# Cobb-Douglas in pre-modern Europe[1]

Simulating early modern growth

**Jan Luiten van Zanden**
**International Institute of Social History/University of Utrecht**
**jvz@iisg.nl**

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[1] The idea for the paper was born after listening to a presentation by Bob Allen at the TARGET workshop in Oxford (in October 2004) on Capital Accumulation, Technological Change, and the Distribution of Income during the British Industrial Revolution: An Analysis with Solow'.

## 1. Introduction.

The question how much growth there was in Europe in the centuries before the Industrial Revolution has become the subject of systematic research since the early 1990s. This began with a number of papers by Graeme Snooks (1990; 1994; 1995) 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 other 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% to 30% between ca 1500 and ca 1820; because labour input per capita probably increased substantially, labour productivity may have remained the same (Van Zanden 2001).

These 'pessimistic' conclusions contrast with the picture that can be derived from the recent synthesis of thousand years of economic growth in the world economy by Angus Maddison (2001). 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, Federico argued, 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.

This paper present, firstly, an update of the research carried out recently, focusing mainly on the country for which estimates of GDP (before 1688) are still rather shaky, England. Also new research concerning a number of other countries (Sweden, Spain, the Netherlands and Italy) will be presented briefly. The main focus of the paper is on testing the results of these country-studies by experimenting with a Cobb Douglas production function. The question is whether the available estimates for the development of the population, of real wages and real rents can be made consistent with the benchmark estimates of the development of GDP per capita in the centuries before 1800. In other words, assuming a Cobb Douglas world (with constant returns to scale and an elasticity of substitution of 1), are the estimates of GDP (per capita) consistent with what we know about the development of factor prices and of population levels (and of the labour input per capita). This means experimenting with the different variables that enter into the production function, with the share of GDP that is invested (which determines the long-term growth of the capital stock), with the number of days worked per year, with the absence or presence of technological progress etc. As I hope to show, this produces new insights into the long-term development

of the European economy in the period before the Industrial Revolution, and also makes it possible to discriminate between the two datasets at hand.

The most important result of such an approach is twofold. First, it bring together two strand of research which have developed more or less independently, i.e. the new research focusing on the measurement of national income and product, and the more traditional approach, the study of real wages, which has dominated the analysis of the early modern economy since the days of Abel, Braudel and Slicher van Bath. In the latter field a number of attempts to synthesize the findings of local and national studies and analyse the European patterns of real wage changes between the 14th and 19th centuries have recently been published (Van Zanden 1999; Allen 2001). In particular the systematic study of real wages of labourers and skilled craftsmen by Allen (2001) has produced new insights into what he termed the 'great divergence' within Europe, eg. the growing apart of real wages between the North Sea region (where they did not decline much between the 15th and the 18th century), and the rest of Europe (where the decline was quite strong, and real wages more or less fell by 50% between the middle of the 15th century and the end of the 18th century. The first aim of paper is to find out if these two approaches to the development of the early modern economy can be recon ciliated using a Cobb Douglas production function.

Secondly, as I hope to demonstrate, such an experiment creates new insights into the determinants of growth in the centuries before the Industrial Revolution. The question, for example, when technological progress (eg. a sustained increase in total factor productivity) began in England and in Holland, for example, and how important it was as a source of productivity growth before 1800, can tentatively be answered with this approach. Similarly, the issue of the importance of Malthusian forces cans be analysed as well: did the growth of population lead to lower wages and GDP per capita, as many have argued in the 1950s and

1960s? Was there a technological ceiling beyond which the economy could not develop, as stated by the famous Annales-school and by Emmanuel Leroy Ladurie in particular?

Before addressing these and similar questions, we will first turn to the recent research on long-term economic growth in England.

## 2. Recent research: England between 1086 and 1688

Modern work on growth before and during the Industrial revolution began with the seminal study by Deane and Cole (1962), who produced estimates of the economic growth of Great Britain in the 18th century. Their work has been extended and refined by Crafts (1985) and Harley (1993), which resulted in a set of estimates of the development of GDP starting in 1688 that have been widely accepted (Crafts and Harley 1992).

As already mentioned in the introduction, Snooks (1990; 1994; 1995) pioneered research estimating national income before 1688 with his work on the Domesday Book of 1086. He ingeniously fills out the data from this venerable source, which gives detailed information on `demesne income', with estimates of income from outside the `demesne' sector, such as that generated by towns. The result is some fairly conservative figures; it is assumed, for example, that the consumption of farmers was on a subsistence level. He then combines his estimates of total income and income per head in 1086 with Craft's revision of Deane and Cole's estimates for 1688 and onwards, and finally makes several (unspecified) estimates for the intervening period. The result is a set of estimates of economic growth between 1086 and 1688 which are astonishingly high: an average growth rate of 0.29% per capita per year over a period of 600 years, leading, according to Snooks, to a quadrupling of

real income per head over the whole period. In some of the component periods - especially in the first half of the 16th century - he even finds annual growth rates higher than 1.5% per head. These results mean that growth between 1086 and 1688 would not have been much less than during the 18th century (1688-1760: 0.31% per capita per year); the pace of growth in the first half of the 16th century would only just be matched by that between 1830 and 1870.

Snooks' optimistic results have met with a great deal of criticism. There is a fairly general objection to his 1086 level, which is probably underestimated, and to the fact that he does not clearly explain how he has apportioned the overall growth between 1086 and 1688 between the various centuries. Neither is it clear how he solves the problem of price changes between 1086 and 1688; here too there is insufficient explanation of the method he has used in his calculations. His estimates have been revised and improved by a number of authors, most notably Nicholas Mayhew (1995) and Bruce Campbell (2000: 406-10). The latter carefully compares Snooks' figures with his much more detailed estimates of the output of arable farming (about which more below), and showed that in view of what we know about the subsistence needs of the population Snooks' estimates are untenable (he systematically underestimates 'the cost of peasant subsistence' and fails 'to allow for the production of a disposable surplus for the unfree'). For 1086 Campbell agrees with the much higher estimates produced by Mayhew, who corrected for some of the problems with Snooks' work.

In another recent study Campbell (2005) produces detailed estimates of national income in the 1290s, which can be compared with Gregory King's very similar estimates (as corrected by Lindert and Williamson (1982)) (Table 1). These estimates show a per household increase of real income of 110%; because the average size of households also declined, per capita income grew by about 150%. This can be compared with the relatively small increase in income per head between 1086 and 1300 (or the 1290s), which Campbell

(in the footsteps of Mayhew) estimates at 10%. Because population growth was strong before the 1290s, total GDP increased by 130-150% between 1086 and 1300 (Campbell 2000:409).

Table 1 Estimates of the structure and level of income in England, ca 1290 and 1688, according to Campbell and Lindert & Williamson (in percent)[2]

| | Share of households 1290s | Share of households 1688 | Share of income 1290s | Share of income 1688 | Real increase income per household 1290-1688 |
|---|---|---|---|---|---|
| Landowners, aristocracy, gentry, high clergy | 2,3 | 2,9 | 15,8 | 22,0 | 132 |
| Tenants, smallholders | 41,8 | 16,4 | 43,6 | 22,4 | 175 |
| Cottagers, (rural) labourers, vagrants | 36,2 | 37,9 | 19,4 | 9,1 | - 6 |
| Non-agrarian sector (commerce, professionals, craftsmen etc.) | 19,8 | 42,8 | 21,2 | 46,4 | 112 |
| Total | 100 | 100 | 100 | 100 | 110 |
| Total population (millions) | 4,32 | 4,9* | | | |
| Total GDP (current prices, million pounds) | | | 3,67 | 54,44** | |

* according to Lindert and Williamson 1982 ; more recent estimates are generally slightly higher, up to 5,06 million
** Lindert and Williamson 1982; Maddison 2004 gives 54,04 million

The comparison shows a strong polarization of the rural income distribution: the 'middle classes' of tenants and smallholders which still dominated the agricultural sector in 1290s, were greatly reduced in relative and absolute terms, whereas the share of landowners in income increased substantially (from less than 16% to 22% of GDP, or from about 20% of value added in agriculture to about 50%). Moreover, the real income of agricultural labourers (and cottagers) declined, in spite of the more than doubling of GDP per capita. Finally, the share of non-agricultural activities in GDP more than doubled in these 400 years; employment in the non-agrarian sector increased from less than 20% in the 1290s to almost

[2] Assumptions: price level increased by factor 5 between 1290s and 1688 (according to Campbell); one-third of labourers in 1688 is non-agricultural, the rest is agricultural.

43% in 1688, and their share in income increased in a similar way. These figures may however still underestimate the growth of the secondary and tertiary activities; because of the spread of proto-industrial activities on the countryside the part of the income of tenants, smallholders, cottagers and rural labourers with non-agricultural sources of income must have increased as well. Crafts estimated that the share of agriculture in GDP in 1700 was as low as 37% (declining to 26% in 1800 (Crafts 1985: 16-7)), whereas in the 1290s this must have been more than 70%.

Perhaps the comparison between the estimates for the 1290s and the detailed reconstruction of the social tables of 1688 is somewhat biased, however. The estimates produced by Mayhew and Campbell are still quite rough, and have not been compared with other data on the socio-economic composition of the population. The main contribution of Lindert and Williamson (1982) was to correct the – initially perhaps also rather rough – estimates by Gregory King, which resulted in a strong increase in estimated total income (by 25.1%). This is an example of what can maybe called the 'first law of historical national accounting': the more we know about pre modern societies, the more detailed our estimates of historical national accounts are, the higher income per capita appears to be. In other words: major revisions of historical national accounts almost always lead to a strong upward correction of the level of income per capita (as the revisions of Snooks by Mayhew and Campbell, or the work by Lindert and Williamson revising Gregory King demonstrate).[3] The comparison of a rough 'first generation' estimate for the 1290s with a very detailed and corrected 'second generation' estimate for 1688 may therefore lead to an overestimate of the

[3] This is in fact still true: even most recent revisions of national accounts result in upward adjustments of levels of GDP, which may be as high as 10% or more; in these cases also the reason for this is that more detailed information and improved estimation methods almost always lead to upward adjustments.

growth rate between these two dates.[4] Also, income per household increased much less than income per capita because household size was falling from 4.4 in the 1290s to 3.5 in 1688; but Lindert and Williamson (1982) may have underestimated population in 1688 somewhat (it was probably 5,06 million instead of the 4,9 million they used), which may also lead to slightly lower per capita GDP estimates for 1688 (on the other hand, the recent revision of GDP in 1688 by Maddison (2004) did not result in higher estimates).

All authors agree that income per capita increased strongly between the 1290s and 1688, an increase that was perhaps as much as 100% to 150% (Campbell 2000: 411). As a compromise I suggest 130%, but this is obviously a very rough approximation. To bridge the gap between 1300 and 1688 I use the results of estimates of the performance of English agriculture in the period 1086-1871 by Overton and Campbell (1996). Starting from data on population, food consumption, yields, imports and exports of agricultural products and the development of arable acreage from a large number of different sources, they could give a rather detailed series of estimates of the total output of grain and potatoes in England in this extended period. The resulting estimates of the development of output per head of the agricultural population show a long-term stagnation in this measure of labour productivity between 1086 and 1600 - with some significant swings - followed by a strong increase in labour productivity between 1600 and 1800 (Table 2). Using a different approach – mainly based on the demand for agricultural products (as determined by real wages) and by the structure of the labour force – Allen (2000) produced another set of estimates of the development of labour productivity in agriculture which are also reproduced in Table 2. Both series show similar trends: an increase in labour productivity in this vital sector in the 14$^{th}$

[4] Another argument is that the 1688 revisions are so good that the resulting estimates may lead to the conclusion that there was no growth during the 1700-1830 period; this is the result of a study by Lawrence Officer into the same issue available via the eh.net; see http://www.eh.net/hmit/ukgdp/ukgdpstudy.pdf

and 15th centuries (following the population decline set in by the Great Famine and the Black Death), a strong decline during the 16th century, which is followed by growth in the next two hundred years. The main difference is that Overton and Campbell are more optimistic about agricultural growth during the 18th century.

