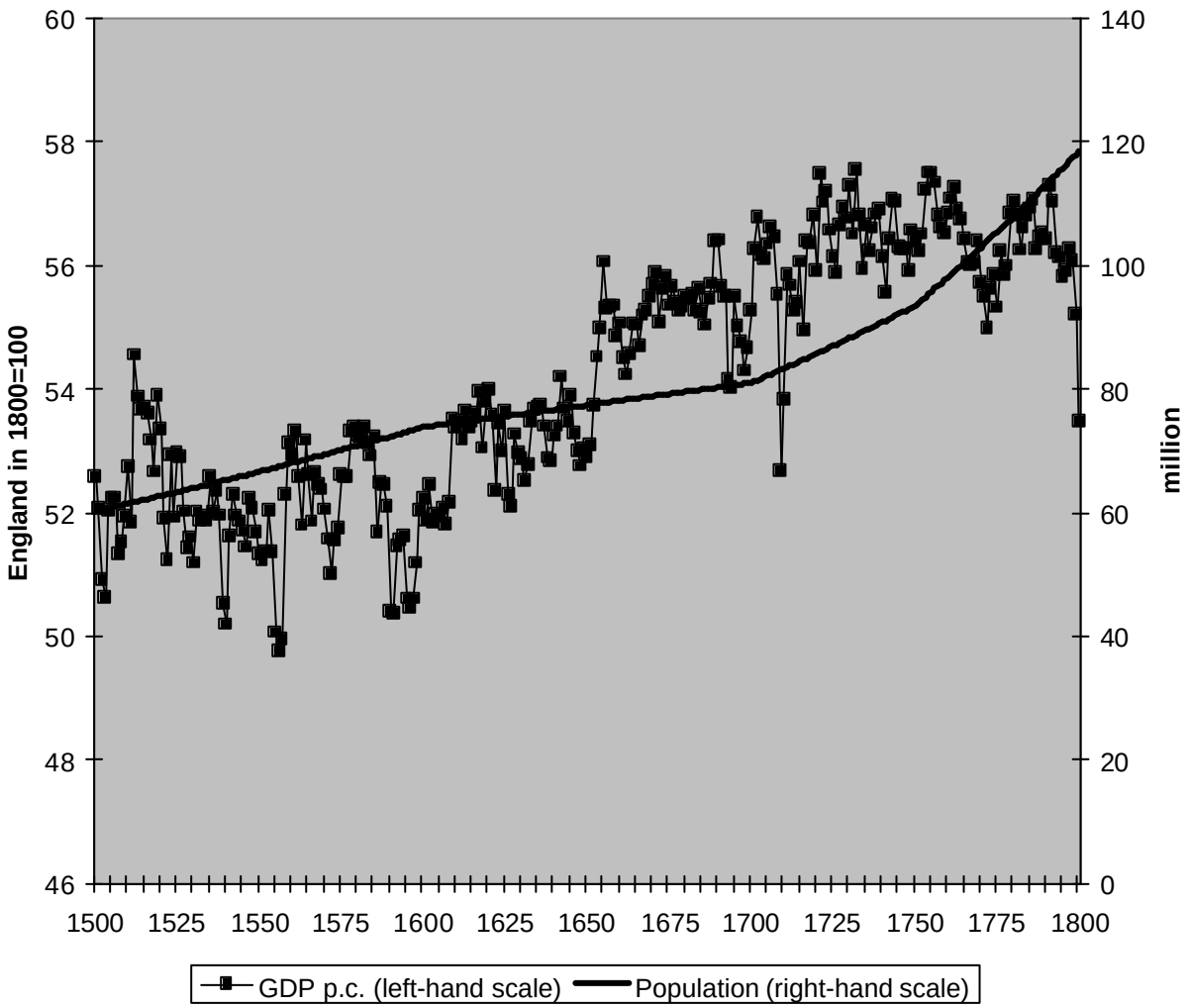
Figure 4 GDP per capita in France, Germany, Belgium and Spain, 1500-1800 (England in 1800=100)



Less spectacular are the trends in the other countries (Figure 4; the estimates for Austria, which are very similar to those of Germany, are not presented here). Perhaps most striking is the long-term decline of Spain (but the model does not capture the increase in GDP per capita that occurred during the 18th century according to Yun (1994) and Carreras (2003)). Belgium shows some positive growth during the 16th century, stagnation during the next, and slow decline during the 18th century. Belgian decline after about 1700 is however inconsistent with established views (as summarized by Blomme and Van der Wee (1994)). France and Germany seem to trade places: in the

16th century German GDP per capita is slightly higher than French, but the German economy does not do very well between 1560 and 1650 (the worst years are those between 1618 and 1648, which is not unexpected), whereas France slowly moves forward during the 17th century. Differences between these two big countries (and Austria) are small, however.

