The origins of 'modern economic growth'? Holland between 1500 and 1800
(with an addendum on the years 1348-1500)

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1. Introduction

Most economic historians would agree that 'modern economic growth' – as defined by Simon Kuznets (1966) as the sustained increase of income per capita, accompanied by shifts in the structure of the economy – began with the British Industrial Revolution of the second half of the 18th century. Kuznets himself was explicit about this,[1] and a lot of the research carried out by scholars working on historical national accounts suggests the same: in large parts of Western Europe, long term economic growth began during the first decades of the 19th century, whereas it probably started at some point in the 18th century in England (Maddison 2001).

There are a few problems with this view, however. The first problem is that Kuznets definition links two changes in the economy – per capita growth and structural change – that are not necessarily the same. In fact, as has been discussed in some detail by Crafts (1985), the development path of the pioneer of 'modern economic growth', England, was already before 1800 characterized by relatively large structural changes in the composition of the labour force and of GDP, whereas the increase of real income had been rather limited. He explained this 'mismatch' between growth and structural change as the result of (amongst others) the special features of English agriculture, which was increasingly concentrated in large farms using wage labour, which lead to a strong economizing on labour in the agricultural sector. This pushed people out of the primary sector, and lead to a strong growth of employment in secondary (and tertiary) activities. More recently it has also been demonstrated that these changes in the structure of the labour force may to some extent have preceded the acceleration of industrial growth after 1760 (or 1780) (Crafts 1985, pp.). A somewhat related problem is that it is still rather unclear when the 'decisive' acceleration of economic growth occurred in England (or rather, Great Britain, as Scotland was clearly a growth area as well) – when exactly 'modern economic growth' began. This is mainly due to the fact that research so far has focused on reconstructing growth per period of 20-30 years, and that we need annual time series to really find the turning point in the growth record (Crafts 1985; see also Crafts, Leybourne and Mills 1989, the annual index of industrial production).

The early beginnings of the process of modern economic growth is therefore still rather unclear, which also makes it more difficult to test various hypotheses about the origins of the process – for example related to the role played by institutional change (such as the Glorious Revolution), technological development, or relative prices (as suggested by Allen 2009). The problem becomes even more complex when we broaden the scope and include other countries into the inquiry. In their seminal study on 'The First

[1] Kuznets 1966: 'modern economic growth spread sequentially from its pioneer beginnings in eighteenth-century England to various follower countries'

Modern Economy', De Vries and Van der Woude (1997) have argued that the Dutch economy already during the 17th century generated a first wave of 'modern economic growth', resulting in substantial gains in income per capita and in real wages. They use a much broader definition of modernity, however, and to a large extent focus on the functioning of institutions, government and markets, but also point to the substantial increases of real incomes that must have occurred during the Dutch 'Golden Age'. They give four criteria for the modernity of the Netherlands in this period, which we quote here:"

1) Markets for both commodities and the factors of production (land, labor, and capital), that are reasonably free and pervasive;
2) Agricultural productivity, adequate to support a complex social and occupational structure that makes possible far reaching division of labor;
3) A state which in its policy making and enforcement is attentive to property rights, to freedom of movement and contract, and at the same time is not indifferent to the material conditions of life of most inhabitants;
4) A level of technology and organization capable of sustained development and of supporting a material culture of sufficient variety to sustain market-oriented consumer behavior." (De Vries and Van der Woude, 1997, p. 693)

There is probably consensus about the fact that Holland met the first three criteria, but the 'weakest link' in this argument appears to be the issue whether the country was 'capable of sustained development'. They also conclude that economic growth stopped after 1670, and that the long phase of expansion was followed by a decline of income per capita. They argued, however, that the post 1670 crisis was not a traditional, Malthusian crisis, caused by overpopulation and scarcity of agricultural resources (and foodstuffs), but a modern crisis, the result of overproduction (De Vries and Van der Woude 1997, 698).

The problem we try to deal with in this paper is this issue: did the Netherlands economy, more specifically Holland, generate a process of 'modern economic growth' in the early modern period? During which periods did real GDP per capita increase, and when did it stop growing? And how did the growth in real incomes relate to structural change of the economy? And, assuming that De Vries and Van der Woude are correct, that institutions were indeed remarkably modern already in the 16th and 17th century, why did this 'first modern economy' cease to generate growth and structural change after 1650 and 1670?

The answering of these questions has been severely constrained by data problems, in particular by the lack of consistent estimates of the national accounts of the country for the period involved. As a result, research has been based on various indirect indicators of economic performance. Jan de Vries already in his study of the system of 'trekschuiten' (barges) in the 17th and 18th century developed an innovative way to estimate income changes in this period, which pointed at a serious decline in demand for inter-city transport in the 1670-1750 period (De Vries 1981). His study appeared to confirm the long cycles known from the demographic history of the region, with peaks in performance during the 1660s and 1670s, and sharp declines of income levels in the first half of the 18th century (see also De Vries 1984). His view on the 18th century was more pessimistic than that of Johan de Vries (1959) in his seminal thesis on the Dutch economy in the 18th century, who concluded that until the 1780s the level of economic activity more or less remained stationary. The only author pleading for continued

economic growth during this period was James Riley (1984), who in an essay published in 1984 tentatively suggested that there may have been continued growth during the 18th century. But his views have been criticized by almost all participants in the debate, including Van Zanden (1987).

The discussion summarized here suggests that Holland is an excellent case study for an analysis of the roots of the process of modern economic growth. It was undoubtedly one of the most dynamic parts of Europe in the centuries before 1800 and had, as demonstrated by De Vries and Van der Woude (1997), already a relatively modern institutional framework. This article sets out to explore these issues and test these ideas about the growth performance of the economy of Holland in the early modern period. Did 'modern economic growth' start in the Netherlands in the late 16th century, or in England in the 18th century? And what was the character of this growth? What was the link to structural transformation? Did the Netherlands also have a precocious change in the structure of labour force and GDP, predating the break through of the process of 'modern economic growth'? And how much productivity growth did occur?

2. The dataset

We think we are now closer to answering these questions, because we have built a detailed dataset of the national accounts of Holland between 1510 and 1807. In the appendix we give the details about this project; it describes the way in which the estimates of the national income for Holland in the period 1510-1807 have been put together. The aim of the project was to produce annual estimates of gross value added of the main industries of the Holland economy in this period, in both current and constant prices, which could then be used to produce estimates of total GDP (and GDP per capita) for these three centuries. The starting point consisted of two benchmark estimates, for 1510/14 and for 1807, the result of previous research into the structure of the Holland economy at the beginning of the 16th century (Van Zanden 2002a), and into the national accounts of the Netherlands in the 19th century (the results of which have been published by Smits, Horlings and Van Zanden 2000).[2] We applied the standard System of National Accounts (SNA) methodology, concentrating on - as we did in previous work - the output of the economy.

The challenge of this project was to find sources that reflect the annual variation in output or value added in different industries between 1510 and 1807, in order to 'interpolate' between these two distant benchmark estimates (it was not possible to create another benchmark at, for example, some point during the 17th century). In the process of working with the data, we sometimes were able to improve on the estimates made for 1510/14 and for the 1807-1913 period, as a result of which there are some discrepancies between earlier studies and the estimates presented here (which we discuss in the appendix). Moreover, the 1807 estimates related to the Netherlands as a whole, and in order to link the Holland estimates to those of the Netherlands, we had to estimate its

[2] The two studies by Horlings (1995) on the services sector and by Jansen (1999) on the industrial sector in the first half of the 19th century were important as models for estimating output and value added in different parts of the economy.

share in Dutch GDP, which lead to a number of (generally small) modifications of the original estimates.