These estimates are used for the following conjectures about growth between 1300 (in fact the 1290s) and 1700 (or 1688). It is clear that in the long run GDP per capita increases much more rapidly than labour productivity in agriculture, which of course means that labour productivity growth in the rest of the economy is much faster than in the primary sector. If it is assumed that labour productivity growth outside agriculture is about twice as fast as in agriculture (and that the share of agriculture in GDP declined from about 75% in 1300 to 67% in 1380) it is possible to estimate in a very rough way the development of GDP per capita between 1300 and 1500. During the 16th century GDP per capita remained constant, in spite of a strong decline of labour productivity in agriculture due to the renewed expansion of population. This is consistent with recent estimates by Greg Clark (2004) who also concluded that English GDP per capita did not increase during the 16th century. In the 17th and 18th centuries the pattern changes again – then, productivity growth in agriculture was almost as rapid or, if we are to believe the Overton and Campbell estimates, even more rapid than in the rest of the economy, which was a characteristic of the transformation of English agriculture in these years (Crafts 1985). The overall picture that emerges from these estimates is one of slow growth during the High Middle Ages, followed by relatively rapid growth in the 1300-1500 period, stagnation during the 16th century and rapid growth in the next two hundred years. Overall GDP per capita increased by about 250% in these 700-odd years.

Table 2 Estimates of the development of the output per head of the agricultural population and of GDP per capita in England, 1086-1800 (indices 1800 = 100)

| | 1086 | 1300 | 1380/1400 | 1500 | 1600 | 1700 | 1800 |
|---|---|---|---|---|---|---|---|
| Crafts/Harley and Campbell* | 29 | 32 | - | - | - | 76 | 100 |
| Labour productivity in agriculture: Overton & Campbell | 43 | 41 | 45 | - | 39 | 64 | 100 |
| Idem, Allen | - | 56 | 64 | 70 | 53 | 80 | 100 |
| GDP p.c. Snooks | 13 | - | - | 20 | 54 | 76 | 100 |
| GDP p.c. this study | 29 | 32 | 42 | 48 | 48 | 76 | 100 |

*1300 (is the 1290s) is linked to 1700 by assuming 4% growth between 1688 and 1700, and 130% between 1300 and 1688 (as explained in the text)

Sources: Campbell 2000; Crafts 1985; Crafts and Harley 1992; Overton and Campbell 1996; Allen 2000; Snooks 1994; 1995.

## 3. European economic growth between 1000 and 1800

In 2001 I published a compilation of estimates of GDP per capita in six European countries – Great Britain, the Netherlands, Italy, Spain, Belgium and Poland – taken from case-studies by different authors, which resulted in the conclusion that growth was rather slow and in fact normally absent in most of them during the three centuries before 1800 (Van Zanden 2001). The new research carried out since tends to confirm this conclusion:

- Olle Krantz made a detailed reconstruction of Swedish national income in 1571, concluding that "despite the margins of uncertainty, it could be inferred that GDP per capita was about the same in the 16$^{th}$ 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);

- Paolo Malanima (2003) in a recent paper produced more detailed estimates for Italian GDP in the very long run (from 1300 to 1861), which confirm the trend of a gradually declining level of income between the high Middle Ages and the early 19th century;
- Albert Carreras (2003) reviewed estimates of Spanish GDP in the early modern period, adding to the estimates previously published by Yun (1995) his own estimates for the beginning of the 16th century;
- Finally, I published detailed estimates of the structure and level of GDP in Holland in the years 1510/14 (Van Zanden 2002b), which can also be compared with estimates for the early 19th century; during these three hundred years, GDP per capita increased by about 50%, almost all of which was concentrated in the period between the 1570s and the 1650s (in fact, between 1650 and 1807/08 levels of real income slowly declined again; see also De Vries (1984), Van Zanden (1987; 1992)).

In Table 3 sets out the results for the seven countries for which point estimates based on a detailed reconstruction of GDP are now available. The relative levels of GDP per capita in 1820 taken from Maddison (2001) are used to render comparable these attempts to quantify economic growth before 1800.

Table 3 Estimates of the development of GDP per capita in six European countries, 1500-1820 (Great Britain 1820=100)

| | c. 1300 | c.1400 | c. 1500 | c. 1570 | c. 1650 | c. 1700 | c. 1750 | 1820 |
|---|---|---|---|---|---|---|---|---|
| Great Britain | 29 | 38 | 43 | 43-45 | 54 | 69 | 84 | 100 |
| Netherlands | - | - | 58 | 58 | 95 | 94 | 94 | 92 |
| Belgium | - | - | 46 | 55 | 53 | 55 | 61 | 62 |
| Italy | 71 | 71 | 67 | 65 | 60 | 57 | 61 | 53 |
| Spain | - | - | 43-48 | 43-48 | 39-48 | 39-44 | 40-41 | 48 |
| Sweden | - | - | - | 51 | - | - | - | 56 |
| Poland | - | - | 45-53 | 42-48 | 42-49 | 35-40 | 30-33 | 41 |
| Average* (unweighted) | - | - | c. 51 | c. 52 | c. 58 | c. 59 | c 62 | c 66 |
| Average** (weighted) | - | - | c. 54 | c. 54 | c. 55 | c. 56 | c. 56 | c.58 |

* without Sweden

Sources: Van Zanden 2001; Maddison 2001 ; Carreras 2003 ; Malanima 2003; Krantz 2004.

The results of this comparison can be briefly summarized. Long-term stagnation is revealed on the periphery; i.e. Italy, Spain and Poland. Between 1500 and 1750 GDP per capita in these countries first fell, after which a certain recovery set in (at least in Spain and Poland). Only in Spain, however, was GDP per capita possibly somewhat higher in 1820 than in 1570. Compared with the stagnation of southern and eastern Europe, the countries bordering the North Sea show relatively gradual (Belgium) or rapid (England) growth in the early modern period. These estimates show a rough doubling of GDP per capita in England between c 1600 and 1820; the estimates for Holland imply a much more modest rise of only about 50% for the same period, and the extent of the increase in Belgium was probably even smaller.

Going back in time the margins of error of these estimates increase. The ranking for the 16$^{th}$ century – Italy being the richest country, followed by the Low Countries – is plausible. Only English income levels appear to be lower than expected – at least in international perspective. The minimum level – Poland in the 18$^{th}$ century, or England in 1300 - was probably about 30% of the base year.

The general picture emerging from these data can be looked at in two ways. It is clear that, over the long term, population growth was more than compensated by the increase in production whereby in `Europe' - the average of these six countries - production per capita between c.1500 and c.1820 increased by an average of some 25% (of which almost 10% occurs after 1750). In total the population in these six countries increased by 91% between 1500 and 1800 (see Table 1). The Malthusian pessimists, who saw a growing tension arising between population and resources, were therefore not right, if we go by these data: the growth of population was clearly matched by a somewhat larger increase in output. But likewise the hopes of the optimists are only met

in patches: economic growth, in the sense of growth in per capita production, is not normal in western Europe, but rather an exception to the rule - certainly before 1700. In Holland there occurred only one `growth spurt' in a period of 300 years, and this was probably also the case in Belgium; moreover, growth in Holland was partly achieved at the expense of Flanders/Brabant, whose economy declined at the same time (when the center of gravity of the economy of the Low Countries moved from Antwerp to Amsterdam). On balance, growth is very modest indeed in these six countries, taken as a whole; the weighted average GDP per capita increases by less than 10% in a period of 300 years, and this growth is mainly due to the inclusion of the most dynamic parts of Europe (England and Holland) in our sample.

Another possible conclusion is that differences in the level of economic activity within Europe were small. The gap between the richest regions (Flanders and northern Italy) and the poorest (England or Poland) in about 1570 was at most 30% (of the level of the richest) and probably even smaller. Differences increased sharply during the 17th century as a result of the rise of Holland and the decline of Poland and Spain, but this was compensated partially by the rise of England and the decline of northern Italy and Flanders relative to the `European average'. In the second half of the 18th century international disparities seem to reduce slightly, due to the increase in GDP in Poland and Spain (and to the stagnation in Holland). In 1820 the spread around the mean was even smaller than in 1700 or 1750, although at that time England was certainly running increasingly ahead of the continental countries.

Growth between 1500 and 1800 was relatively slow, except for the countries bordering the North Sea. The story for the five centuries before 1500 may be very different though. It is plausible that English GDP per capita increased by as much as 50% during

the ‘crisis’ of the late Middle Ages (see Table 2), after a more modest increase of ‘only’ 10% per capita between 1086 and 1300. One wonders how exceptional this was.

There are different ways to address this issue. One way to approach it is to find out how typical Medieval England was; are there, for example, reasons to assume that English GDP per capita in 1086 was systematically higher or lower than on the Continent? There is no doubt that compared to the Low Countries and southern Europe (Italy, Spain, the Mediterranean in general perhaps) England in 1086 was a relatively backward country, although the difference was not that big when one compares England with Western Europe as a whole. Moreover, large parts of the Continent, such as Flanders and northern Italy, developed more rapidly during the High Middle Ages than England, which specialized on being a supplier of agricultural commodities (wool in particular) during the great boom of 1000-1300, whereas Flanders and northern Italy concentrated on industrial and tertiary activities with a higher value added. The result was probably that growth was more rapid in the latter regions.

Another way to approach the same problem is to estimate some kind of (subsistence) minimum below which income cannot fall. A reference point is Maddison’s estimate of British GDP per capita in 1820: 2121 (1990 international) dollars, the benchmark of Table 3. British GDP per capita at about 1500 was 910 dollars, and following the estimates presented in Table 2 this would be around 550 dollars in 1086. In a recent study of income and inequality in Byzantium around the year 1000 Branko Milanovic (2004) estimated that the absolute minimum level of GDP was probably about 400 (international 1990) dollars. This result seems plausible; English GDP per capita in 1086 would be about 40% above the subsistence minimum, which is consistent with the Campbell (2000) estimates that the value added of arable output would be about 55-60% of GDP. The level of GDP per capita of Western Europe

as a whole would probably be somewhat higher than that in England, say between 550 and 600 dollar. In the same study Milanovic also estimates the GDP per capita of Byzantium. He arrives at a figure of between 640 and 720 dollars, which sets the upper limit of European GDP because at the turn of the millenium Byzantium was probably the richest part of Europe. At about 1500 the average for Western Europe was about 1100 dollars (Table 3), which implies that it might have doubled in the preceding five centuries (the increase in England was more modest, from 550 to 910 dollars). Summing up, and taking into account that the two estimates used here to (of Campbell for England in 1086 and of Milanovic for Byzantium in 1000) are highly tentative, we can perhaps conclude that the five centuries before 1500 were more dynamic in terms of per capita growth than the three centuries after 1500.

## 3. Holland 1500-1800

How plausible are the results presented here? Are they consistent with other evidence on the long-term development of the European economy in these years? And what was driving growth in the two cases that were more dynamic, the Netherlands and England? To try to answer these questions, a number of experiments with a simple Cobb-Douglas production function were carried out to simulate the relationships between real wages, real rents (when data are available), population, labour input and land input.