Figure 5 GDP per capita and population of Europe, 1500-1800



Because we have estimates of GDP per capita and of total population of nine European countries, it is also possible to estimate European GDP per capita between 1500 and 1800 (see Figure 5). Note that these estimates do not include the Nordic countries, Portugal, Switzerland, Ireland, Wales and Scotland, but do include Poland, and that Austria, which is included, also encompasses Czechoslovakia and Hungary. Figure 5 shows a small decline during the 16th century (falling real wages, and economic difficulties in the Netherlands and Germany), followed by a long period of modest growth between the 1600s and 1730s, which is initially driven by the expansion of the Dutch economy, later on by English dynamism. During the second half of the 18th century the continued expansion of England is balanced by the decline of GDP levels in most other countries (most strongly in Italy). The long-term growth record is not very impressive: GDP per capita increased by less than 10% in the three centuries between 1500 and 1800. Figure 5 also shows the development of the European population; it is clear that GDP per capita growth was relatively slow in periods of rapid population growth (during the 16th century and the second half of the 18th century) and relatively rapid in the 'depression' of the 17th century, when population growth was slow. This Malthusian link is much less evident when the estimates are analysed on a more disaggregate level, because population growth was relatively rapid in the more dynamic parts of Europe – in England and the Netherlands.

4. A millennium of growth

Can the model also be applied to the Middle Ages? Remember that it was estimated on the basis of 33 point estimates of GDP per capita in six European countries, of which

only two (England in 1380 and Italy in 1450) relate to the period before 1500. In the original specification no time dummies were included in the model. The alternative model presented in the appendix, in which time dummies are introduced, shows that these dummies have negative coefficients, which implies that the same level of structural transformation in the 16th or the 18th century leads to a lower level of GDP per capita than in the 15th century. This result is consistent with the findings for the 19th and 20th centuries reported in section 2, when a similar change of the relationship between structural change and GDP per capita occurred. Therefore, if the model is applied to the period before 1500 growth is probably *overestimated*. Yet, it may be worthwhile to find out what the implications of the model are for the (simulated) pattern of long-term growth.

For two countries, England and Italy, wage series and estimates of the structure of the labour force are available for the 1300-1500 period. Moreover, it is also possible to estimate European GDP per capita for the centuries before 1500 by assuming that real wages in Europe were the average of Italian (Florence) and English (London) wages.[12] For the 15th century we can rely on the Allen (2000a) estimates of the structure of the labour force in Europe in 1400 (I made additional estimates for the Netherlands between 1400 and 1500 to fill that gap, based on Van Bavel and Van Zanden 2004). For 1300-1400 the development of urbanization ratio (from De Vries, 1984, 43, and Malanima 1998) is used to estimate the development of the share of agriculture in the labour force. Before 1300 our method cannot be applied anymore, but for England we can use the discussion by Campbell (2000, 406-11) of the various estimates of GDP per capita between 1086 and 1300. He concludes, after carefully making comparisons with his estimates of agricultural output in these years, that GDP per capita probably increased

[12] For 1500 average real wage (weighted by population numbers) in the nine countries studied here was only three percent higher than the unweighted real wage of Florence and London; for the 15th century also Antwerp real wages were available, but adding them hardly changes the picture at all.

by 10 to 20% between 1086 and 1300. I have adopted the higher estimate, which brings the GDP per capita of England in 1086 to somewhat less than 37% percent of the 1800 level.

Finally, I made a set of guestimates for Europe in 1000, assuming that 1/ the share of the labour force in agriculture was between 85 and 95% at the time (against 70% in 1300), and 2/ that real wages were similar (plus/minus 25% of the 1300 level) to those in the early 14th century.[13] This gives a range of estimates of GDP per capita between 36 and 42 percent of the England in 1800 level, only slightly higher than the England in 1086 estimate derived from Campbell (the preferred estimate for Europe in 1000 is 38).

The results are presented in Figure 6 and in Table 2; to create a real long-term perspective I have also added the Maddison (2001) series for the 19th and 20th century. The most important conclusion that can be drawn from this is that 'modern economic growth' in the Kuznetsian sense of a sustained increase in GDP per capita began in England during the (first half of the) 17th century.[14] Growth was relatively slow but remarkably continuous and persistent between the 1630s and the 1820s (at about .4 per cent per annum on a per capita basis); a second acceleration occurred during the 1820s and 1830s, after which again the rate of GDP per capita growth seems to have been almost stationary in the long run. The strong performance of England during the 17th and 18th century contrasts with the rest of Western Europe (with the possible exception of the Netherlands), where the big break in economic growth occurred after 1800, probably during the 1820s and 1830s.