The economy has been broken down into three sectors (primary, secondary and tertiary). The primary sector includes agriculture and fishing (herring fishing and whaling); the main branch we miss here is fresh water fisheries which were quite important in the 16th century, but declined afterwards (see De Vries and Van der Woude 1997: 237-239). The secondary sector consists of textiles (wool and linen), clothing, construction, peat digging, food (bakeries, brewing, gin – *jenever* – distilling, and other foodstuffs), paper, shipbuilding, printing, soap production and sugar refining. The tertiary sector was covered by international shipping, international trade, domestic trade, inland transport (via inland waterways), banking, education, government services (military sector and the rest), housing, domestic services, and professional services, which were approximated by notaries and book traders. In all, we have annual estimates of the value added (in current and constant prices) for 27 branches of industry, many of which are constructed on the basis of several underlying time series (for example, the output of shipping sector is based on data on shipping to the Baltic, Asia, the Americas, and 'the rest', the other trades which had to be estimated on the basis of the number of ships entering the Netherlands in these years). A lot of data relate to yields of various taxes, such as the famous Soundtoll registers (Bang et al 1906-1953); fortunately, there is detailed information on the many indirect excises levied by the government (Liesker and Fritschy 2004). In addition, detailed accounts of the activities of the Dutch East Indies Company (VOC) (De Korte 1981), the central government of Holland (Liesker and Fritschy 2004), the Amsterdam Wisselbank (Van Dillen 1964), and the university of Leiden (Sluijter 2004) have also been used for the project. Moreover, thanks to the work by Posthumus (1943/64), Noordegraaf (1980), De Vries and others, there is a wealth of information on the development of prices and wages, which is also of fundamental importance for reconstructing the national accounts (Van Zanden 2005 for a recent overview). The weakest part of the project are the estimates of technical coefficients and cost structures, for which we often have only very tentative estimates, related to one or two years (for the soap industry, for example, we know for only one year, 1699, which share of the output value of an industry is value added). We were mainly interested in the long term changes in the economy of Holland; for lack of sources, gaps in series sometimes had to be interpolated, but this does not affect the long term picture that we get. Such gaps occurred more often during the 16th century, when there are serious data constraints, and annual fluctuations are therefore perhaps underestimated. The *Informacie*, the very extensive and detailed census of 1514, which is probably the richest source for the study of the national accounts in the pre 1800 period, to some extent compensates, by supplying the basis for a detailed benchmark estimate, for the data problems during the rest of the 16th century. From the 1580s onwards, when the newly independent state expands and starts to raise many new taxes, the data flow increases steadily, and the quality of our estimates increases as well.

The estimates of the national accounts of Holland between 1510 and 1807 are, in our view, the best summary of the information that is available – in many different sources, and spread over a sizeable literature – abut the long term development of the economy of this region in that period. The beauty of the system of national account s is that it allows for a consolidation of all this information, from many these sources, all

having their limitations and are subject to certain margins of error, into one consistent framework, the SNA, which 'takes care' of the selection and the weighting of all the data. The result is a set of estimates of GDP and its components that is, in our view, the state of the art summary of our present state of knowledge.

3. Patterns of growth and structural change

To give more flesh to these bones, we will first present the long term changes of the most important branches of the economy, and study the pattern of structural change that can be discerned. Focusing on the province of Holland has big advantages: it was the most urbanized, dynamic and richest province of the Dutch Republic, which is therefore very typical for the patterns of change that can be found in the three centuries between 1500 and 1800.[3] Every advantage has its downside, however. Holland was already at the beginning of the 16th century a remarkably 'modern' economy: less than 40% of the labour force was active in the primary sector (and less than a quarter in agriculture, the rest being employed by fisheries (12%) and peat digging (3%)). Industry was already in 1510/14 the biggest source of employment (with almost 40% of the total), and the share of services was also substantial. As a result, structural change in the next three centuries was limited. What happened between 1510 and 1807 – to make a long story short – was that the share of services in the labour force and in GDP increased strongly, which is what may be expected during economic development. Moreover, its relative productivity remained higher than 100%, implying that this shift contributed to income growth. Agriculture saw its share decline a bit (from 25% to 22%), the rest of the primary sector shrank much more (fisheries went down to less than 1%), but also the share of industry fell by a few percent. Differences in levels of labour productivity between the three sectors declined markedly, and were very small indeed at about 1807, but this was a year of inflated agricultural prices, and depressed industrial prices, the result (amongst others) of the Continental System imposed by Napoleon (which also depressed international trade), which must exaggerated the tendency for the equalisation of relatyive incomes in this period.

Table 1: Structure of the economy and relative labour productivity, 1510 and 1807

		Primary*	Industry	Services
1510	GDP	27.7%	38.7%	33.6%
	Occupational structure	39.4%	38.4%	22.2%
	Labour productivity	0.70	1.01	1.51
1807	GDP	19.2%	32,5%	48.3%
	Occupational structure	21.9%	35.9%	42.2%
	Labour productivity	0.87	0.90	1.15

[3] For other provinces the sources necessary for reconstructing the national accounts are also not available – which is of course also linked to the 'modern' character of the Holland economy.

* includes agriculture, fisheries, and peat digging

Consistent with these changes in relative share of sectors, the services sector was indeed growing most rapidly (consistent with it increasing its share in GDP), as Table 2 demonstrates, but industry was not lagging behind a lot (.52 percent annually of industrial value added, compared with .57 percent of services), and agriculture was in fact the least dynamic from this point of view (.29% annually).

As pointed out in the previous section, the fact that changing weights of the sectors over time only results in a small difference in growth rates of GDP suggest that the structural transformation in the economy in this period was limited. Hence, all sectors grew at more or less the same rate. To have a closer look at this issue, in this section we focus on branches in the economy that are generally considered to be important, i.e. agriculture, banking, and industry that represent a tendency from labour intensive to capital intensive.

Indeed, looking at below table, we can see that agriculture grows slowest, followed by industry and services. Within industry, it is largely textiles that drives

Table 2 Growth rates by economic sector (%)

Growth rates by economic sector (%)

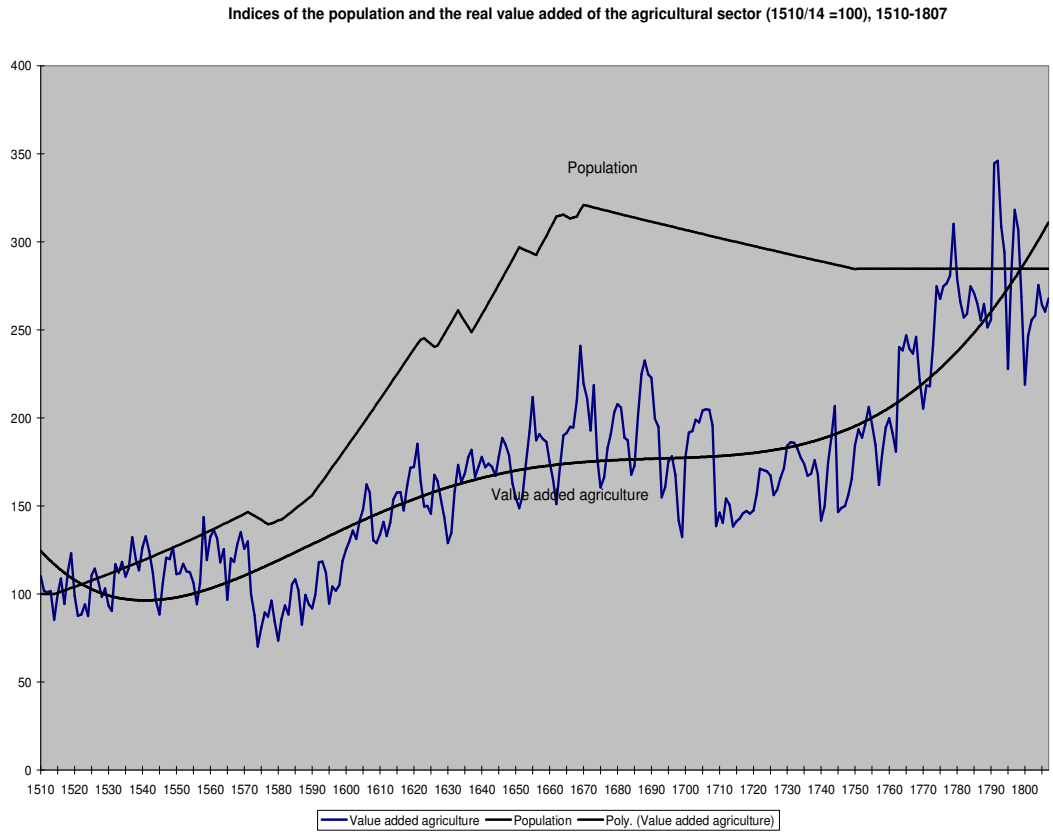
	Agriculture	Industry	Of which *Food & Drink*	*Textiles*	*Building*	*Other Industry*	Services	Of which *Transport*	*Trade*	*Government*	*Banking*	*Other Services*
1512-1565	0.36	0.87	0.79	0.05	1.57	0.86	2.03	2.14	2.76	0.65		0.94
1565-1620	0.86	1.48	1.42	2.46	1.33	0.56	1.08	1.77	0.40	3.17		1.27
1620-1670	0.47	0.51	0.71	0.73	0.11	-0.01	-0.18	0.26	-1.58	0.28	1.88	0.95
1670-1750	-0.36	-0.13	-0.25	0.05	-0.19	0.15	0.25	-0.15	0.86	0.39	0.97	-0.11
1750-1806	0.42	0.19	-0.09	0.60	0.32	-0.48	-0.15	-0.31	-0.54	0.34	1.80	-0.04
1512-1806	0.29	0.52	0.44	0.72	0.56	0.20	0.57	0.66	0.43	0.92		0.53
Average share of sector in GDP (%)*	0.15	0.40	0.10	0.10	0.07	0.13	0.45	0.11	0.14	0.08	0.003	0.12