The production function that is used has three inputs, land, labour, and capital, which are all assumed to be homogenous and unchanging in terms of quality (an assumption to which we will return). We start with Holland, an economy for which detailed estimates of the structure of GDP in 1510/14 and 1807/08 are available. It is

possible to estimate the share of each factor in GDP in 1510/14 (land .07, labour .60 and capital .33);[5] all simulations will be expressed in prices of that base period. Other ingredients of the model are:

- factor prices: estimates of real wages of an unskilled labourer per day (from Allen 2001) and of nominal and real rents (per hectare) (the latter deflated with a CPI) (Van Zanden, work in progress)
- factor inputs: an annual series of the cultivated land (Van Zanden, work in progress), and the population and the labour force (apart from the changes in the number of days worked per year, the ratio between labour force and population was assumed to be constant at 40%)
- the capital stock in the base period 1510/14 was estimated by assuming an average rate of profit/interest on capital stock of 12%, which in combination with a share of 33% of GDP accruing to capital resulted in an estimate of the capital stock in the base year; it was furthermore assumed that depreciation reduced the capital stock by 2.5% per year; additions to the capital stock were the results of investment expressed as a certain percentage of GDP (so the capital stock in year t+1 was 97.5% of the capital stock in year t plus gross investment during year t).

The instrument variables are:

- the share of GDP that was invested annually (the starting point here is level of 5%);[6]

[5] The average values for 1510/14 were estimated at 7% for land, 67% for labour and 26% for capital, but the share of labour tended to decline during the early modern period, so a slightly lower share was chosen for the simulation

[6] It was of course also possible to vary the rate of deprecation, which was now set at 2.5%; experimenting with this share had a similar effect as experimenting with different investment shares

- technological progress, which was Hicks-neutral, i.e. affected all factor contributions equally; the starting point was the hypothesis was that there was no technological progress;
- the number of working days per labourer; for Holland this variable was set at 200 before 1560, increasing gradually (under the impact of the Reformation and declining real wages) to 250 in 1660 (according to Noordegraaf 1985 58-61; see also De Vries and Van der Woude 1997: 616-7).

The model isolates two causes of long-term growth of real wages: capital accumulation and productivity growth. As the simulations will show, the re-investment share has generally only a limited effect on the long-term development of the economy (which is restricted by the share of capital in GDP). By definition, productivity growth translates itself directly in a proportionate increase in GDP and in real wages, and it therefore a much stronger candidate for explaining long-term change. The simulation can therefore help to answer the question when European countries began to experience sustained productivity growth: was this only during the Industrial Revolution of the second half of the18$^{th}$ century, or did periods of productivity growth occur already before 1750? Was, for example, the Dutch Golden Age characterized by 'modern' productivity growth as De Vries and Van der Woude have maintained, or was growth simply the result of a higher level of capital formation?

The third instrument variable (i.e. changing the relationship between labour input and population) makes it possible to bridge the gap that might arise between the development of real wages and the point estimates of GDP per capita (as will be explained below). It is also an attempt to test the hypothesis formulated by Jan de Vries (1994) that an 'industrious revolution' preceded the industrial revolution of the 18$^{th}$ century. He hypothesizes that labour input per capita increased strongly due to the fact

that men, women and children worked more days and hours per year than they did in the late Middle Ages.

The procedure has been as follows: the real wage as simulated by the model was compared to the real wage as estimated by Allen (2001), or rather the long-term pattern of the wage series as estimated by a second-degree polynomial; the instrument variables were manipulated in such a way that the development of the simulated real wage is almost identical to this estimated second-degree polynomial (it is in practice impossible to follow the ups and downs of the real wage curve itself, because the enormous fluctuations are driven by many erratic supply and demand-shocks). Figure 1 pictures the results.

Real wages decline between 1500 and the mid 1570s, thereafter there is a strong increase of real wages continuing until about 1710; during the second half of the 18th century real wages decline again. This pattern is simulated with different combinations of the investment share and the rate of technological progress. The model easily 'predicts' the decline of real wages during the first three-quarter of the 16th century when an investment share of 5% is used; declining capital stock and land per capita are the explanations for the decline. After the 1570s population growth accelerates, but real wages also start to increase, which clearly point to a (well known) break in economic development in these years (which has for example been analyzed by De Vries and Van der Woude as the Dutch 'take off'). It is this combination of rapid growth of population (and of the labour force – which may have increased even faster because immigration of young adults was a major factor contributing to the increase in population) and an increase in real wages (the magnitude of which is still being disputed however, see Van Zanden 2002a) which can – given the slow growth of the cultivated land – only be

explained by either a massive increase in the accumulation of physical capital and/or the growth of total factor productivity. The different combinations of investment ratio and the rate of productivity growth that produce almost identical results are: 12% and 0%, 10% and .1%, 7% and .25%, and 5% and .35%. Because it is likely that both the investment ratio and the rate of technological progress went up simultaneously during these years, a combination in the middle of this range (i.e. an investment ratio of 7% and an increase of productivity of .25%) was selected to run the simulation. Moreover, this hardly affects the growth path of GDP (per capita), because the wage income is a fixed share of GDP (and the labour supply is exogenously given); the real wage curve therefore directly determines the growth of GDP (see Figure 1).

The next turning point – again well known from the more qualitative literature – is the 1660s and 1670s, when the increase in real wages begins to flatten, whereas at the same time rapid population growth ends and the population of Holland even begins to fall. This could be simulated by assuming that technological progress comes to an end (in 1670), and that the investment ratio begins to fall from 7% in 1670 to 4% in 1750, after which it remains constant.

The following step in this exercise is that we can now derive estimates for the development of GDP (total and per capita) from the simulation. Figure 2 presents the results by comparing the simulated estimates of the development of GDP per capita in Holland with those of the Van Zanden 2001 dataset. According to this 'first round' simulation GDP per capita increased by 'only' about 30% between 1510 and 1805, less than the 50% which was the result of comparing the benchmark estimates. The long-term development of GDP per capita shows the same pattern, however: the simulation 'predicts' a decline of GDP per capita during the 16$^{th}$ century (consistent with the

stagnation of the point estimates), followed by a strong increase during the Golden Age (1580-1670) which is however less steep than the point estimates suggest.

**Figure 1 Real wages in Holland: estimated and simulated, 1510-1805 (indices 1510/14=100)**

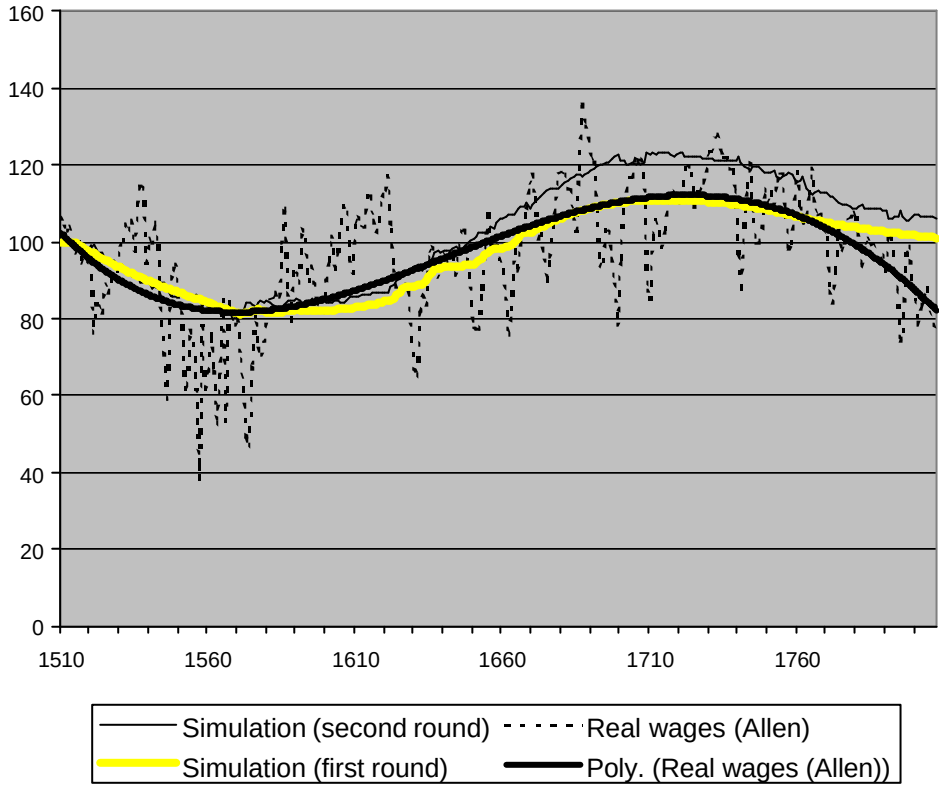
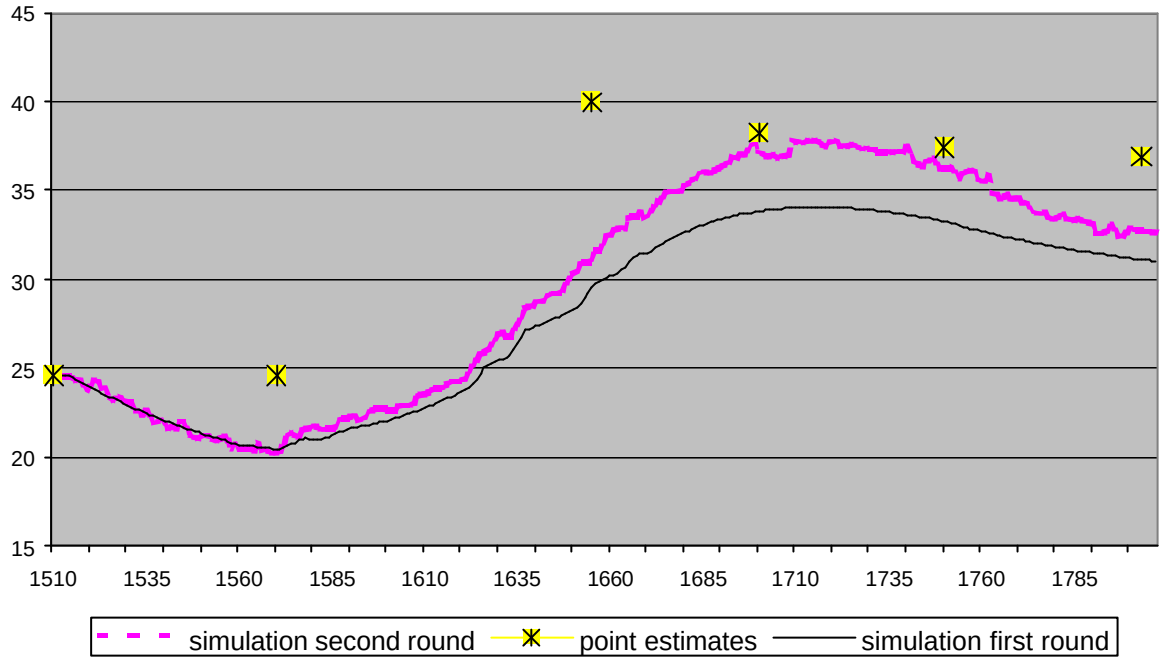