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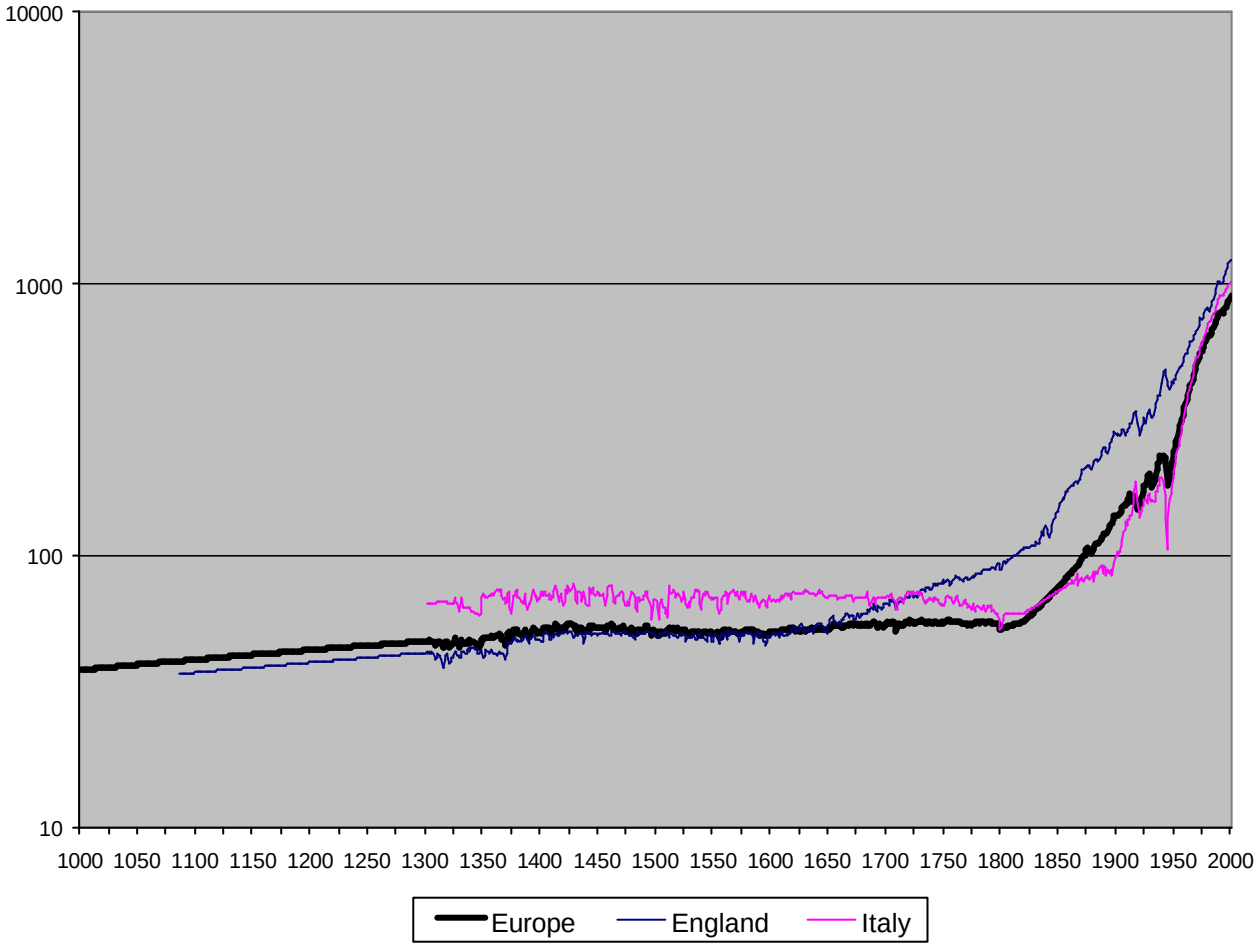
[13] The growth that is guestimated for 1000-1300 is therefore the 'result' of the decline of lshare.

[14] I disagree with the claim by De Vries and Van der Woude (1997) that the Dutch economy was the 'first modern economy' generating a similar process of modern economic growth because after a century of expansion between the 1580s and the 1670s followed a century-and-a-half of economic stagnation; see Van Zanden 2002.

Turning now to the medieval growth record: what is striking is that if these estimates are correct most of the per capita growth before 1800 occurred in the centuries before 1450, after which the economy of Europe - with the notable exception of a few regions around the North Sea - stagnated for about 350 years. Growth before 1450 seems to have occurred in two stages. The commercial and urban revolution of the Middle Ages between about 1180 and 1330 was characterized by both an expansion of GDP per capita and of population. During the second phase of per capita growth, between 1348 and 1450, population numbers went down strongly; total GDP also fell, but by less than total population. It seems that the 1348 shock pushed Europe (and in particular southern Europe, which had expanded most during the previous three centuries) into a 'high-level equilibrium trap' (Elvin 1973) lasting until the (end of the) 18th century.

Figure 6 Estimates of GDP per capita of England, Italy and (Western) Europe 1000-2000 (indices; England in 1800=100)



How plausible are these results? To be frank, I expected more growth to have taken place in Europe between 1000 and 1800 than these estimates imply, because for Europe as a whole GDP per capita 'only' increases by about 50%. Assuming that all European countries were at about the 36-40 range in 1000, only two countries did much better in the long run: England and the Netherlands both increased their GDP per capita by about 150% before 1800. Italy had a much higher levels of GDP per capita during the (high and) late Middle Ages - perhaps it doubled its income level between 1000 and 1400 - but part of the difference between north and south of Europe probably antedates the past

millennium (eg. already in the year 1000 Italy was significantly more developed than the rest of western Europe). The near stagnation of European GDP per capita between 1450 and 1800, and the negative correlation that seems to exist in most cases between population growth and per capita GDP growth is striking and demands further analysis. Should this be interpreted as evidence of an early modern productivity ceiling?