growth, while within services, banking, government (including army), and transport are the three fastest growing sectors.

It is possible to distinguish three distinct patterns of long term change. The agricultural sector is the first one. Agriculture was in a way the weakest link in the Holland economy of the 16th century: since the late 14th century, output fell short of demand for foodstuffs, and the food supply was to a large extent dependent on imports from abroad (Northern France, the Baltic). The gap between population and output of foodstuffs even widened sharply during the 1500-1670 period (Figure ***); but at the same time, te structure of the sector was modernized and productivity increased (although not dramatically, see below). The decline of population after about 1670 did not lead to a closing of the gap because agriculture also suffered from the tendency of prices to decline (Figure 1). In the second half of the 18th century output began to grow much more

rapidly; gradually exports of livestock products to (amongst others) England grew in importance, and at the beginning of the 19th century the Netherlands had become a net exporter of foodstuffs (albeit by a small margin); this trend would continue into the 19th century (and even the 20th century); paradoxically most of the most solid parts of the heritage of the 'Golden Age' was a highly productive and export-oriented agriculture, which formed one of the main pillars of the Dutch economy after 1800 (in fact, as Joel Mokyr (1976) has argued, the high labour productivity which drove up wages in the Netherlands, may have even retarded the industrialisation process after 1800, see also Van Zanden and Van Riel 2004). The explanation of this paradox is that the pull by the big cities of Holland and Zeeland in the 16th and 17th centuries induced farmers to increasingly specialize and increase their productivity, and this favourable structure of agriculture became a permanent feature of Dutch economy (De Vries 1974).

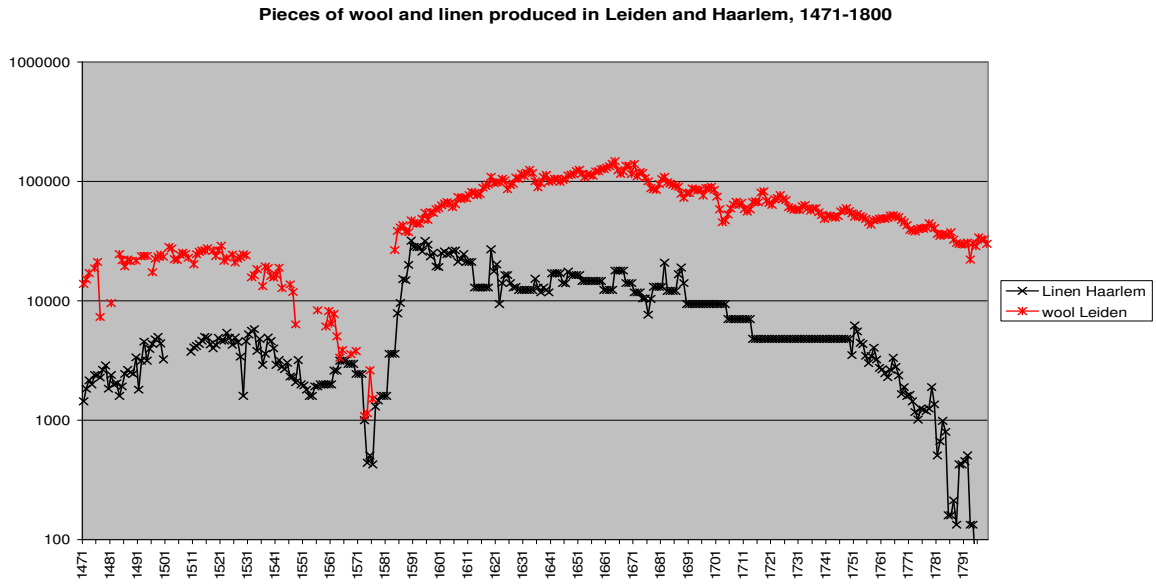
Figure 1
Indices of the population and the real value added of the agricultural sector (1510/14=100), 1510-1807



The timing of the second pattern of long term change – of industrialization (before about 1670) and de-industrialization (after that date) – was in many ways contrary to that of the

agricultural sector. The development of the textiles industry is the best example of these trends: the output series we have, begin at about 1470, when the first wave of industrialization is Holland is under full swing. Textiles were a major export commodity, and the industry employed about 11% of the labour force in 1510/14 (Van Zanden 2002a, 138) (Figure 2). Between 1550 and 1575 the industry went through a difficult period caused by increased international competition, but the Revolt of 1572 and the influx of entrepreneurs and skilled labourers from the mid 1570s onwards result in a strong revival of the industry. It is booming until the middle decades of the 17th century, but after about 1670 there follows a long term decline, steeper in Haarlem than in Leiden. The second most important export industry during the 16th century, beer brewing, developed in a similar way; it went through difficult times in the 1550s and 1560s, was launched again after the Revolt, but went into long term decline from the 1660s onwards (due, in this case, increased competition from coffee and tea). Only a few smaller industries such as printing, paper, distilling and sugar refining, had a different growth curve, and continued to expand during the 18th century.

Figure 2
Pieces of wool and linen produced at Leiden and Haarlem, 1471-1800



The third pattern, of the services sector, is represented here by the growth of international shipping (Figure 3). Here we see very rapid growth during the 1540s-1560s (contrasting with the difficulties experienced by industry in this period), a continuation of growth immediately after the downturn of the early 1570s, followed by spectacular expansion during Truce with Spain (1609-1621), another big increase in the 1640s, more or less long term stability between the 1650s and the middle of the 18th century, and a new phase of growth in the second half of that century (Van Zanden and Van Tielhof 2009 for the

details). The very important international trade sector more or less follows the same trends, and also continued to be quite dynamic into the second half of the 18th century. Other rapidly growing parts of the services sector are government – with huge swings in activity following periods of war and peace (Figure 4) – and banking, which is the most dynamic sector of the economy after 1750. The services sector as a whole was therefore much more robust during the 18th century, when industry was going through difficult times.