**Figure 2 GDP per capita: point estimates and simulations, 1510-1805**



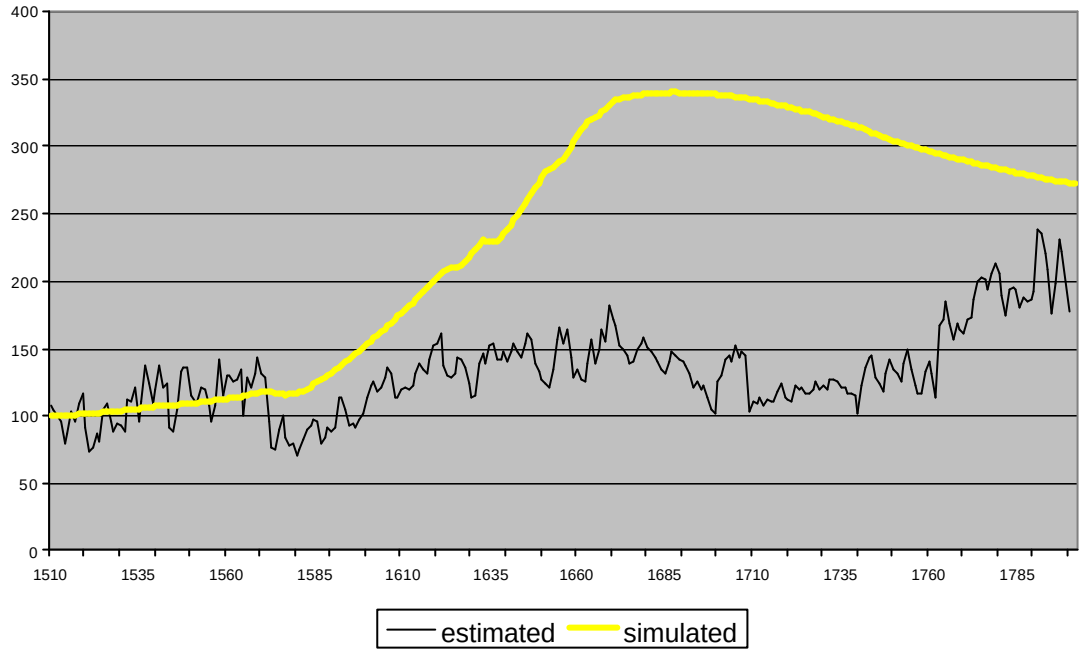

The difference between the point estimates and the simulation can be bridged by manipulating another instrument variable, the number of days worked annually. This instrument variable captures both quantitative and qualitative changes in the labour force. The quantitative dimension is a real increase of the number of hours worked per capita – via the lengthening of the working week (through, for example, the abolishment of holidays following the Reformation), or the increase of children and women's labour. Jan de Vries (1994) has suggested that during this period an 'industrious revolution' occurred resulting in a strong increase in per capita working hours, and the fact that simulated GDP per capita seems to grow much less than might be expected on the basis of the development of the real wage in this period can be interpreted as confirmation of his hypothesis. But qualitative changes much also be taken into account. The average quality of the labour force increased substantially during the same period; the share of

services in the labour force for example went up from 22 % in 1510/14 to 42 % in 1807/08, and a large part of this increase consisted of highly skilled and paid work by professionals, merchants, government employees etc. (but also the number of servants and soldiers grew); moreover, the relative pay of these professionals did probably also rise quite a lot. Also in industry the share of skilled workers may have increased, whereas branches mainly using unskilled personnel (fisheries, peat digging and agriculture) saw their relative size decline. These changes in the composition of the labour force are one of the reasons why indices of real wages – which are entirely based on the wages of construction labourers (or of agricultural labourers) – are not completely reliable guides to the long-term development of the wage income. Ideally, one would like to have a weighted average of wages of all members of the labour force. Assuming that the average 'quality' of the labour force increased by about 20-30% - which is probably still an underestimate - will already bring the two curves (of simulated GDP per capita and the point estimates of GDP per capita) quite close to each other.

Another limitation of the model is that it assumes a closed economy, which Holland clearly was not. Already at the beginning of the 16$^{th}$ century a large part of the food supply consisted of imported grains, and this share increased strongly in the next 150 years. The imports from the Baltic are a good index of these changes: they went up from 10.000 lasts (of about 2 tonne) representing about 25% of the total grain supply during the first decade of the 16$^{th}$ century, to more than 50.000 lasts between 1610 and 1650 (or more than 70% of supply – but part of its was re-exported). In return for these land-intensive imports, Holland exported large amounts of labour-intensive and capital-intensive products and services. It has been suggested that the economic development of Western Europe in the early modern period was facilitated by the fact that Holland and

(from the 18th century onwards) Great Britain had access to the 'ghost acreages' of northern Europe/the Baltic and their colonies (see the discussion in Pomeranz 2000). The simulation presented here can give an idea of the quantitative importance of these 'ghost acreages' by looking at the gap between the actual development of real rents (which is affected by these international trade flows) and the simulated rent following from the Cobb Douglas model assuming a closed economy. Unsurprisingly the simulated rent increases much more during the Golden Age than real rents (see Figure 3); in a closed economy real rents would have increased by almost 250% between 1500 and 1700, in reality they only grew by about 50%. Population decline and agricultural productivity growth during the 18th century did much to reduce the gap between the two series though (at about 1800 the Netherlands as a whole had become more or less self-sufficient again, but Holland was still a net-importer of grains).

**Figure 3 Real rent in Holland: estimated and simulated 1510-1800 (1510/14 = 100)**




To find out how much this may have affected growth, a second simulation was carried out with a recalculated series for the land input; the difference between the real rent and the simulated rent from the first simulation was taken as a measure of the 'ghost acreage', and another series of GDP and real wages was calculated with the new, larger land input. The 'second round' simulations in Figures 1 and 2 show that at their peak the impact of the 'ghost acreages' was about 10% of GDP per capita, and somewhat more in terms of real wages.

Summing up, the model can replicate the long-term development of the economy of Holland, identifying clearly the well-known turning points in the 1590s and 1660s quite well; between 1580 and 1670 there was a more or less constant rate of productivity growth and investment was probably higher than before and after. To get an increase in GDP per capita that matches the point estimates, one has to assume a

rather strong increase in labour input per capita – stronger than the assumption used here that it increased by 25% (from 200 to 250 working days per year). The model does have some problems with the openness of the Dutch economy; real rents are not simulated correctly, but this part of the experiment can give insight into the importance of 'ghost acreages' for economic growth.

## 5. England 1500-1800

The same procedure was applied to the English data. Obviously, the contribution of different inputs to GDP was different from the Dutch case, and was estimated at 20% for land (following Clark 2002), 30% for capital, and 50% for labour (rough estimates based on a.o. the social tables by King, as reconstructed by Lindert & Williamson).[7] The real wage series of unskilled labourers by Allen was again taken as a starting point. Estimates of population were supplied by Wrigley et al (1997), cultivated land was assumed to grow by 10% per century (Campbell and Overton 1996); the capital stock in 1500 was simply estimated on the basis of a share of 30% in GDP going to capital, and an average profit rate of 12%.

Figure 4 shows the degree of fit between the simulation and the estimated series of real wages that results from the following manipulation of instrument variables: in the sixteenth century the investment ratio was set at 4.5%, and there was no technological progress. This results in a slow decline of real wages as the per capita capital stock and in particular the per capita supply of land goes down. During the 1590s

[7] Assuming 250 days per annum, a participation ratio of 40% and a wage rate of an unskilled labourer of 14 d., the wage sum is exactly 50% of the total national income as estimated by Lindert and Williamson 1982.

things start to shift and the real wage begins to develop more favorably. The decline of real wages comes to an end, but population growth continues, a combination that is inconsistent with the previous specification of the model. As in the case of Holland, different combinations of an increased investment ratio and of productivity growth can generate the pattern that emerges at about 1600/1610. In the simulation presented here, we experimented with the variables that could be derived from growth accounting studies for the second half of the 18th century, which show that 1/ the capital stock per capita remained more or less constant and 2/ that the growth of total factor productivity was about .25 to .30 per annum (Crafts 2004 for an overview). Surprisingly, assuming the same variables (an investment ratio of 6.5% from 1590s onwards and a consistent increase in total factor productivity of .25% from 1615 onwards) gives an almost prefect simulation of the growth path of real wages during the 17th and 18th centuries. Keeping these two variables constant for the rest of the period produces the turning point in the early 1600s, an increase in the simulated real wage between the 1610 and the 1750s of about 50%, and stabilization of real wages during in the second half of the 18th century (when population growth accelerates again). After 1750 the Allen series is rather pessimistic however (I have to assume a decline in investment ratio or in technological progress to get the same result); Feinstein's more comprehensive series shows a stabilization between 1750 and 1800 which is similar to the simulation results presented here (Feinstein 1998).

In order to get a development of GDP per capita which is more or less consistent with the available point estimates a very strong increase in labour input per capita has to be assumed. Figure 5 presents the result of this part of the simulation, assuming a linear

increase of working days per year from 200 in 1500 to 350 in 1800.[8] It should again be pointed out that this increase consists of a qualitative and a quantitative component. England seems to be the heartland of Jan de Vries' industrious revolution, where the labour force grew much more rapidly than total population as a result of a strong increase in (a.o.) the labour input by women and children. As a result, in the early 19th century the ratio between labour force and population was in Great Britain was much higher than elsewhere (ca 45% against 41% in the Netherlands and 35% in the United States). Of course, at the same time the structure of the labour force changed dramatically, the share of agriculture going down from more than 70% in 1500 via 55% in 1700 to 35% in 1800 (Allen 2000), which must have had similar effects on the quality of the labour force as we discussed for Holland.

These simulations clearly show that, if real wages are a reliable guide to macro-economic performance, the transition towards 'modern economic growth' of the English economy did not occur during the 18th century, but at some point between the 1590s and the 1620s, when it moved from what was basically a trajectory without technological progress to one with a higher level of investment and a more or less constant rate of productivity growth. The fact that this occurred during the same years as the 'take off' of the Dutch economy is striking; the big difference is, of course, that productivity growth was sustained into the 18th century and beyond. What is perhaps equally striking is that productivity growth did not accelerate during the 18th century. I added in Figure 5 a similar pattern of growth that emerged from another experiment in simulating growth using a regression model with real wages and the degree of structural transformation of

[8] This assumption has of course also consequences for the modeling of real wages; the development of the instrument variables discussed in the previous paragraph (an increase of the investment ratio from 4.5% to 6.5% after 1590 and a continuous rate of productivity growth after 1615 of .25%) are from the same simulation in which the increase of the number of working days from 200 to 350 is assumed; if one drops this assumption and only assumes that is increased from 200 to 250 the other instrument variables become 6% after 1590 and .2% technological change.

the economy as independent variables (described in Van Zanden 2004). Experimenting with this ‘model’ also pointed to a relatively early start of ‘modern economic growth’ in England – at some point during the 1610s or 1620s. As I have argued elsewhere, there can be no doubt at all that the English economy grew at an exceptional rate, precisely in the centuries leading up to 1800 while its growth in the two centuries after 1800 has not been so unique (see also Wrigley 2000). It is perhaps an irony that the country which has provided the model for the classical `Industrial Revolution' - the decisive break between a stagnating agrarian society and a dynamic industrial economy - was in fact characterized by such dynamism in the centuries preceding this `revolution'. From this research it would appear that the `Industrial Revolution' of the second half of the 18th century was no `accident', as Crafts would have us believe (Crafts 1977), but was the logical continuation of the exceptionally dynamic development of the British economy in previous centuries.