Table 2 Estimates of GDP per capita (indices; England in 1800=100)

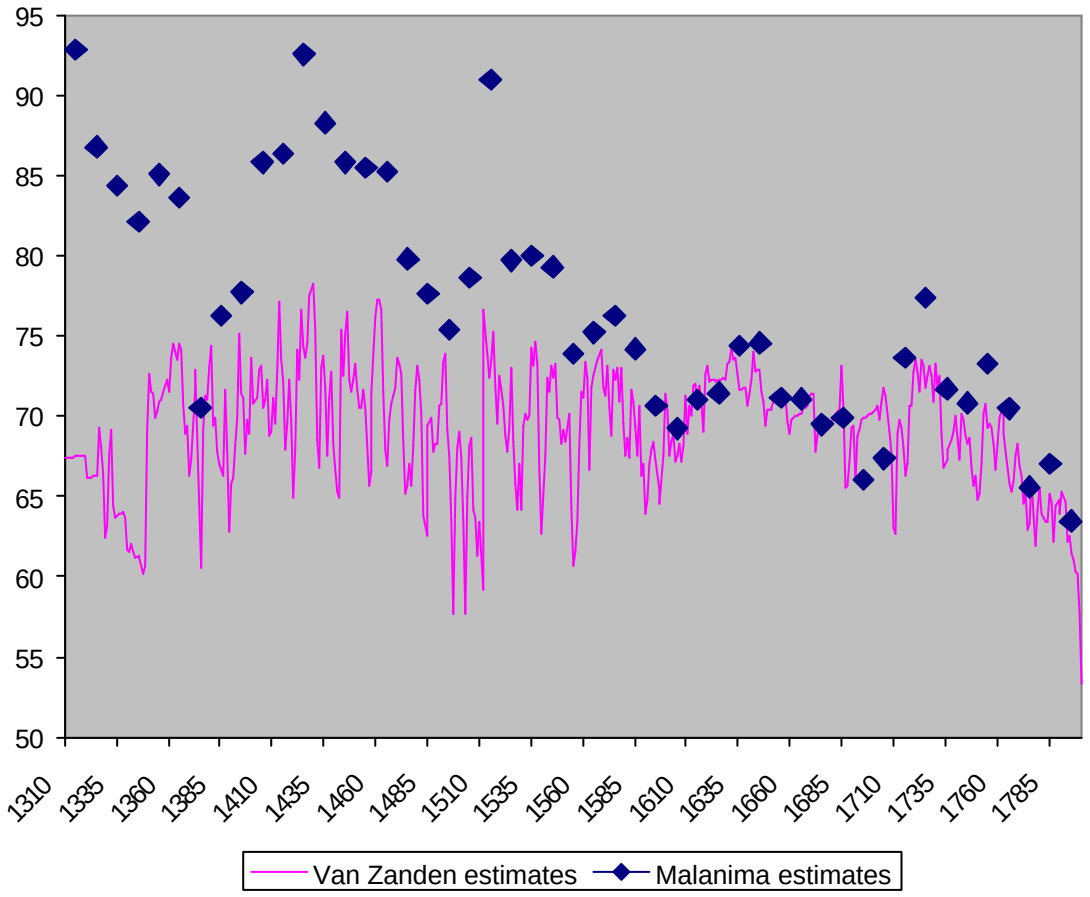
	1300	**1400**	**1500**	**1600**	**1700**	**1800**
England	43.8	48.5	50.7	50.6	65.8	92.4/100*
Netherlands	-	-	77.0	84.1	97.6	97.1
Belgium	-	56.1	57.1	61.2	63.1	60.4
Italy	66.4	70.8	66.6	69.1	70.3	56.7
Spain	-	-	49.7	46.7	45.3	41.7
France	-	-	46.7	47.7	51.3	51.1
Germany	-	-	52.1	47.4	51.1	51.1
Austria	-	-	48.8	44.6	49.7	52.8
Poland	-	-	40.3	43.8	45.9	48.1
Europe	48.3	52.1	52.1	52.0	55.5	55.4

* model ‘predicts’ 92.4; actual standard is 100

The only more or less independent series I can compare with is the recent set of estimates of the development of GDP per capita of Italy between 1310 and 1800 by Paolo Malanima (2003). These estimates are more detailed than the ones he published earlier – which were included in the Van Zanden dataset used previously – but are also based on the same kind of information: the development of real wages, the urbanization

ratio, and derived estimates of output in agriculture and in the rest of the economy. Both sets of estimates are presented in Figure 7. The comparison shows that the most recent Malanima estimates are even more pessimistic about the long-term development of GDP per capita in Italy than mine, and that the divergence increases going back in time. If Malanima's estimates are correct, GDP per capita in Italy at the start of the 14th century (or at about 1420) was almost as high as in England in 1800, which is hard to believe. My somewhat lower estimates are therefore perhaps more realistic. But the trends of the two series are very similar.