Figure 3 Volume of shipping 1500-1793 (in 1000 tonkm)

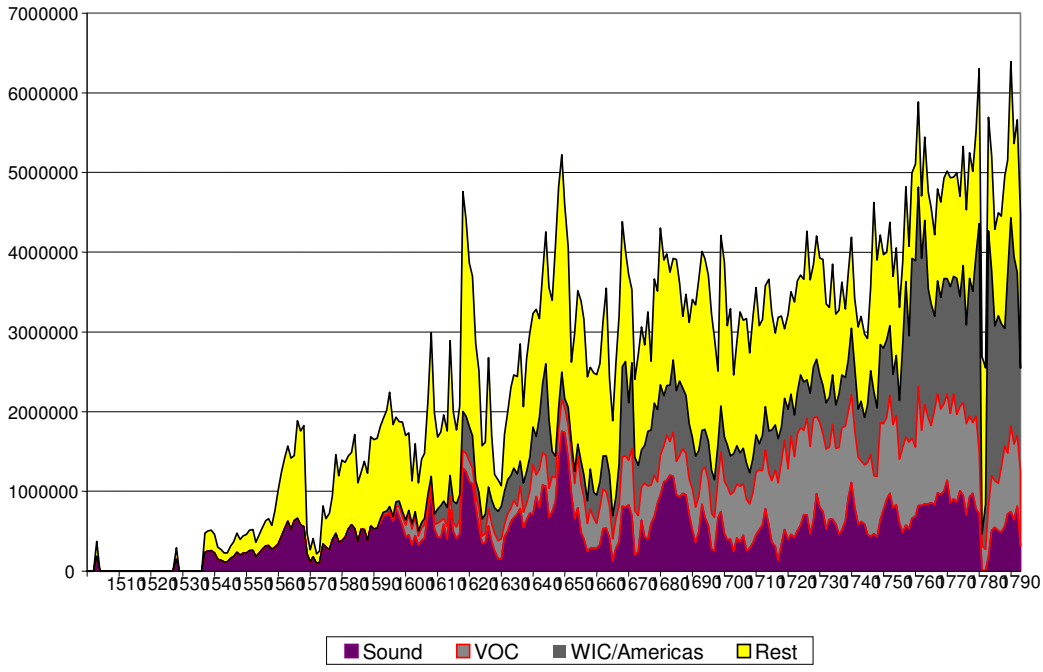
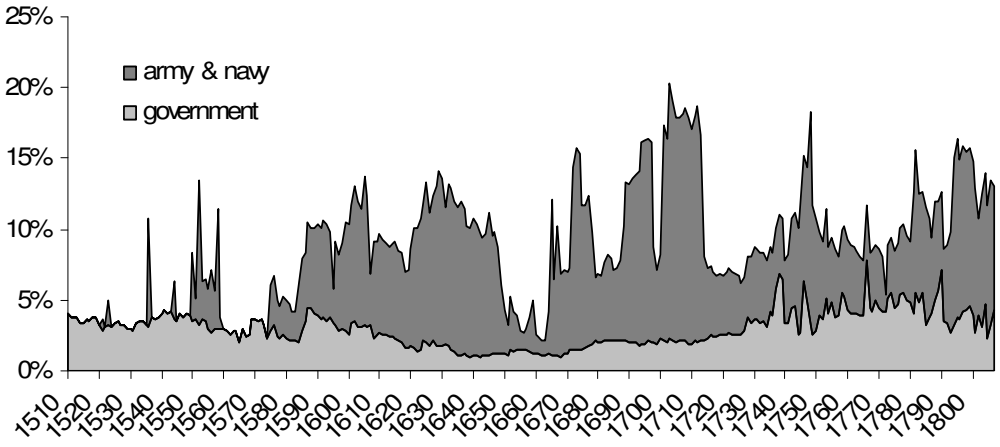


Figure 4
Share of government (including army and navy) in GDP, 1510-1807



4. The growth of GDP, 1510-1807

The sum of these three patterns of sectoral development gives the growth of total GDP. Figure 5 presents three indices set at 1510=100, one of population (which increased from 275.000 in 1510/14 to 880.000 in 1670, after it declined to stabilize at about 780.000 between 1750 and 1800), the other two are the two estimates of the growth of GDP. The two GDP series are to (a) all outputs and inputs are valued at constant prices of 1800, or (b) all outputs and inputs are valued at current prices, and the GDP in current prices is deflated using a GDP deflator with changing weights.[4] The Figure shows that GDP grew quite a bit faster than population, although the margin was quite small in the first decades of the 16th century; moreover, it appears that measured in deflated current prices gives a slightly higher rate of growth of GDP than in constant prices of 1800, which is what would be expected on the basis of the so called Gerschenkron effect (Gerschenkron 1947). It means that the relative prices of fast growing sectors were declining compared with the prices of branches of industry that grew more slowly; but the difference is relatively small, and in fact insignificant during the 16th century, which means that structural changes were limited and/or that relative prices did not change a lot. We will return to this issue below. The big picture that can be read from these estimates is one of rapid growth in the first half of the period - say until about 1650 - followed by stagnation in the second half of the period. The demographic curve shows the same pattern – slow growth before 1570, and acceleration between 1570 and 1650, and stability afterwards.

[4] The weights used were the following: 1510-1565 uses the 1510-14 weight; 1565-1620 uses the 1565-1569 weight; 1620-1670 uses the 1620-1624 weight; 1670-1750 uses the 1670-1674 weight; 1750-1807 uses the 1750-1754 weight.

Figure 6 presents the estimates of GDP per capita (the deflated current prices series). Instead of showing the familiar patterns of growth before ca 1650 and stagnation afterwards, it appears that growth of per capita GDP was more or less stable in the very long run, at about .17 percent per year. There are, obviously, large swings: the series peak in the 1560s, before the collapse of the economy of Holland during the first years of Revolt against Philip II (between 1566 and 1573), when, from peak to through, income per capita almost halved (which was probably the worst depression in ´recent´ history). The period between the mid 1570s and 1620 was one of very rapid growth, initially in spite of the war with Spain, but the Truce with Spain between 1609-1621 leads to a further acceleration of growth. The next phase, the renewed war between 1621 and 1648, is again a period of continued growth (although the peak of the early 1620s is not surpassed); but the peace with Spain was followed by a sharp contraction of the economy, partially the result of the ´peace dividend´; expenditure in the army and the navy contracted sharply in these years (Figure 4), but the rest of the economy also did not fare very well. The sharp decline after 1713 has the same explanation, a massive reduction of public spending on defense. If we ignore the expenditure on navy and army the growth of GDP per capita becomes smoother, but the growth retardation of the second half of the 17th century still is a fact. Most striking in both Figure 2 and 3 is perhaps the continued increase in GDP per capita in the 18th century, in particular in its second half. Seen in the very long run, per capita growth in the 18th century is not very dissimilar, and not (much) lower, than in the preceding two centuries. This is in sharp contrast with the usual view that growth came to a complete standstill, or was even negative, in the century and a half after 1670.

There are reasons to be even more optimistic about the growth performance during the 18th century. The Netherlands exported much of its capital during this period, which led to strongly increasing flows of income to Dutch citizens. This means that the growth of real income was faster than the development of real product, measured here. On the basis what is known about these investments and income flows, it can be estimated that at the end of the 18th century Dutch GNP was perhaps five percent higher than GDP, a difference which was close to zero at the start of the century (Van Zanden and Van Riel 2004: table 1.4). Holland was contributing disproportionally to this, and may have received about 70 to 80 percent of the income from abroad, increasing its income by 6-8%. Real incomes therefore increased even more than the GDP estimates suggest, and much of this increase was concentrated in the second half of the 18th century.

Overall, GDP per capita increased by about 70%, somewhat more than was expected on the basis of the comparison of the two benchmark (1510/14 and 1806/7), which pointed to an increase of about 50% (Van Zanden 2001a, or according Van Zanden 2002a, to between 37 and 54%).

Figure 5
Estimates of the population and GDP of Holland, 1510-1807 (indices 1510=100)