**Figure 4 England: real wage, simulated and estimated, 1500-1800 (1500=100)**

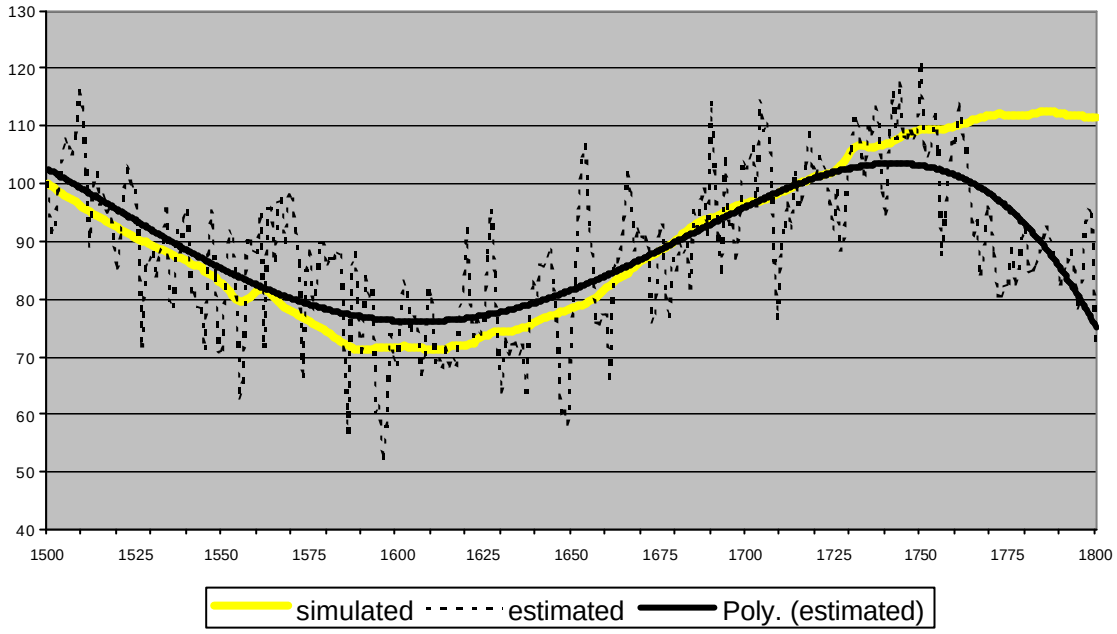
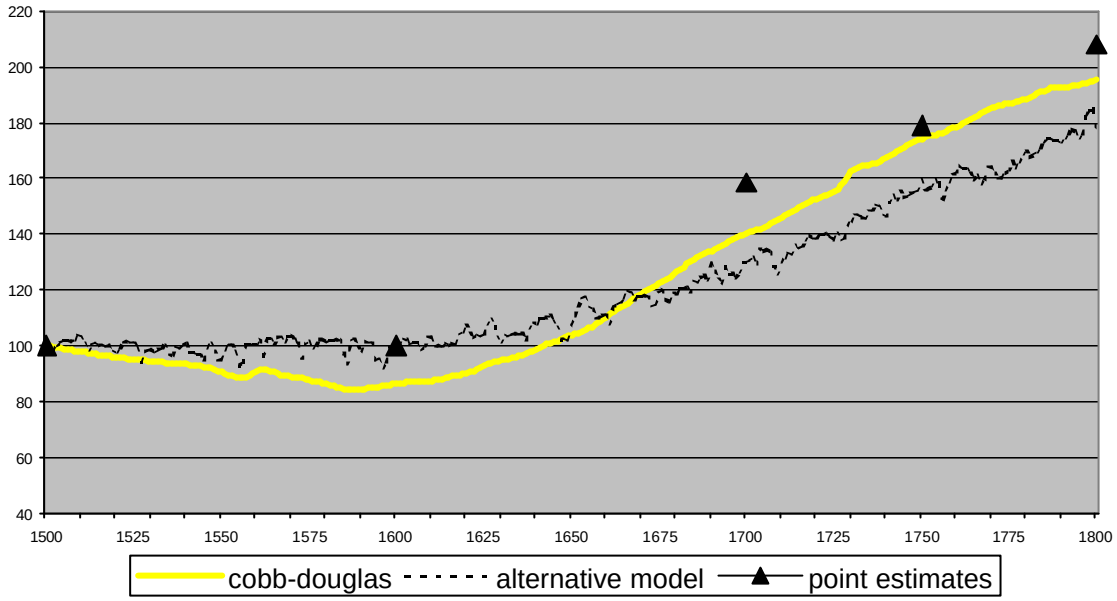


**Figure 5 English GDP per capita: point estimates and simulated values, 1500-1800 (1500=100)**

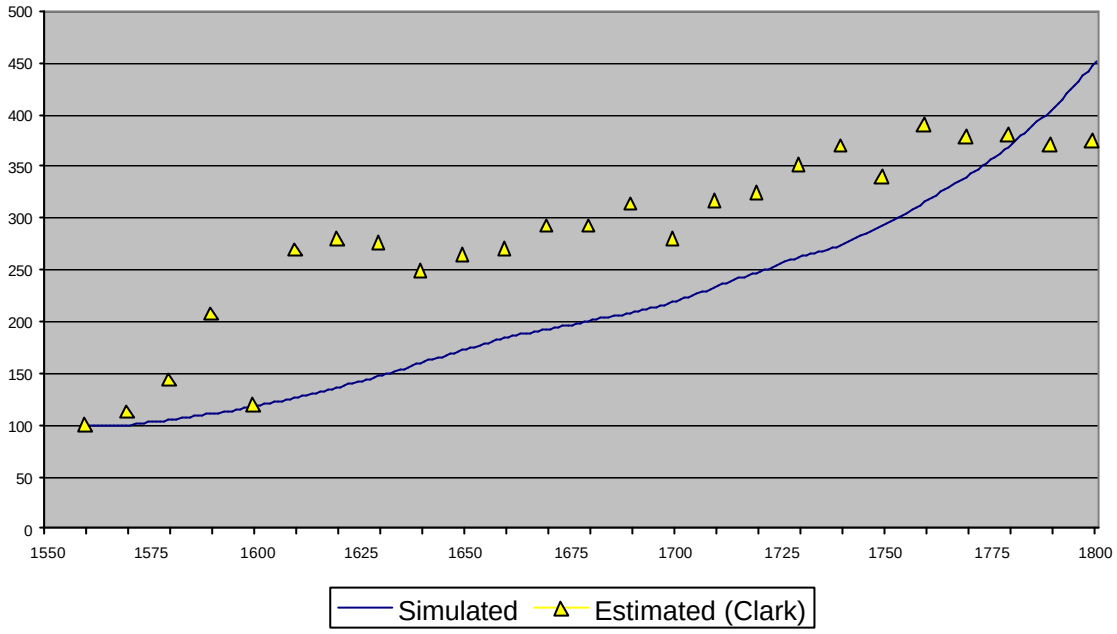



Did England also profit from access to ghost-acreages? Figure 6 compares the series of real rents as simulated by the Cobb-Douglas production function with the estimates presented by Gregory Clark (2002). During much of the 16th and 17th centuries the two series run more or less parallel; England was an exporter of agricultural commodities until the middle of the 18th century, but these exports were a much smaller fraction of supply or demand than in the case of Holland. This changed during the second half of the 18th century, when it became a large net importer of grains (from the Baltic), colonial products such as sugar and tea from the colonies, and, after 1780, of cotton from the America. These developments are accurately reflected in the ratio between simulated and real rents, and this comparison therefore adds credence to the approach developed here.

Between the mid-18th century when agricultural trade was probably more or less in equilibrium, and 1800 the ratio between simulated rents and real rents increased by

almost 40%, which is an index of the degree to which England profited from ghost acreages. Given a share of 20% of land in GDP (which was assumed for this simulation), this would add about 7% to GDP, but this 20% share is probably accurate for the 16th and early 17th century and does not really reflect the changing structure of English GDP thereafter (the share of agriculture in GDP was only 27% in 1800, and the share of land cannot have been more than half that amount, say 10-12%, so the extra GDP will have been less than 4.5%). Of course, as in the case of Holland, these are upper-bound estimates, the result of the assumption that as a result of international trade these countries acquired extra land as a free lunch, because we simply added ghost acreages to the inputs in the production function. In reality, there are no free lunches, and the services of this extra land were bought by selling capital- and labour-intensive products to the land-abundant countries and colonies. This solved bottlenecks, and made it possible to continue growing in spite of the 'Malthusian' constraints, but the gains must have been much smaller than the estimates presented here.

**Figure 6 English land rent: simulated and estimated, 1550/59-1790/99 (in constant prices, 1550/59=100)**




## 6. England 1300-1500

Allen also offers a real wage series for England 1300-1500 that can be used for simulating growth in the late Middle Ages. The idea that the increase of real wages in the period after the Black Death points to an increase in productivity and GDP per capita is now new (see Epstein 2001), but has not been tested in this way. I changed the shares in GDP somewhat by augmenting the share of land to 30% (consistent with Campbell 2005), brought capital down to 20% and kept labour at 50%. Capital stock in 1300 was again estimated on the basis of the share of capital in GDP, and an assumed profit rate/interest rate of 20% (higher than the 12% assumed for the post 1500 period). A population series was taken from Clark (2004); it shows an almost continuous decline

of the population from the 1310s onwards; only during the second half of the 15th century did English population stabilize at slightly more than 40% of the 1300 level.[9] It was also assumed that the strong increase in real wages led to a reduction of working hours and days (from 250 days per year before 1348 to 200 days after 1400). The estimates of the cultivated land were derived from Overton and Campbell (1996), according to whom it shrank by about 10% between 1300 and 1380 (a decline that was assumed to have taken place between 1348 and 1380).

The simulation presented in Figure 7 starts with the assumption of a 4.5% investment share, which basically remains unchanged between 1300 and 1500; the underlying idea was that – because the ratio between capital stock (and land) and population did improve much in these two centuries – incentives for increasing the investment ratio were not strong (although, at the same time, the interest rate also went down, which may have favored investment). In order to get the strong increase in real wages that is characteristic of this period, between 1348 and 1430 a constant rate of productivity growth of .30 % has to be assumed; the increase in total factor productivity during the whole period is almost 30%. This estimated growth total factor productivity is obviously dependent on the exact specification of the parameters of the Cobb-Douglas production function, and in particular of the share of labour in GDP. The preferred simulation is based on a 50% labour share, which might be too low.[10] Increasing the share of labour in GDP results in even higher estimates of productivity growth between 1350 and 1430; a 75% share, for example, is consistent with an .50%

[9] Linking his series to an estimated total English population of 2,5 million in 1500 gives a population estimate of 5,3 million in 1300, which is higher than the estimates by Campbell which I adopted for Table 1; perhaps the Clark series is overestimating the population decline, but it is not possible To Whom It May Concern: correct for this; if the actual decline of the population was less than Clark's series suggests, the model would 'predict' an even milder increase in real wages than actually occurred, suggesting that productivity growth in that scenario would have been even higher than in the simulation presented here.

[10] Based on an average daily wage of 1.5 d., a 40% labour force participation rate and 250 working days per annum, the total wage sum for the 1290s can estimated at 2,7 million pounds, or 74% of the estimated GDP according to Table 1

rate of productivity growth. Experimenting with a lower share of labour in GDP gives results with very low or even zero productivity growth – the latter is consistent with a share of labour in GDP of 40%. The most plausible scenario seems to be that the radical changes in relative prices that occurred after 1348 – and in particular the strong rise of real wages – resulted in the search for new technologies, a search that led to a substantial increase in total factor productivity (see Mokyr 1990 for a discussion of the technological dynamism of the late Medieval period).

The estimates of the development of GDP per capita that result from the preferred experiment (with a 50% labour share) are presented in Figure 8; varying the share of labour in GDP does not affect the increase in GDP per capita, though; also in the other experiments does GDP per capita increase substantially between 1300 and 1450. Such an increase is quite striking, and is even faster than the point estimates suggested. Characteristically, the increase of about 70% during these two centuries more or less mirrors the decline of population numbers (by almost 60%). Had we assumed that the number of working days per year remained constant between 1300 and 1500 (instead of a decline by 20%), the increase of GDP per capita would have been even larger (in such a scenario one has to assume a constant rate of productivity growth of .40% between 1349 and 1440 to get the best fit; GDP per capita increases by more than 100% in this version of the model). All these simulations lead to the conclusion that there was strong productivity growth in England between c. 1350 and c. 1450 – but also that after the middle of the 15$^{th}$ century this 'technological transition' came to an end. The net result was a much higher GDP per capita, and probably some reduction in working hours.