Figure 8 Two sets of estimates of Italian GDP per capita 1310-1800



Sources: Malanima 2003; simulations presented in this paper.

Given the simple model used to estimate the development of GDP, these patterns are driven by two variables: real wages and the share of the labour force in agriculture. The near stagnation of European GDP per capita between 1450 and 1800 is the result of a strong decline in real wage levels – by about 50% on a European level – in combination with an ongoing decline of the share of agriculture in the labour force (from almost 70% in 1450 to 57% in 1800). Similarly, the increase of income levels between 1350 and 1450 is the effect of the strong increase in real wages in this period (as is evident from Figure 8). Real wage levels changed much more strongly than GDP per capita (the estimated elasticity is .219) which suggests that large changes in income distribution must have occurred during the centuries before 1800; in particular slow growth between 1450 and 1800 went together with a decline of real wages, which may have resulted in an increase in income inequality (see Van Zanden 1995; Hoffman et.al. 2003).

Figure 8 Average real wages in capital cities and the share of the labour forces in agriculture in Europe, 1300-1800

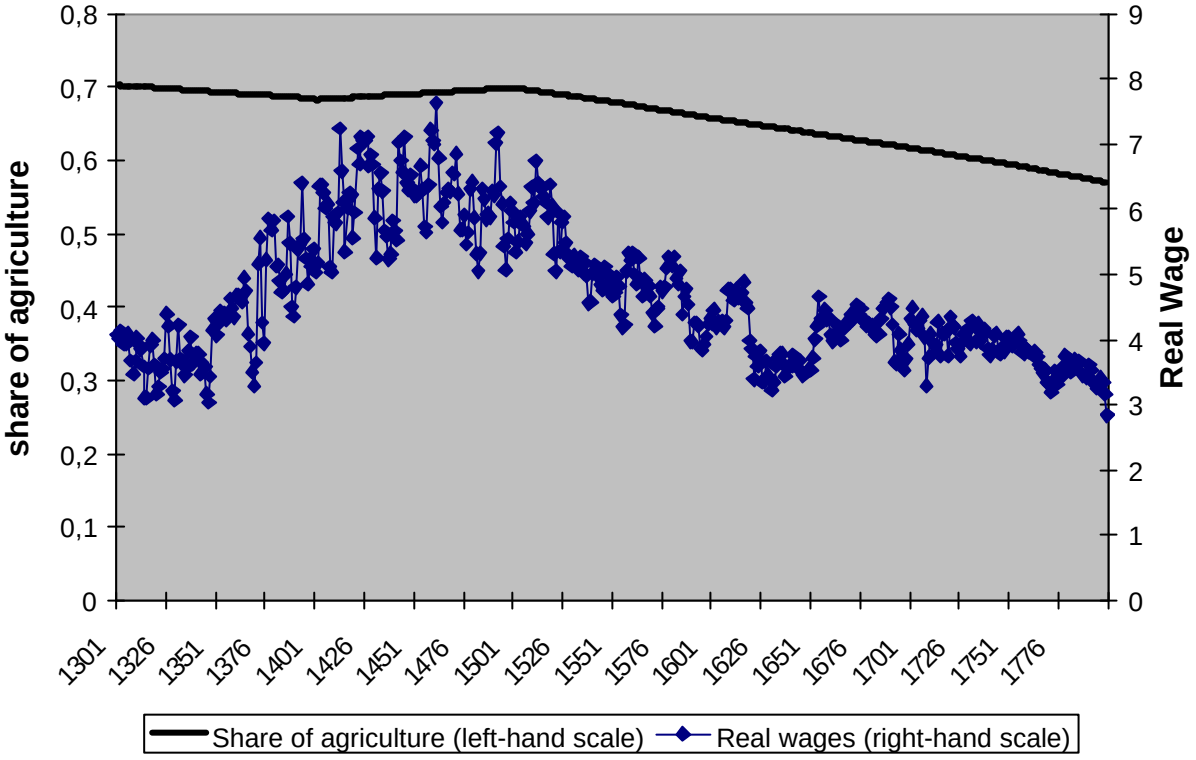
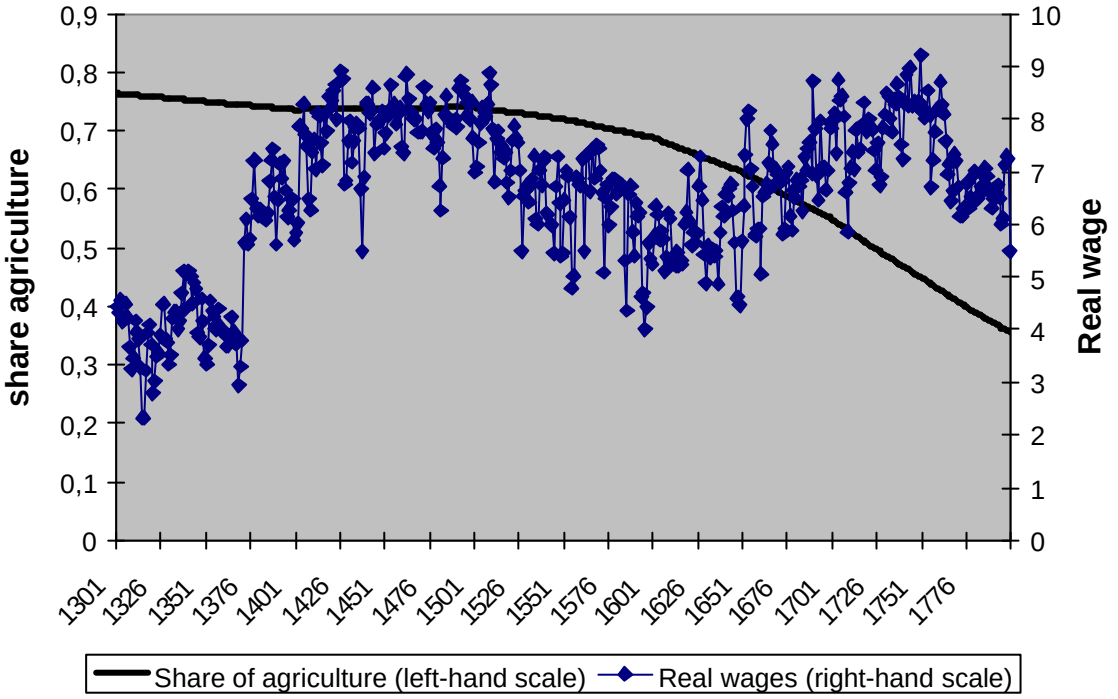