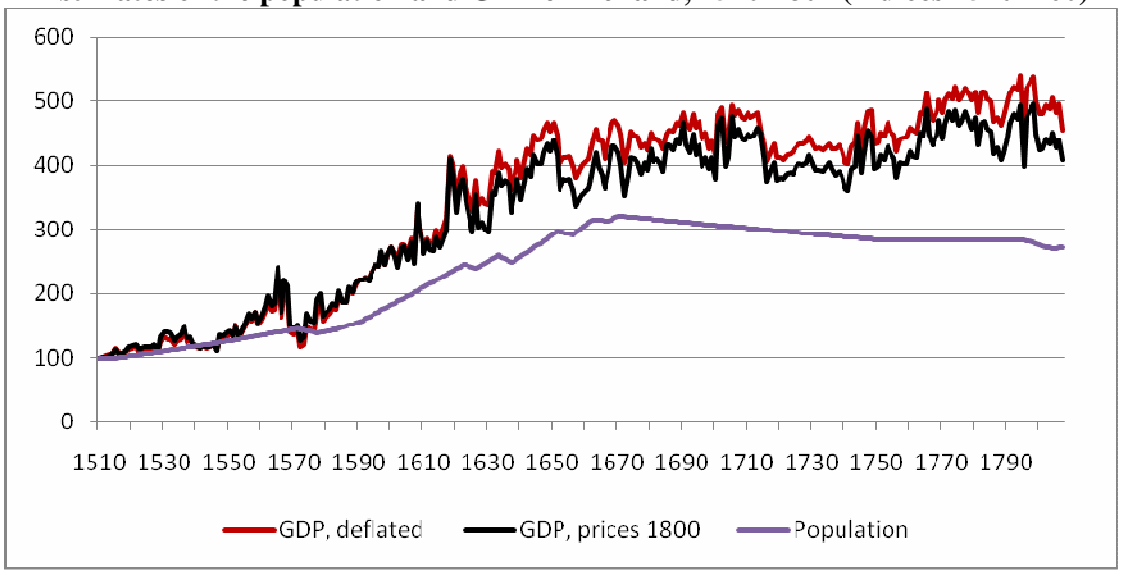
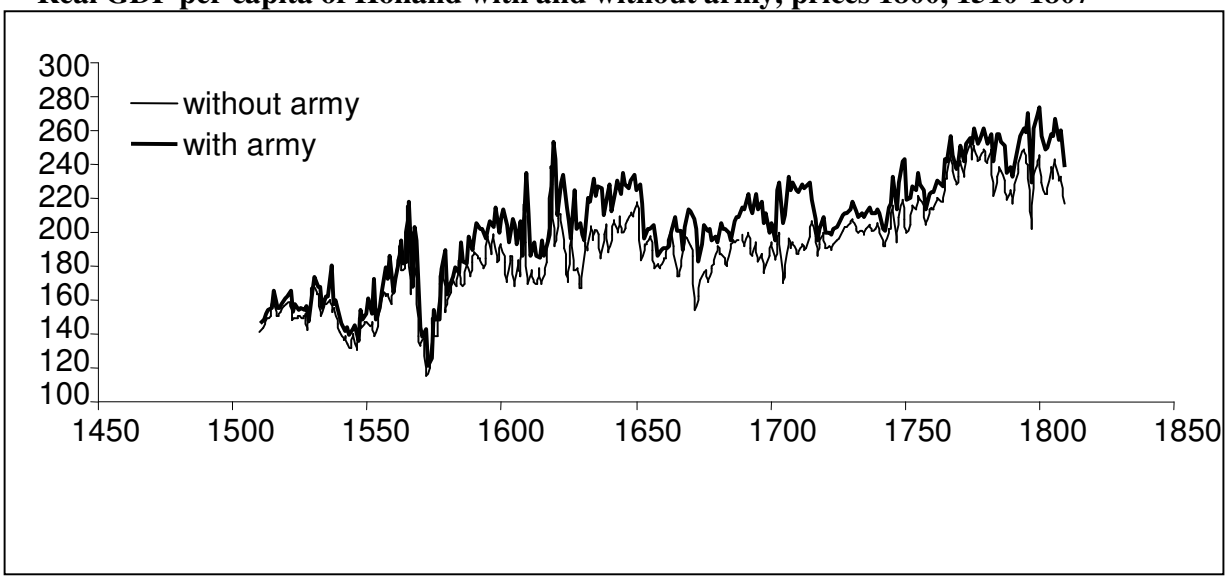


Figure 6
Real GDP per capita of Holland with and without army, prices 1800, 1510-1807



The over-all stagnation in the last half of the seventeenth and the first half of the eighteenth century compares with a decline in population as well as a shift from

Table 3: growth rates per annum of GDP

growth rates

	GDP	Population	Per capita GDP
1512-1565	*1.11*	*0.65*	*0.46*
1565-1620	*1.36*	*0.97*	*0.39*
1620-1670	*0.29*	*0.58*	*-0.29*
1670-1750	*0.00*	*-0.14*	*0.14*
1750-1806	*0.11*	*-0.09*	*0.19*

agriculture to industry. This changed in the second half of the eighteenth century when expanding agriculture combined with a declining population could only be fed by a strong increase in land productivity. This result is shown in table 3 as well. We see population decline in the entire 18th century.

Table 3 seemingly points to a number of breaks in the growth record; the graphical presentation of Figure 6 on the other hand suggests as almost continuous growth of GDP per capita. Obviously, since the decline in population went hand in hand with stagnating, or even declining GDP, per capita growth remained largely unaffected. More importantly, however, there seem to have been no structural changes in the growth pattern of the Dutch republic over time, even for total GDP.

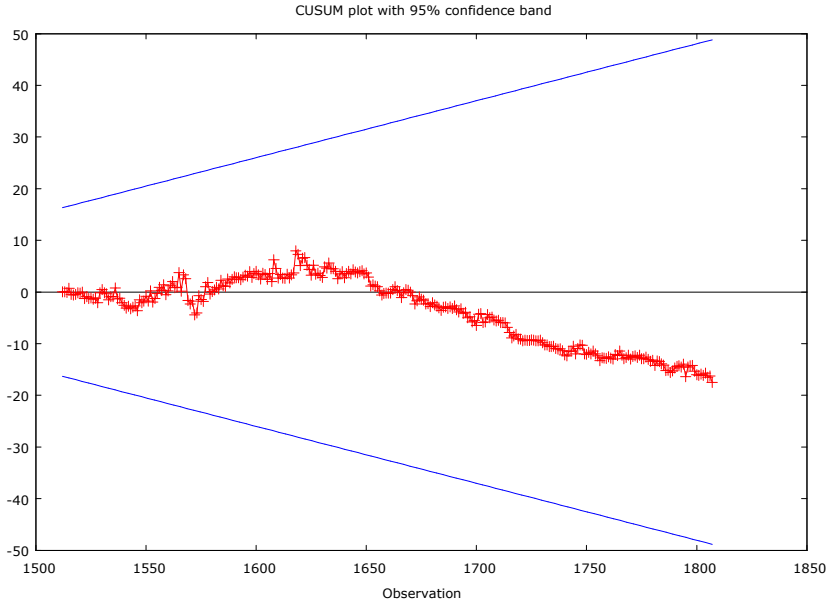
We tested for break points in the Dutch GDP series 1510-1807. In Table 4 we show a regression of the growth of total GDP on a constant and several time trends. It turns out that only the constant is significant, indicating that the assumption of a constant growth rate of time has to be accepted (the same turns out to be true for per capita GDP

Table 4: OLS estimate of GDP, 1511-1807

Dependent variable: growth of GDP

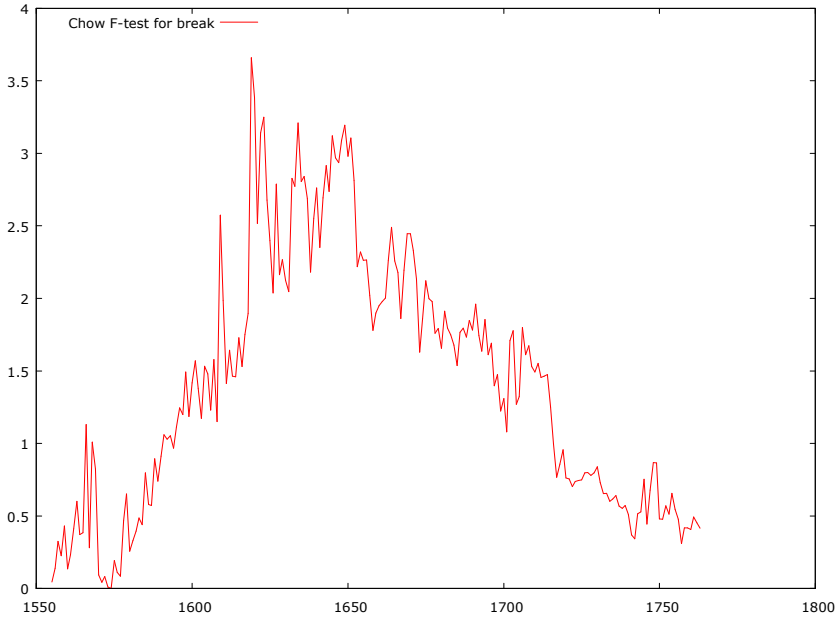
	Coefficient	std. Error	t-ratio	p-value
Constant	0.739	0.265	2.791	0.0056***
No. Obs.	297			

Figure 7 CUSUM plot with 95% confidence interval of GDP growth



Note: CUSUM test for parameter stability - Null hypothesis: no change in parameters
Test statistic: Harvey-Collier t(295) = -1,0188 with p-value = P(t(295) > -1,0188) = 0,30913

Figure 8 Cow F-test for break



growth). The same we find in Figures 7 and 8 where neither the CUSUM nor the Chow-test find structural breaks in economic growth although there is some deviation after 1670. However, this deviation is not significant.