**Figure 7 English real wages: simulated and real, 1301-1500 (1300=100)**

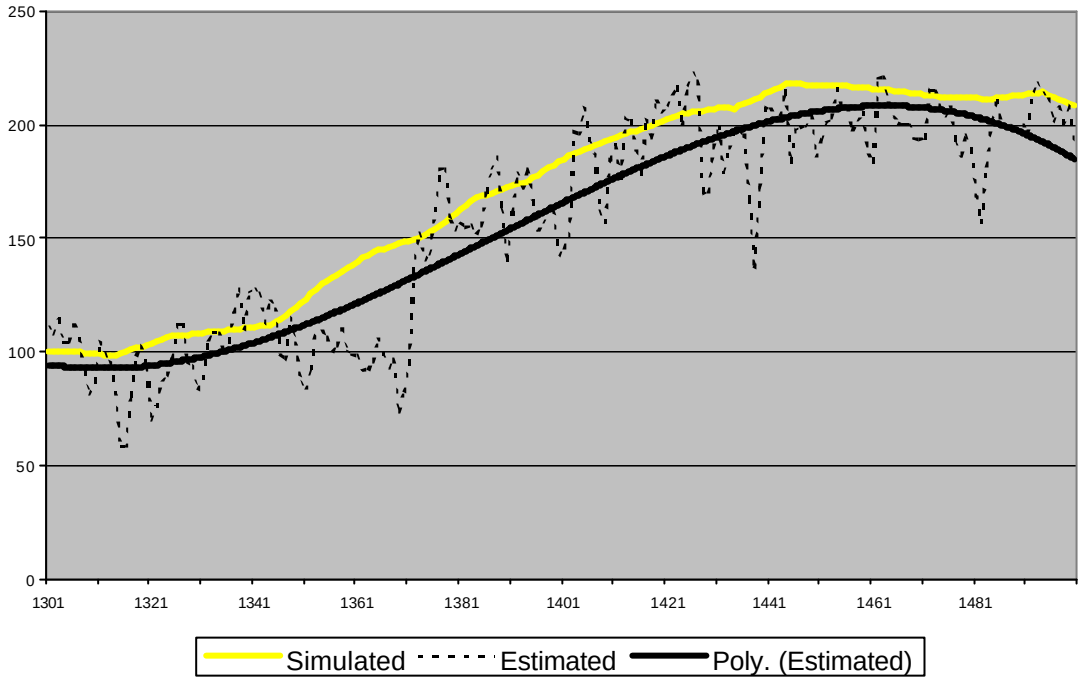
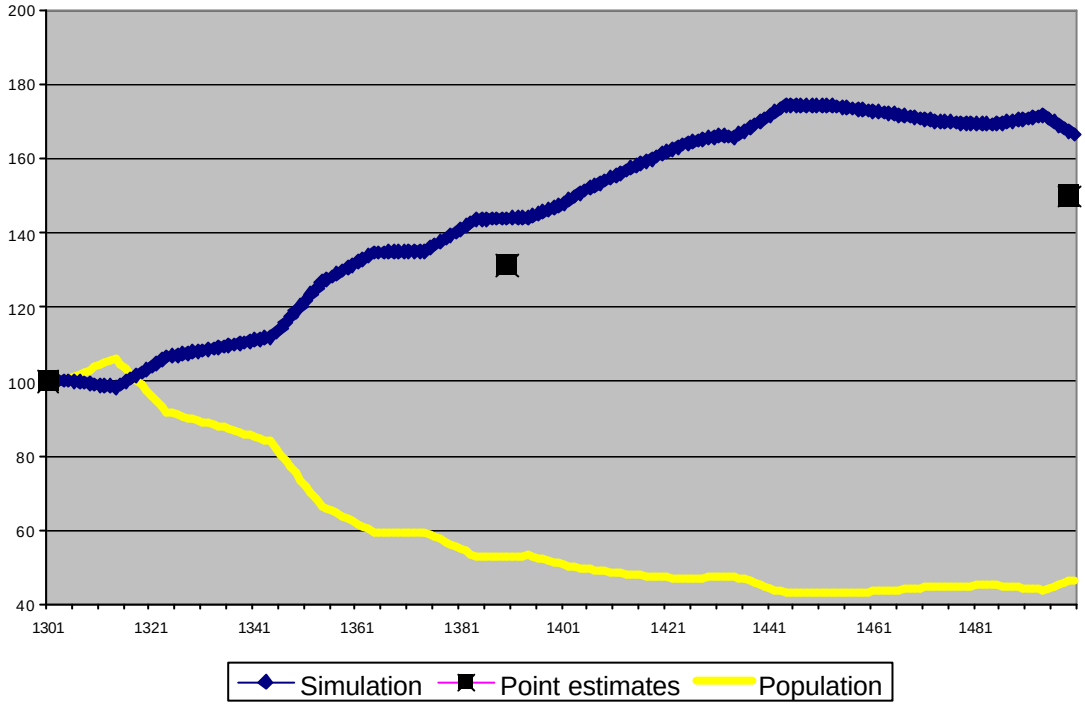


**Figure 8 English GDP per capita (simulation and point estimates) and English population, 1301-1500 (indices 1300=100)**



**7. Italy 1300-1800**

The same experiment was carried out for Italy, for which we have the point estimates of GDP and population by Malanima (1998, 2003). Because his estimates relate to northern Italy, we are dealing with a relatively urban society here, in which land played a smaller role than in England. Italy was also more or less self-sufficient in foodstuffs, which means that we probably do not have the problems encountered in the case of Holland. I assumed shares in GDP of 15% for land, 60% for labour, and 25% for capital, but also experimented with a model with radically different shares (25%, 40% and 35% respectively) to find out how sensitive the estimates are for this assumption. Cultivated land remained basically unchanged between 1300 and 1800, the labour input increased with population (and I experimented with a decline of working days from 250 to 200 between 1350 and 1450 followed by an increase from 200 to 250 between 1500 and 1600), and the capital stock in 1300 was determined by its share in GDP of 25% (or 35%) and an interest rate of 20%. For the first decades of the 14$^{th}$ century the Allen (2001) wage series (which begin in 1326) was supplemented by the wage series published by Malanima (2004).

Figure 9 presents the result of the simulation: real wages rise in the second half of the 14$^{th}$ and first half of the 15$^{th}$ century by about 60% on average (less than in England), and begin to fall after c 1450, a decline that is almost continuous but slow until about 1750, and accelerates in the second half of the 18$^{th}$ century (according to Malanima (2004) the Allen estimates overestimate the decline after 1750 however). This pattern can be matched by the model assuming 1/ that the investment rate was 4,5% initially en 2/ that between 1348 and 1400 there was continuous growth of total factor productivity of .40 % annually, the rate of which fell constantly to zero between

1400 and 1450, and 3/ that after 1450 the investment share also declines to a mere 1 % of GDP, at which very low level is remains until the end of the 18th century (and, if the simulation was to follow the sharp decline of real wages after 1750, investment would have to fall to less than that, but in the results presented here investment remains at 1%). The alternative experiment (with a much lower share of labour in GDP) started with the same assumptions, but needed a more modest rate of technological progress after 1340 (of .20% between 1349 and 1420) and a slightly higher level of gross investment after 1450 (of 2% annually); the second experiment may therefore be somewhat more realistic.

Figure 10 pictures the resulting estimates of GDP per capita (of the two experiments). In the very long run both sets of estimates seem to concur, but the model in both cases predicted a strong increase in the sixty to eighty years after the Black Death, which is missing from the Malanima estimates. Between 1450 and 1550 the Malanima estimates and the results of the Cobb Douglas simulation converge again, and for the rest of the Early Modern period the two approaches give more or less similar results (but note that if the simulation had followed the decline of real wages after 1750 according to the Allen estimate more closely, the fall in GDP per capita had been larger than Malanima (2003) estimated). Differences with England in the same period are striking: there the increase in real wages is higher (but the population decline is also larger: almost 60% in England versus less than 30% in Italy), and real wages remained on a relatively high level until the first quarter of the 16th century, whereas in Italy they declined strongly after 1450. This is also reflected in different trajectories of GDP per capita: in England the growth between 1350 and 1450 resulted in more or les permanently higher income levels, whereas in Italy the gains were not consolidated after 1450. Apparently, during the century or so after the Black Death (northern) Italy was a

very dynamic economy, with a consistent rate of productivity growth for 70 to 100 years, but this dynamism completely disappeared after c 1450. By contrast, England remained very dynamic in the long run, and per capita growth was 'only' interrupted by the population explosion of the 16$^{th}$ century. After about 1600 the same dynamism (in terms of the growth of total factor productivity) returned in England (and the Netherlands), whereas no such thing happened in Italy (and in other European countries).

**Figure 9 Italy: real wages, simulated and estimated, 1300-1800 (indices 1300=100)**

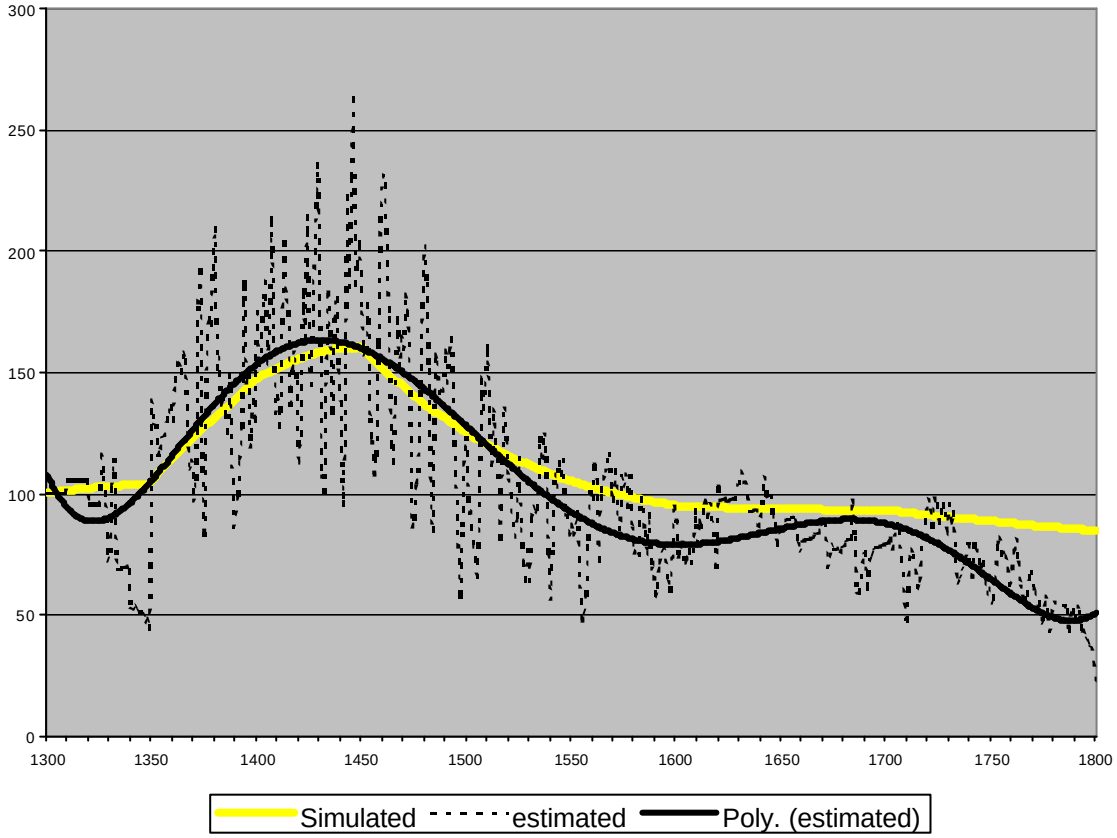
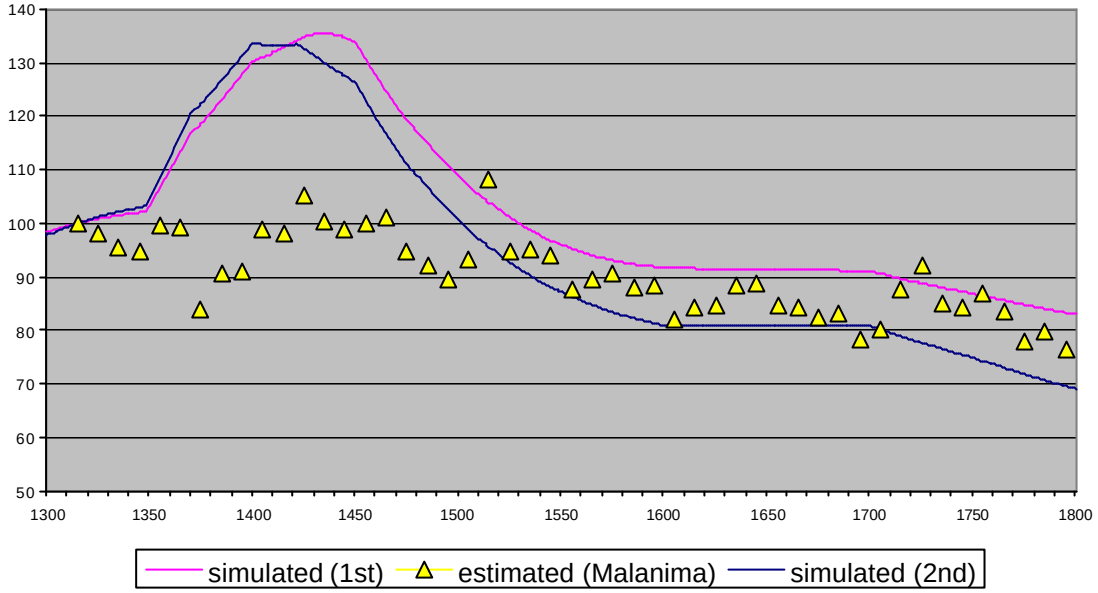