Figure 9 presents the same series for England. It shows that the divergence of England from the 1620s onwards can be attributed to two (related) developments, the more rapid decline of the share of agriculture in the labour force after about 1600 and the strong increase in real wages after about 1620. Only in England do real wages, after a sharp decline during the 16th century, in the early 18th century 'return' to the high late-Medieval level. The divergence of the Netherlands during its 'Golden Age' can be attributed to similar changes; in this case the sharp decline of the share of agriculture in the labour force has a larger impact than the increase of real wages.[15]

[15] In a follow-up paper I hope to analyze the patterns of structural change that are implied by these estimates (see Federico, 2002, 117) and the links with changes in relative prices of agricultural and non-agricultural commodities, which will also create opportunities to test the plausibility of these estimates more in detail.

Figure 9 Real wages and share of agriculture in labour force in England, 1300-1800



5. The comparison with China

As explained in the introduction of the paper, one of the reasons why Maddison assumes relatively fast economic growth in Europe between 1000 and 1800 is the comparison with China. Not many scholars will disagree with his hypothesis that at about 1000 China was more developed than Europe and therefore had a higher GDP per

capita. In his study of Chinese economic performance in the long run he gives a review of the literature arguing this point (Maddison, 1998, 19-38). For the early 19th century, however, Maddison estimates that Chinese income levels were only one-third of the British level, and at about one half the level of Europe as a whole. This gap is, in his view, not the result of a decline of Chinese income levels. So the obvious conclusion is: Europe must have grown rapidly between 1000 and 1800 to create the 1820 gap. Therefore, if we are to believe the estimates presented in this paper, which show much lower growth rates for Europe, the question about the relative performance of these two regions should be addressed.

Recently, the relative income level and performance of the Chinese economy in the early modern period has been the topic of much new research and even more debate. Li Bozhong (1998), Ken Pomeranz (2000) and Roy Bin Wong (1997) have argued that parts of China – the Yangtze delta in particular – developed much more favorably in the centuries before 1800 than was assumed so far. Traditionally the long-term development of the Chinese economy between the Sung (960-1275) and the 19th century was either analyzed as a process of involution (i.e. declining income levels as a result of population growth, see Huang 1990), or as a 'high equilibrium trap', meaning that income levels remained more or less the same (Elvin 1973). Moreover, in particular Pomeranz has maintained that in terms of income levels China in 1750 may have been on par with Europe, and that the Yangtze delta region may well have been as prosperous as the most developed parts of Western Europe (England and the Netherlands). Maddison (2003, 249-51) rejects those views, however. He derives his 1820 benchmark estimates on the basis of PPP-comparisons from the 1990s in combination with time series of GDP per capita for the 1820-1990 period. This method is open to criticism (as is probably any method for that matter). One of the problems is the poor quality of historical national

accounting for China; for the period before 1912 no serious studies are available, and the evidence for growth between 1912 and 1949, and again after 1949 is quit shaky (Maddison 1998). The discontinuities in the times series that are available – caused by the Second World War and the Communist take over of 1949 – and the poor state of statistics in the period after 1949 are all causes for doubting the accuracy of the time series used to link 1990 benchmark estimates with the early 19th century.