The reason that we find different growth rates in table 3, even though we just rejected changes in growth rates over time, may be explained by exogenous shocks. This result is quite important. It implies, for example, that any shocks (such as in the 1570s), although they had a negative effect on the growth rates, did not have a permanent effect; after the initial shock, the growth rate continued to the same level. In other words, there was a more or less constant increase in GDP and in GDP per capita, which began before 1510, and did not change fundamentally between 1510 and 1807. In other words, continuous economic growth began already before 1510, and persisted during the next three centuries. To find the origins of 'modern economic growth' we have to turn to the late Medieval period (Van Zanden 2002b).

5. Technological change and growth

This does not imply that there was one period of unbroken, unchanging growth. We think that basically two different phases of growth can be distinguished. During the first period, basically the continuation of late Medieval growth, it is largely driven by technological change. In order to illustrate this point, we have analyzed long-term changes in relative prices, and used them as indices of underlying patterns of technological change. It is well known that branches of industry with high rates of technological change will usually see their relative prices decline, whereas at the same time their share in GDP increases. We have reconstructed the price development of all major industries between 1510 and 1807, and can therefore compare their development with that of the GDP deflator. In order to analyse patterns of technological change and the growth of total factor productivity, it is theoretically better to compare, for each industry, the development of output prices with that of total factor costs (the weighted sum of factor prices) – the deflated output prices can be interpreted as an index of tfp-growth. This is not feasible for all industries however; as an alternative we deflate with the GDP-deflator: branches with rapid growth of productivity – such as printing – show a rapid relative decline of their output price, which we take as a measure of productivity growth. When during a certain period output prices decline more than 10% relative to the GDP deflator, we assume that tfp growth occurred. The degree of decline is a rough proxy of tfp growth.

Table 5 lists the industries in which we found substantial productivity growth according to this measure. The degree of decline of output prices was furthermore weighted by the share of the industry in GDP at the start of each period, to get a sense of the quantitative impact of the changes. The idea is that technological changes in a sector with 20% share in GDP of which the output prices decline relative to the GDP deflator by 50%, leads to 'social savings' of 10% of GDP.

Let us review the estimates presented in table 5. To begin with, tfp growth measured in this way shows a curve well known from the literature on the technological development of the Dutch Republic: it is modest during the first six decades of the 16th century, there

is a sharp increase during the first half of the 'Golden Age' (until the 1620s), after which a gradual deceleration occurs. That tfp growth may have continued during the 18th century is a relatively new idea, which however can also be found in the recent analysis of the technological development of the Dutch republic by Davids (2008). TFP-growth in the period after 1670 is dominated by textiles, however, a sector of which the share in GDP is declining in this period. This points to one of the limitations of this analysis: it assumes that prices are determined by endogenous factors, whereas outside influences – increased international competition in this case – may also have played a role.

In the 16th century shipping and are the main sources of tfp-growth, with a modest contribution of the printing industry (due to its small size). Between 1565 and 1620 tfp growth accelerates, and is concentrated in textiles. In shipping the introduction of the fluyt (or flyboat) was perhaps the most important source of productivity growth, but there is also evidence that the efficiency of the network improved a lot (Van Zanden and Van Tielhof 2009). The next period – 1620-1670 – saw surprisingly modest productivity growth; it is clear from a detailed analysis of productivity change in the strategic shipping sector that after the 1620 the increase in tfp growth came to an end, confirming what we find here (ibidem). But it is remarkable that in this period – the apex of the 17th century Golden Age – productivity growth apparently did not spread to more sectors of the economy (but seems to be confirmed by the fact that also the growth of GDP per capita stagnated in these years). In a number of new industries – sugar refining, paper industry, whaling – technological changes lead to substantially reduced prices, but its net effect was more limited than before 1620. After 1670 tfp growth contracted to the textiles industry (woolens and linen), and to the sugar industry (but the declining price of sugar may also be related to changes in the international trading system and the emergence of new plantation economies in the Caribbean).

Overall, the estimated impacts on GDP growth are relatively small, but that seems to be one of the features of such experiments; remember that Von Tunzelmann's estimate

Table 5 Estimated impact of TFP-growth, per period, per branch, in percent of GDP

Period*	Shipping/ Shipbuilding	Textiles	Printing/ Paper	Sugar and Gin	Peat	Fisheries	Total
1512/1565	**0,10	0,09	**0,0003		0,11		0,30
1565/1620	1,05	**0,10				1,30	2,44
1620/1670			**0,01	**0,02		1,25	1,29
1670/1750		1,66		**0,03			1,68
1750/1805		0,78	0,22				1,00
Total	1,14	2,63	0,23	0,05	0,11	2,55	6,71

*1512=1510/14, 1565=1563/67 etc.
** Increase in share of that sector in GDP

of the social savings of the steam engine demonstrated that in 1830 this accounted for only 0.1% of the national income of Britain (Von Tunzelmann 1978); compared with this yardstick, the results presented in Table 5 are not insignificant.

Finally, it is significant that some sectors do not appear in the table; agriculture is missing because output prices move more or less in tandem with the GDP deflator; during the first half of the 16th century and the second half of the 17th century, they even go up more rapidly than prices in the rest of the economy.

The wave-like character of technological development, which accelerated between 1570 and 1620, but slowly declined its growth rate in the following century, is also confirmed by studies of the number of patents granted by Dutch authorities (which peak in the 1620s and 1630s, and slowly decline afterwards (Van Zanden and Van Riel; Table 1.5), and by the qualitative information on the rise and decline of Dutch technological leadership collected and analysed by Davids (2008). The technological progress realized in this period also had important implications for the competitiveness of the Holland economy. Most famous example is perhaps the development of the fluyt, mentioned already, whose efficiency contributed much to the growing share of the Dutch in international shipping. When this wave of technological change subsided, competitives came under pressure, as competitors learned to copy the Dutch technologies, or developed their own.

6. Continued growth after 1650

The usual story of Dutch economic advance in this period is indeed one of progress until the middle decades of the 17th century, followed by relative – and in most interpretations also absolute – decline in the century after 1650 (or 1670). One would expect, on this basis, that the growth of GDP per capita would show the same wave like patterns, but this does not appear to have been the case. By contrast, per capita growth was rather slow during the post 1620 period, but much faster than expected in the (second half of the) 18th century. The next question therefore seems to be: why did growth continue after 1670, when technological change decelerated? What was driving the continued increase of per capita real income?

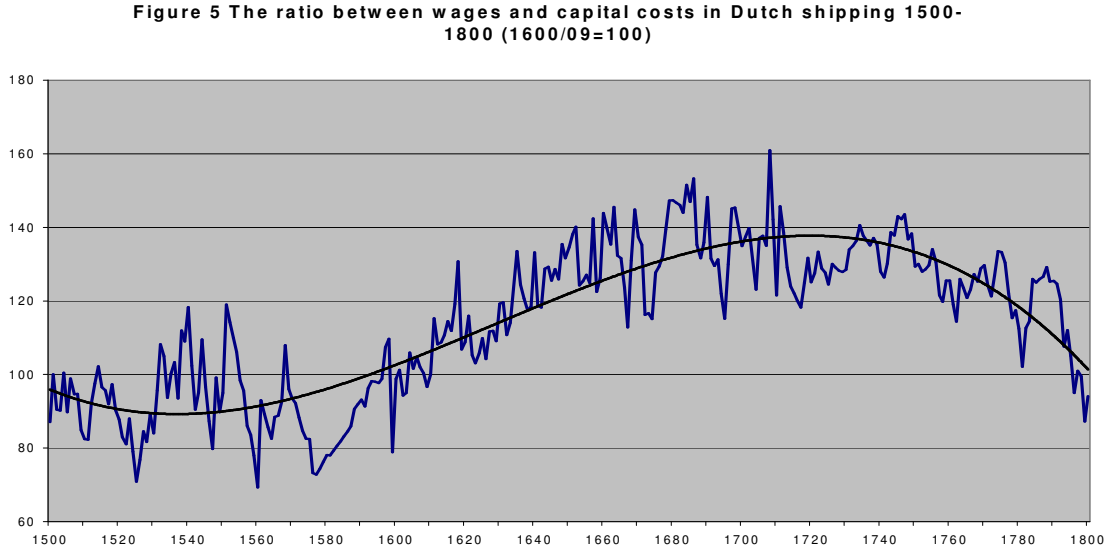
Structural change was a rather limited source of growth, as we have argued already. There was the tendency for more labour intensive industries such as textiles to contract, and for a few capital intensive industries to grow (printing, paper, gin distilling, sugar refining), but these changes were relatively modest. The most significant change in this respect was probably the increase of the banking industry – based on the low interest rates, the excellent financial infrastructure, and the availability of large domestic savings surpluses which were exported abroad. But even the banking industry contributed only a few percent to GDP during its best years in the 1770s, 1780s and 1790s.