**Figure 10 Italy: GDP per capita estimated and simulated, 1300-1800 (1310/19=100)**




## 8. Europe 1500-1800

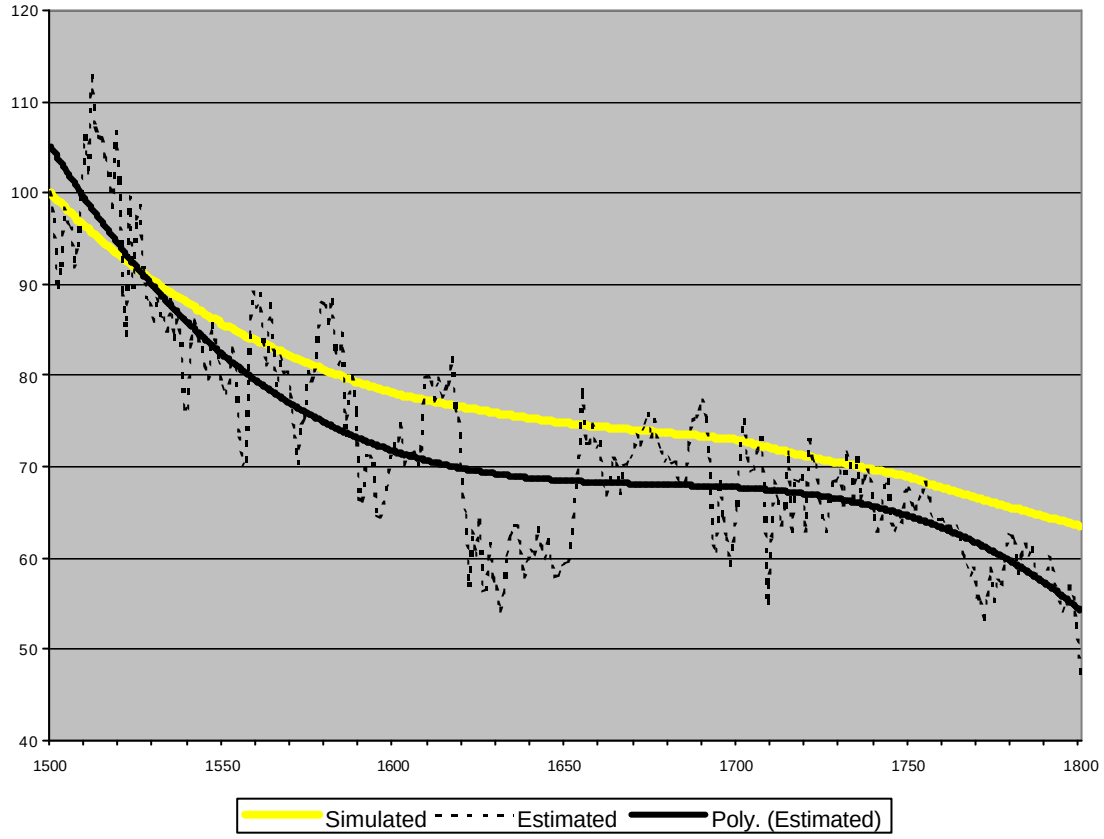
The three countries this paper concentrated on so far, are all rather exceptional: Italy because of its strong long-term decline, Holland and England because of their dynamic development. In between these two extremes were the other European countries, of which the GDP per capita may not have changed very much between 1500 and 1800. In principle the experiment can be carried out for all countries for which we have long-term series of real wages and population estimates, but in order to make a long story short, I experimented with Europe as a whole only. Allen 2001 has estimates for the development of real wages in (capital cities of) Italy, Spain, France, Austria, Germany, Poland, the Low Countries and Great Britain, which can be weighted with their respective populations (taken from Allen 2000) to get a series for real wages in Europe.

The following standard assumptions are used in this version: share of labour 60%, of capital and land both 20%; cultivated land increases by 5% per century; capital stock is estimated on the basis of an interest rate in 1500 of 12%; working days per annum increases from 200 in 1500 to 300 in 1800.

The results are presented in Figure 11; this simulation assumes a very low investment ratio (of only 2%), and no technological change. The general pattern of the simulation is rather similar to that of the estimated wage series: rapid decline during the 16th century, stabilization between 1600 and 1750, followed by another decline after about 1750. The long term development of European wages seems to follow a path that can be simulated by a Cobb Douglas production function assuming no technological change and a very low level of new capital formation; the different phases of population growth (in the 16th century and after 1750) then produce the pattern estimated by Allen. It is also clear that the divergent development of real wages in England and Holland – where wages began to rise again during the 17th century as a result of productivity growth – has a very limited impact on the European average. The reason for this was that their combined population was quite small, although as a share of European population it grew from slightly less than 6% in 1500 to 9% in 1800.

Estimates of the development of European GDP per capita that can be derived from this experiment all give a rather bleak picture: assuming a 50% increase in working days per annum over the whole 1500-1800 period gives an in the long run almost flat curve (Figure 12), with some decline during the 16th century and a small recovery in the next 150 years. In order to get a little per capita growth (consistent with the estimates of Table 3), one has to assume an even larger increase in labour input per head of the population, which is unlikely to have occurred however.

**Figure 11 Europe, real wage: estimated and simulated, 1500-1800 (indices 1500=100)**

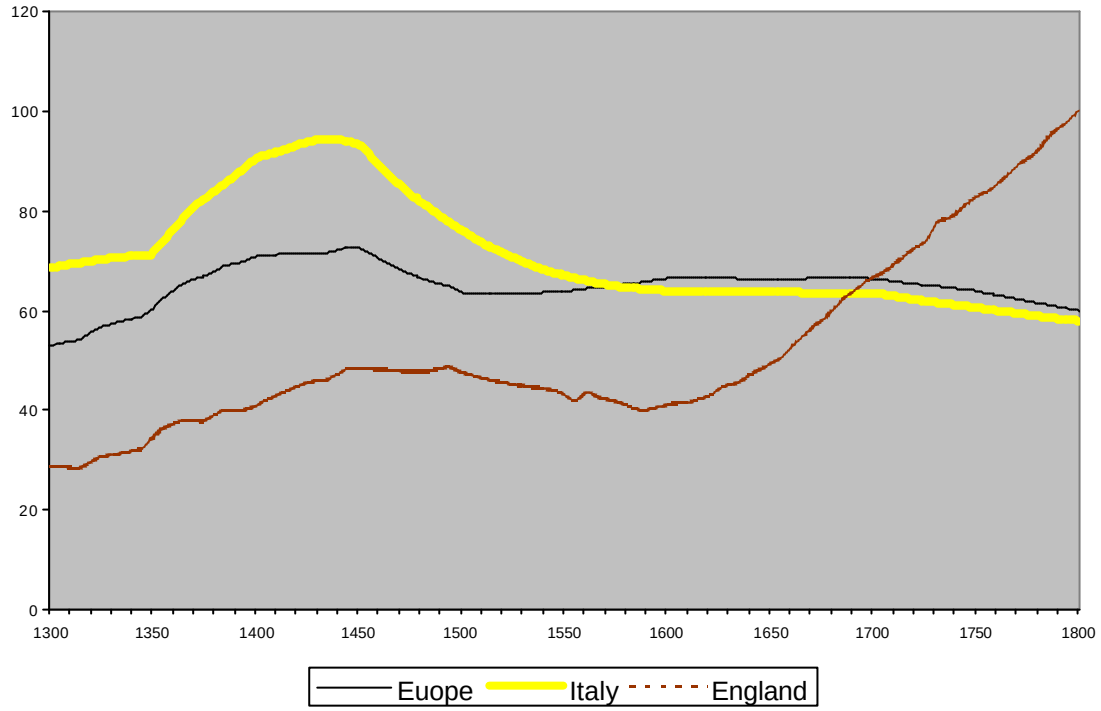



## 9. Conclusion

This paper presented a synthesis of recent research into the long-term development of a number of European economies in the centuries before the Industrial Revolution, and an attempt to find out if these estimates are consistent with the (more detailed) evidence that we have on the evolution of real wages, population, labour input, land input and real rents, given the assumptions of the Cobb Douglas production function. The overall conclusion is that these estimates are indeed consistent with this evidence, although a

few times we had to assume quite substantial increases in the quality and per capita quantity of the labour input to get reconciliation between the real wages series and the GDP estimates. This would be much more difficult with the estimates published by Maddison, which generally show much higher rates of economic growth. For Europe as a whole, for example, Maddison estimates a 56% increase in per capita GDP between 1500 and 1820, which is not consistent with the decline of real wages occurring in the same period (even my much more modest estimates of 10-25% growth are at the limit of what might be consistent with the real wage data). The same applies to his assumption that in the same period income levels in the Netherlands increased by 140% (against my 50% estimate); especially the near doubling of per capita GDP between 1500 and 1600 is difficult to reconcile with the decline of real wages (and the near constancy of real rents) during this century.

**Figure 12 Simulated GDP per capita: Europe, Italy and England, 1300-1800 (England in 1800=100)**




The results of the experiment with the Cobb Douglas production function can be summarized in Figure 12 and Table 4 (I added guestimates for Europe as a whole for the 1300-1500 period, based on an average of the wages in Italy and England). The contrasting long-term trajectories of Italy and England are quite clear from this comparison (which is consistent with the estimates presented in Table 3). Before 1550 Italy has a (much) higher income level than the rest of Europe, and even at about 1600 it is still considerably richer than England. The latter country has its transition to 'modern economic growth' during the first half of the 17$^{th}$ century, when the rest of Europe (with the exception of the Netherlands) stagnated after the decline due to Malthusian forces during the 16$^{th}$ century.