One of the comparisons that can be made easily is via another country for which more reliable GDP estimates are available. In a detailed study of income levels and PPP's comparing Java and the Netherlands during the first half of the 19th century I concluded that the Maddison estimates of the income gap between these two regions at 1820 was about right: Dutch GDP per capita was about three times Javanese GDP per capita (Van Zanden 2003). Maddison estimates, however, that Chinese per capita GDP in 1820 was lower than the Indonesian level, which is unlikely. For Java (and for the rest of South-East Asia), China clearly was the more developed economy, from which it imported entrepreneurship, skilled labour, technology and capital as well as manufactured goods. One would expect Chinese GDP per capita to be considerably higher than that of Java.

One way to approach this problem is to try to fit China (or parts of China) into the 'model' that was estimated for Europe. Robert Allen (2000b) has made estimates of real wages of farm workers at about 1750 indicating that Chinese wages were 82% of the English level. Additionally, there are a number of estimates of the structure of GDP and/or the labour force. For the beginning of the 19th century Rozman (1973) estimated that agriculture contributed 70% of GDP, which can be taken as a rough estimate for China as a whole. More detailed estimates can be made for the Yangtze delta, the most developed and prosperous part of the empire. Jack Goldstone (2003) used the detailed

estimates of Li Bozhong (1998) of the size and structure of the rural economy in Jiangnan (part of the Yangtze delta) to make a set of estimates of income levels of the agricultural and proto-industrial population there in 1620 and 1750. What is missing are estimates of the income levels of the non-agricultural population in the countryside (estimates by Li at 10% of the rural population) and of the urban population (in 1620 15% and in 1750 20% of the total population of the region). When it is assumed that this non-agricultural population had an income level two to three times the level of the farmers – which is perhaps reasonable – it is also possible to derive estimates of the structure of GDP and of the labour force in Jiangnan. The differences between the estimates for 1620 and 1750 are rather small; in both cases agriculture contributed about 55% to 65% of GDP (dependent on the assumption one makes concerning the relative income level of the non-agricultural population). The share of agriculture in the labour input in the total labour force was even smaller, i.e. 51% (1750) or 54% (1620). This points to the fact that labour productivity in agriculture was (marginally) higher than in industry and services.[16]

Feeding these estimates into the model developed for Europe gives the following results (all indices England in 1800 = 100): Chinese GDP per capita in 1750/1800 is 53% of the base level, assuming a real wage 82% of the English level, and 70% of the labour force in agriculture. This is similar to Europe in 1750 (which is 56) and 35% lower than England in 1750 (80). Jiangnan in 1750 (real wage 82% of the English level, and 51% of the labour force in agriculture) has a level of 68, which is higher than Europe as a whole, and only 15 percent lower than the contemporary English level. This

[16] This is the direct consequence of the estimates by Bozhong Li and Jack Goldstone, when one day of female labour is taken as the equivalent of one half day of male labour; the relatively high productivity of agriculture both in 1620 and 1750 may help to understand the development path of China in this period, in particular the slow rate of structural transformation, because it implies that incentives to move labour from agriculture to industry and services were weak.

result is somewhat in between the Pomeranz view and the Maddison view on these gaps.

The problem with making more direct comparisons between China and Europe using the established method of estimating income levels and PPP's, is the scarcity of price information on China. One way to circumvent this is to use rice as a standard for comparison. The Jiangnan estimates derived from the work of Bozhong Li and Jack Goldstone imply that per capita GDP in this region was the equivalent of 650 to 790 kg rice of 1750, and slightly more, 680 and 800 kg, in 1620 (again, dependent on the estimate of the relative level of income of the non-agricultural population). Per capita GDP in Java between 1815 and 1835 was on average the equivalent of 490 kg of rice, which gives an indication of the big gap between the 'underdeveloped' Java and 'developed' Yangtze delta. Measured in terms of a basket of consumer goods would probably widen the gap, because China exported industrial products and services, and Java exported rice (but the price data to test this idea are not available). Since Javanese GDP per capita was according to Van Zanden (2003) about half the level of Europe in 1820, the estimated gap between Europe and Jiangnan would be quite small – or perhaps non-existent. This again suggests that the Maddison estimates for Chinese GDP per capita in 1820 (being lower than those for Indonesia) may be too low.

These different approaches lead to the conclusion that relative level of GDP per capita in China in the 18th century was perhaps on par with or slightly lower than in western Europe (western Europe interpreted as in this paper; including the rest of central and eastern Europe would raise this ratio), and that GDP per capita in the most developed part of China, Jiangnan, was perhaps 80 to 90% of the English and Dutch level. Does this solve the China problem? Assume for a moment that the relative level of China in 1750 was indeed between 50 and 55 of the English level of 1800 and

remained constant between 1000 and 1800. According to the estimates presented here, Europe would then be then be on par with China during much of the Early Modern Period, in fact from the 15th century until the acceleration of growth in the 1820s and 1830s (see Table 2). Such a scenario would be consistent with the Pomeranz (2001) interpretation of the Great Divergence (in the year 1000 Chinese GDP per capita would have been about 50% higher than the European level).[17]

Fortunately we do not have to solve these issues here. I only want to argue that because Maddison has probably underestimated Chinese per capita GDP at about 1800 relative to European levels a relatively slow growth of European GDP per capita can be consistent with a trading of places of the two regions at some point in time between 1000 and 1800. In other words, one does not have to assume that European GDP per capita tripled in these eight centuries to solve this problem.