Change in factor proportions within industries may have played a more important role, however. In a case study of productivity changes in the shipping sector we were able to shed some light on this question. In that sector, tfp-growth was concentrated in the period before the 1620s, but labour productivity continued to grow – even accelerated – after 1620, as a result of a substitution between labour and capital. Because wages increased strongly during the first six decades of the 17th century, and capital costs declined (mainly due to declining interest rates), the labour input was reduced relative to the capital input; the tonnage per sailor increased strongly, a process already analysed by

Lucassen and Unger (2000). Figure 8 presents the estimates of the changes in relative factor costs that occurred in the shipping industry.

The process of capital intensification – of substitution of labour by capital goods – may well have happened in other branches as well. There, wages increased as much as in the shipping sector, and interest rates fell as well. Moreover, the prices of ships – composed of the costs of timber, iron, copper, and wages of skilled labourers – were probably more or less representative of the prices of other capital goods – such as in

Figure 8
The ratio between wages and capital costs in Dutch shipping 1500-1800 (1600/09=100)

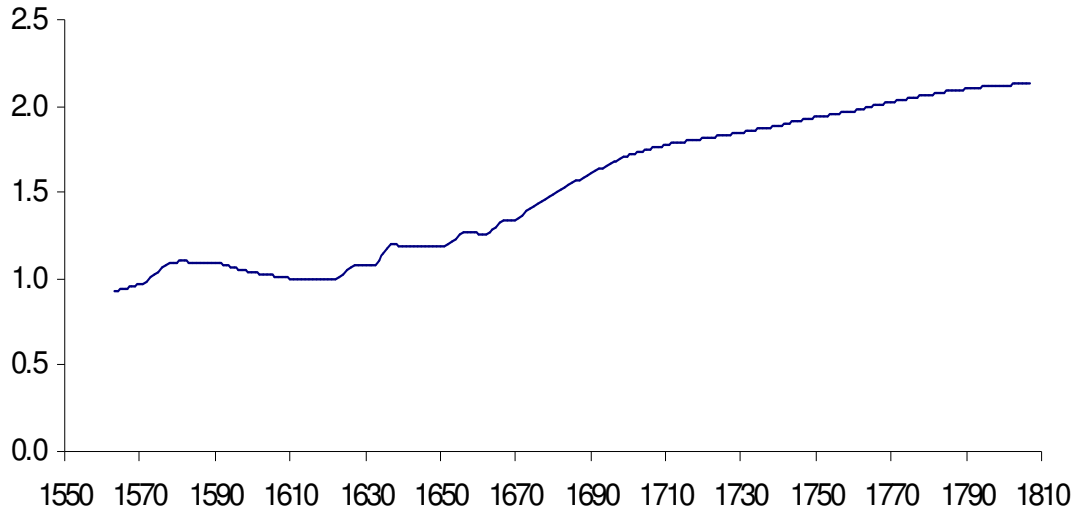


particular wind mills, which played a large role in the 'mechanisation' of all kinds of industrial processes. The most important innovations in this field – the application of the 'general purpose technology' of the windmill to various branches of industry – occurred in the period before ca 1630 (Davids 2008), but this created new opportunities to change the mix between labour and capital, a process that may well have continued into the 18th century. Continued economic growth was therefore, if this idea is correct, not based on new technological changes – on a change in the productivity frontier -, but on a movement along the productivity frontier induced by changing relative factor costs.

Another source of per capita growth that was probably increasingly important was human capital formation. Already in the 16th century levels of human capital in Holland were relatively high, as was remarked by contemporary visitors, who found that not only men but also women could usually read and write, and that these skills were not only concentrated in the cities, but also spread over the countryside (De Moor and Van Zanden 2009). We estimated the development of the average years of education of the Holland population at (not more than, but also not less than) about 1 year in the middle of the 16th century, increasing to about 2 years in the second half of the 18th century when 84% percent of the males and 64 percent of the females did sign a marriage certificate. Levels

of literacy were very high by international standards – much higher, for example, than in England or Belgium.

Figure 9
Average years of education in Holland



Summing up, we can distinguish two stages of economic growth: the first one, until the middle decades of the 17th century, is both extensive and intensive: it is based on relatively rapid technological development, and is combined with relatively rapid growth of population; during the second stage, which begins in the 1650s or 1660s, population growth comes to an end, technological change becomes much more slow, but changes in relative factor proportions allow for a further increase in per capita incomes.

Conclusion

When did 'modern economic growth' begin? When we look at the case of Holland – the only region of Europe for which we have detailed, annual estimates of GDP going back to the early 16th century, the perhaps rather unsatisfactory conclusion is that it began before 1500. Going back to the two elements of Kuznets' definition this is immediately clear for 'structural change'; as we demonstrated, the structure of Holland's economy was already very modern, with only 25% of the population employed in agriculture, and services and industry contributing more to income than the primary sector. There are broad similarities with what Crafts and others found for the English economy, that structural change of the labour force and of GDP tended to be much more radical in the pre 1800 period than per capita growth. Or, in terms of the relationship between structural change and GDP growth, one percent of 'decline of agriculture' was accompanied by a much smaller increase in real income than in the 19th century (interestingly, comparing

the 19th century patterns for Europe as discussed by Crafts with the post 1950 patterns found in Chenery and Surquin also points to a further change in this relationship).

'Dramatic' structural change, resulting in an economy that was in terms of its structure strikingly modern, occurred already before 1500, at least in Holland. Searching for the origins of 'sustained per capita growth', the second part of Kuznets' definition, resulted in similar findings. The period 1510-1807 was one of continuous growth of per capita real income – with certain swings in the rates of growth, but those occurred in the 19th and 20th century world as well. In that respect De Vries and Van der Woude (1997) were quite right: modern growth was a typical feature of the Holland economy of the early modern period. And they were even more right than they thought themselves, as per capita growth persisted in the late 17th and 18th centuries, although it changed in character.

This neatly also solves the problem, implicitly raised by De Vries and Van der Woude, that Holland did indeed have a (more or less) modern set of institutions and was a (more or less) modern market economy, without generating the (more or less) modern economic growth that is supposed to be the result of those markets and institutions (if we are to believe new institutional economics). Modern economic growth originated in the late medieval period (or perhaps even before that, we need similar data and estimated for the Middle Ages to be able to tell), continued in the early modern period, and accelerated in the period after 1800.

Appendix 1: the estimation of the national accounts of Holland 1510-1807[5]

1. Introduction

This appendix describes the way in which the estimates of the national accounts for Holland in the period 1510-1807 have been put together. The aim of the project was to produce annual estimates of gross value added of the main industries of the Holland economy in this period, in both current and constant prices, which could then be used to produce estimates of total GDP (and GDP per capita) for these three centuries. The starting point consisted of two benchmark estimates, for 1510/14 and for 1807, which resulted from previous research into the structure of the Holland economy at the beginning of the 16th century (Van Zanden 2002a), and into the national accounts of the Netherlands in the 19th century (the results of which have been published by Smits, Horlings and Van Zanden 2000). The two studies by Horlings (1995) on the services sector and by Jansen (1999) on the industrial sector in the first half of the 19th century were important as models for estimating output and value added in different parts of the economy.