Table 4 Estimates of the growth of GDP and GDP per capita in Europe, 1300-1800 (in average annual growth rates)

| | 1300-1350 | 1350-1450 | 1450-1600 | 1600-1700 | 1700-1800 |
|---|---|---|---|---|---|
| Italy, GDP | 0.07 | 0.06 | 0.01 | 0.00 | 0.23 |
| Italy, GDP p.c. | 0.09 | 0.26 | -0.25 | -0.01 | -0.09 |
| England, GDP | -0,25 | -0,20 | 0.29 | 0.71 | 0.91 |
| England, GDP p.c. | 0.37 | 0.34 | -0.11 | 0.49 | 0.41 |
| Europe, GDP | -0.04 | -0.14 | 0.14 | 0.09 | 0.28 |
| Europe, GDP p.c. | 0.27 | 0.18 | -0.06 | 0.00 | -0.10 |

Source: see text.

Potentially even more interesting are the new insights that this experiment has produced. It was possible to identify a number of periods during which there was a more or less sustained increase in total factor productivity: Italy and England during the century or so after the Black Death, England again after the 1610s (and, strikingly enough, unchanging in tempo between the 1620s and 1800), and Holland between the 1590s and 1670s (and it is probable that a similar process of productivity growth occurred in Holland between 1350 and 1450, see Van Bavel and Van Zanden 2004). In the rest of Europe there was no similar increase in productivity between 1500 and 1800; in fact, income levels could only be maintained because of increases in labour input per capita.

This experiment also threw some light on the importance of 'ghost acreages' for economic growth in the core countries around the North Sea. For England, a net exporter of agricultural commodities before 1750, this was not an important source of

growth. Only after 1750 did imports of agricultural goods (foodstuffs and cotton) contribute (a bit) to solving the land constraint, but the overall effect on GDP was limited to a few percent. For Holland the story is clearly different, and international trade – access to foodstuffs and building materials from the Baltic in particular – was essential for its development. A very rough simulation of this effect leads to the conclusion that these 'ghost acreages' may have increased the level of GDP by perhaps as much as 10% at the economic peak of the region in the second half of the 17th century.

The contrast between the North Sea region (Holland and England) and the rest of Europe that is well known from the literature and from the real wage study by Allen (2001), who even used the term 'great divergence' to describe it, is also very clear from this attempt to measure GDP growth. The consistent strong performance of England is perhaps the most striking result, but also the near stagnation of the rest of Europe demands explanation. Why were most Europeans, in view of the absence of productivity growth, unable to improve their institutions, technologies and the quality of their inputs in a systematic way between 1500 and 1800? Why did the incentives created by a market economy not produce a systematic search for more efficient solutions – or why was this search so relatively fruitless? Or is such a pattern normal, similar to what can be observed in other highly developed societies such as China, India, or the Ottoman Empire during the Early modern period. This 'normal' pattern has been coined Smithian growth, characterized by an increase of population and income, driven by the expansion of markets and related processes of specialization and urbanization, but without the qualitative leaps of sustained productivity growth which can be found in parts of Europe after the Black Death and during the 17th and 18th centuries (see Bin Wong 1997).

Another series of questions is related to what happened in other European countries before 1500. Was, for example, the increase in productivity growth found in Italy and England (and possibly in Holland) a pan-European phenomenon? Our brief excursus into the Medieval period already suggested that the GDP growth found in England – an increase of per capita GDP of as much as 50-60% between 1086 and 1500 – was probably normal; in fact, large parts of Europe may have developed more rapidly during the high Middle Ages. Why did growth stop? What happened in northern Italy during the 15$^{th}$ century that its economy almost came to a standstill, after it had been perhaps the most dynamic region in the previous centuries (see Epstein 1991 for an interpretation)?

References

Allen, R.C., 2000. Economic structure and agricultural productivity in Europe, 1300-1800. European Review of Economic History, 4, pp. 1-27.

Allen, R.C., 2001. The great divergence in European wages and prices', Explorations in economic history, 38, pp. 411-47.

Bavel, J.P.B. van, and J.L. van Zanden, 2004. The Jump-start of the Holland economy during the late Medieval crisis, c. 1350 – c. 1500. Economic History Review, LVII.

Blomme, J., and Van der Wee, H., 1994. 'The Belgian economy in a Long-Term perspective', in A. Maddison and H. van der Wee, Economic growth and structural change. Comparative approaches over the long run on the basis of reconstructed

natinoal accounts. Eleventh International Economic History Congress Milan 1994, session B 13.

Campbell, B.M.S., 2000. English Seigniorial Agriculture 1250-1450. Cambridge University Press, Cambridge.

Campbell, B.M.S., 2005. England circa 1290. A view from the Periphery. Unpublished paper, Belfast.

Carreras, A., 2003. Modern Spain. In J. Mokyr et.al. (eds.) The Oxford Encyclopedia of Economic History. Oxford U.P., Vol 4, pp. 546-53.

Clark, G., 2002. Land rental values and the agrarian economy: England and Wales, 1500-1914. European Review of Economic History, 6, pp. 281-309.

Clark, G., 2004. The long march of history: farm laborers' wages in England, 1209-1869. Unpublished paper, Davis.

Crafts, N.F.R., 1977. Industrial Revolution in Britain and France: some thoughts on the question "Why was England First". Economic History Review 30, pp. 429-41.

Crafts, N.F.R., 1985. British Economic Growth during the Industrial Revolution. Clarendon Press, Oxford.

Crafts, N.F.R. and C.K. Harley, 1992. Output Growth and the British Industrial Revolution: a restatement of the Crafts-Harley view. Economic History Review 45, pp. 703-730.

Deane, P. and W.A. Cole, 1962. British Economic Growth 1688-1959. Trends and Structures. Cambridge University Press, Cambridge.

Epstein, S.R., 1991. Cities, Regions and the Late Medieval Crisis: Sicily and Tuscany compared. Past and Present, 130, pp. 3-50.

Epstein, S.R., 2001. The late medieval crisis as an 'integration crisis'. In M. Prak (ed.) Early Modern Capitalism. London: Routledge, pp. 25-51.

Federico, G., 2002. The world economy 0-2000 AD: a review article. European Review of Economic History, 6, pp.111-121.

Feinstein, Charles H., 1998. Pessimism perpetuated: real wages and the standard of living in Britain during and after the industrial revolution, Journal of Economic History, 58, pp. 625-58.

Harley, C.K., 1993. Reassessing the Industrial Revolution. In J. Mokyr (ed.) The British Industrial Revolution. Westview, Boulder, pp. 171-226.

Krantz, O., 2004. An estimate of Swedish GDP in 1571, in S. Heikkinen and J.L. van Zanden (eds.) The experience of economic growth. Aksant, Amsterdam, pp. 105-131.

Lindert, P.H. and J.G. Williamson, 1982. Revising England's social tables 1688-1812. Explorations in Economic History, 19, pp. 385-409.

Maddison, A., 2001. The world economy: a millennial perspective. OECD, Paris.

Maddison, A., 2003. The world economy: historical statistics. OECD, Paris.

Maddison, A., 2004. Macromeasurement before and after Colin Clark. Working paper at http://www.eco.rug.nl/~Maddison/articles/colin_clark.pdf

Malanima, P., 1994. Italian Economic Performance, 1600-1800, in A. Maddison and H. van der Wee (eds.), Economic growth and structural change. Comparative approaches over the long run on the basis of reconstructed national accounts. Eleventh International Economic History Congress Milan 1994, session B 13.

Malanima, P., 1998. Italian cities 1300-1800. A quantitative approach. Rivista di storia economica, XIV, 2, pp. 91-126.

Malanima, P., 2003. Measuring the Italian economy, 1300-1861. Rivista di storia economica, XIX.

Malanima, P., 2004. Labour, Productivity, Wages in Italy 1270-1913. Paper for conference 'Towards a global history of prices and wages' Utrecht 2004.

Mayhew, N., 1995. Modelling medieval monetisation. In Richard H. Britnell and Bruce M.S. Campbell (eds.) A commercialising economy. England 1086 to c. 1300. Manchester University Press, pp. 55-78.

Milanovic, B., 2004. An estimate of average income and inequality in Byzantium around the year 1000. Working paper; Economics working paper archive, available at http://ideas.repec.org/p/wpa/wuwpeh/0501003.html#download

Mokyr, Joel, 1990. The lever of riches. Technological creativity and economic progress. New York, Oxford U.P.

Officer, L.H.. n.d.. What was the UK GDP then? A data study. Working paper available at http://www.eh.net/hmit/ukgdp/ukgdpstudy.pdf

Overton, M. and Campbell, B.M.L., 1997. Production et productivité dans l'agriculture anglaise, 1086-1871. Histoire et Mésure, 11, pp. 255-97.

Pomeranz, K., 2000. The Great Divergence. China, Europe and the Making of the Modern World Economy. Princeton U.P.

Snooks, G.D., 1990. Economic Growth During the Last Millenium: A Quantitative Perspective for the British Industrial Revolution, Working Paper in Economic History no. 140, Australian National University.

Snooks, G.D., 1994. Great waves of economic change, in Snooks (ed.) Was the Industrial Revolution necessary? London, pp.43-79.

Snooks, G.D., 1995. The dynamic role of the market in the Anglo-Norman economy and beyond, 1086-1300. In Richard H. Britnell and Bruce M.S. Campbell (eds.) A commercialising economy. England 1086 to c. 1300. Manchester University Press, pp. 27-55.

Vries, J. de, 1984.The decline and rise of the Dutch economy 1675-1900' in G. Saxonhouse and G Wright (eds.) Forms and methods in economic history: essays in honor of William N. Parker, Greenwich, pp. 149-189.

Vries, J. de, 1994. The Industrial Revolution and the Industrious Revolution. Journal of Economic History 54, pp. 249-70.

Vries, J. de and Van der Woude, A., 1997. The first modern economy: success, failure, and perseverance of the Dutch economy, 1500-1815. Cambridge 1997.

Wong, R. Bin, 1997. China transformed: historical change and the limits of European experience. Ithaca.

Wrigley, E.A., et.al., 1997. English population history from family reconstitution, 1580-1837. Cambridge.

Wrigley, E.A., 2000. The Divergence of England: the growth of the English economy in the seventeenth and eighteenth centuries. Transactions of the Royal Historical Society, 6th series, 10, pp.117-41.

Yun, B., 1994. Proposals to Quantify Long Term Performance in the Kingdom of Castile, 1550-1800, paper Session 'Economic Growth and Structural Change' (Milan, 1994)

Zanden, J.L. van, 1987. De economie van Holland in de periode 1650-1805: groei of achteruitgang? Bijdragen en mededelingen betreffende de geschiedenis der Nederlanden 102, pp. 562-609.

Zanden, J.L. van, 1992. Economic growth in the Golden Age, Economic and social history in the Netherlands IV, pp. 5-26.

Zanden, J.L. van, 1999. Wages and the standard of living in Europe, 1500-1800. European Review of Economic History, 2, pp. 175-197.

Zanden, J.L. van, 2001. Early modern economic growth: a survey of the European economy 1500-1800, in M. Prak (ed.) Early Modern Capitalism. London: Routledge, pp. 69-87.

Zanden, J.L. van, 2002a. The revolt of the early modernists: an assessment', *Economic History Review*, LV, pp. 595-623.

Zanden, J.L. van, 2002b. Taking the measure of the early modern economy. Historical national accounts for Holland in 1510/14, European Review of Economic History 6, pp. 3-36.

Zanden, J.L. van, 2004. Simulating early modern economic growth. Working paper IISH, available at http://www.iisg.nl/research/jvz-simulating.pdf

Zanden, J.L. van, and A. van Riel, 2004. The strictures of inheritance. State, economy and institutional change in the Netherlands 1780-1914. Princeton U.P.