6. Conclusion

This paper has been critical of some of the results of the very ambitious project of Angus Maddison to estimate the development of GDP per capita in the past millennium. This is not for lack of respect for his work. In fact, I consider his project to be one of the most interesting and ambitious undertakings of economic historians in recent times, the crown upon of a life long dedication to (historical) national accounting. One of the aims

[17] That Chinese GDP per capita remained constant is not evident, however. The interpretation of Jiangnan economic growth between 1620 and 1750 presented here suggests that income levels may have declined somewhat, even in this most dynamic region of China. There is some evidence that in China as a whole, levels of urbanization may have declined between the 13th and the 19th century (this has been concluded by Skinner, Elvin, Perkins and most recently Chao (1986)). This trend has not been taken into account by Maddison, who relies on Rozman's very tentative findings. Again the Yangtze delta may have been the exception to the rule. A parallel that comes to mind is the stagnation and slow long-term decline of Spanish and Italian economies in the same period, which was also accompanied by a decline of urbanization ratios after 1300 (Italy) or 1560 (Spain) (Malanima 1998; Reher 1990).

of his work is to go beyond the estimates that have been produced by (more cautious) scholars working on individual countries and the more recent period. By producing new estimates for previously unknown territory, Maddison has often challenged established views and forced others to improve upon his tentative findings. I (and Giovanni Federico before me) was forced by the bold synthesis of *The World Economy. A millennium perspective* to reassess what I thought was happening in Europe between 1000 and 1800. Therefore this paper fits into the Maddisonian grand strategy to improve his and our estimates of economic growth in the past.

The main contention of the paper is that I agree with Giovanni Federico that European growth between 1000 (1500) and 1820 must have been much slower than suggested by Maddison. I have given two reasons for this: the relationship between growth and structural change in 1820, and the estimates produced by a number of leading scholars (Malanima, Yun, Krantz, Carreras) about growth in their region or country. Moreover, I presented a way for estimating European growth before 1800 that makes use of the available data on long-term economic change (i.e. estimates of real wages and of the structure of the labour force). This made it possible to chart – very tentatively – growth between 1000 and 1800. The model 'predicted' the *growth trajectory* of most countries (in particular Italy, Spain, the Netherlands and England) more or less 'correctly', i.e. consistent with established views, which is perhaps no surprise because it was based on a quantitative summary of these views. The overall picture is one of slow growth in Europe between c. 1000 and 1450, followed by near stagnation during the next three and a half centuries. Average European GDP per capita may have increased by about 50% between 1000 and 1800, which is probably less that expected on the basis of the literature, but the aim of these experiments is of course to test and modify such views. Parts of southern Europe, Italy in particular, had relatively

rapid growth during the first three or four centuries of the millennium resulting in perhaps a doubling of income levels, but after 1500 per capita GDP in Spain and Italy declined in the long run. The Netherlands and England are the two outliers with a per capita growth of perhaps as much as 150% between 1000 and 1800. This experiment also led to the insight that 'modern economic growth' began during the first half of the 17th century, when – after stagnation during the 16th century – GDP per capita in England began to increase slowly but persistently. Finally, I argued that these estimates are not inconsistent with a comparison with the long-term evolution of the Chinese economy, but evidently a lot of work has to be done before we can enter on somewhat more safe grounds in that respect.

Appendix: an alternative model.

An interesting alternative model can be tested by adding time dummies for all years except 1380/1450 (the first years for which estimates of GDP per capita are available); the results are:

	Coefficient	Std.Error	t-value	t-prob
Lshare	-0.759688	0.2053	-3.70	0.002
Llabourers	0.226109	0.1490	1.52	0.146
Netherlands	0.203624	0.05239	3.89	0.001
Belgium	-0.096218	0.05441	-1.77	0.094
Italy	0.263184	0.1023	2.57	0.019
Spain	-0.142582	0.07089	-2.01	0.060
Poland	-0.180360	0.09176	-1.97	0.065
Constant	3.41537	0.2934	11.6	0.000
T1500	-0.148665	0.05690	-2.61	0.018
T1570	-0.0263169	0.1345	-0.196	0.847
T1600	-0.188378	0.08566	-2.20	0.041
T1650	-0.0837402	0.1495	-0.560	0.582
T1700	-0.141310	0.09967	-1.42	0.173
T1750	-0.171945	0.1019	-1.69	0.109
T1800	-0.0676745	0.1689	-0.401	0.693

R^2 0.8733038

RSS 0.36254196343 TSS 2.8615070682

no. of observations 33 no. of parameters 15

Adding the time dummies does not change the model in a fundamental way; the coefficients of the main explanatory variables are very similar to the ones estimated in the model without the time dummies. What is surprising is that all time dummies have negative signs, which implies that GDP per capita in 1380/1450 is higher than ‘predicted’ by the model (or alternatively, between 1500 and 1800 is lower than predicted).

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