The challenge of this project was to find sources that reflect the annual variation in output or value added in different industries between 1510 and 1807, in order to 'interpolate' between these two benchmark estimates. It was not possible to create another benchmark at, for example, some point during the 17th century. Although this was originally the intention, it proved not possible to find the right sources for this (but it may be subject of future research). In the process of working with the data, we sometimes were able to improve on the estimates made for the 1510/14 and 1807+ period, as a result of which there are some discrepancies between earlier studies and the estimates presented here (which we discuss in section 6). Moreover, the 1807 estimates related to the Netherlands as a whole, and in order to link the Holland estimates to those of the Netherlands, we had to estimate its share in Dutch GDP, which lead to a number of (generally small) modifications of the original estimates.

The aim of this working paper is to explain which sources were used, and which procedures applied to them, in order to measure the development of value added in current prices and in constant prices in the different industries. In general, we have rather good data on the development of output of those industries, although their quality differs from branch to branch and from period to period (in general, the quality of data improves over time). Also, price information is of a relatively high quality, making it possible to convert output series into series of gross value added. Data on the structure of inputs and on the share of value added in gross output generally are only available for one or two years, and estimates are often based on very small samples. However this applies to almost all studies of historical national accounts, because input and output tables have not been constructed in the past.

The economy has been broken down into three sectors (primary, secondary and tertiary). The primary sector includes agriculture and fishing (herring fishing and whaling); the main branch we miss here is fresh water fisheries which were quite important in the 16th century, but declined afterwards (see De Vries and Van der Woude

[5] We thank Christiaan van Bochove, Oscar Gelderblom, Peter Koudijs, Matthias van Rossum, Christiaan van der Spek, Milja van Tielhof and dr. F Snapper for their help in collecting the data.

1997: 237-239). The secondary sector consists of textiles (wool and linen), clothing, construction, peat digging, food (bakeries, brewing, gin – *jenever* – distilling, and other foodstuffs), paper, shipbuilding, printing, soap production and sugar refining; the largest branch for which we have no good information is metal working, but we assume that this (in Holland) relatively small sector was dominated by the demand from the military sector (for guns, canons) and from shipbuilding, and we have estimated the value added of these sectors in such a way that this part is of the metal trades is included there. Finally, the tertiary sector was covered by international shipping, international trade, domestic trade, inland transport (via inland waterways), banking, education, government services (military sector and the rest), housing, domestic services, and 'the rest', which was approximated by the development of notaries and book traders. The services sector was continuously the largest of the three sectors; moreover, it was also the sector which was most difficult to measure; therefore, we start with the way in which we approached this sector, and will then move on to industry; the primary sector (the smallest of the three) will be dealt with last.

2. Services

2.1 Services: international shipping

The biggest challenge was the estimation of the development of international services, which was probably the most dynamic part of the Holland economy, but at the same time a sector with a very high degree of volatility, which makes it less easy to make reliable estimates. In a related paper, by Van Tielhof and Van Zanden (2008), the details of the construction of the series of value added of this branch have been explained. The study by Horlings (1995) on the Dutch services sector in the period 1800-1850 has been used as a model, making it possible to link the estimates from this study to the 19th century estimates.[6] The following estimates have been made:

1. The volume of international shipping (in million tonkm) between Dutch ports and other ports;
2. The load factor (per route and on average): which share of the shipping capacity (on different routes) was actually used to transport goods;
3. The volume of transported goods (in million tonkm), the product of 1. and 2.;
4. The freight rate (per route): how much was being paid for transporting these goods;
5. The total freight sum, the product of 3. and 4;
6. The value added of the shipping industry, the result of substracting estimates of the value of inputs from the total freight sum;
7. The real value added is acquired by deflating 6. with an index of freight rates (resulting from 4.).

[6] E. Horlings, *The Economic Development of the Dutch Service Sector 1800-1850* (Amsterdam 1995).

It is clear that much information is needed. Fortunately, the Dutch shipping industry has been the subject of a lot of in depth research. We are particularly well informed about two large segments: the route to the Baltic via the Sound (thanks to the invaluable registers of the Sound toll and the many studies based on this source), and the trade with Asia, carried out by the Dutch East Indies Company (VOC), of which the accounts have been preserved and have been studied quite intensely. Also the development of shipping with (West) Africa and the Americas could be analyzed separately, thanks to a number of sources pertaining to this route. The other routes however – the trade with Russia/Archangel, Norway, England, France, Portugal/Spain and the rest of the Mediterranean (which will be grouped under the heading 'the rest') – could not be reconstructed independently. For the period after 1642 their importance could be derived from the total number of ships entering Amsterdam/Holland, which forms the basis for the annual estimates for 'the rest'. Moreover, for a number of benchmark years there are detailed estimates of the size and composition of the merchant fleet and the routes on which they are active, which can be used to anchor all estimates; in particular the estimates for 1636 and 1780 are extremely valuable, but additional benchmarks are available for about 1500, 1532, 1567, 1607 and 1695.[7] Because we have these relatively reliable benchmark estimates, most of the work is to construct annual series for the intrapolation of these benchmarks. This also implies that the estimates of the long term trends are relatively robust; the margins of error are particularly large in the estimates of the yearly changes in between those benchmarks.

First shipping through the Sound was estimated for 1503, 1528, and 1537-1780, using the information from the Sound toll registers.[8] Starting point was the number of voyages to the west, and estimates of the average size of the ships acquired from 1/ the data on ships sizes for the period 1537-1644 and 2/ estimates of the size of the transported goods divided by the number of ships for the period 1600-1780; the comparison of these estimates shows that the estimates number of lasts of ships between 1600 and 1644 is almost the same as the estimates tonnage of actually transported goods, suggesting a loading factor of 50% (as one last is two tons).[9]

Shipping volume by the VOC could easily be estimated on the basis of the data on the number and size of ships leaving for Asia and coming from Asia;[10] shipping within Asia was not included in the estimates, and it was assumed that all ships went to/came from Batavia (distance 21107 km).

Shipping volume of the WIC/to the Americas is estimated in the following way: for 1780 we used the benchmark estimates by Van der Oudermeulen, who gives detailed estimates of shipping volumes on all major trade routes at about 1780; this series was linked to the yield of the paalgeld paid explicitly by WIC/American ships from Heeres (1983), a series that goes back to 1712.[11] Between 1636 and 1712 the series was based on

[7] A recent survey of these estimates for the 17th and 18th century in Van Lottum 2007, and Van Lottum and Lucassen 2007; for the 16th century benchmarks Van Zanden 1987; the two most important benchmarks are those of 1636, which were part of a detailed inquiry by the Estates of Holland, and of 1780, the result of the work by the merchants and political economist Van der Oudermeulen; both estimates are considered to be highly reliable.

[8] Bang and Korst 1906/53.

[9] Moreover, it was assumed that ships came from/went to Gdansk, to which the distance is 1552 km.

[10] Bruijn, Gaastra and Schöffer (1979/87) and Bruijn 1990.

[11] Heeres 1982; 1983.

an index of the activities of the WIC in these years, derived from Den Heyer (1997).[12] It is based on data on the trade in slaves and the export of gold from West Africa. For 1636 this could be linked again to the benchmark estimate of total shipping activity by the States of Holland; between 1592 (when this trade began) and 1636 this estimate is based on the development of sugar imports from Brazil from Gelderblom (2007).[13]

The remaining shipping activity is reconstructed as follows: from a number of sources (a.o. paalgeld and lastgeld) Welling (1998) has estimated the number of ships entering the Amsterdam port between 1742 and 1810, a series that can be extended back in time (until 1643) using the same data for 1662-1747 published by Oldewelt (1953), and in addition the yield of the lastgeld for the period 1643-1662 from the same source.[14] We estimated the share of other port cities via their share in the 'convooien en licenten' of these years to get a series of ship entries into the Netherlands (Amsterdam's share fluctuated around 75%). From this series of total number of entries into the Netherlands between 1643 and 1810 we substracted the entries from the Sound, from Asia and from Africa and America estimated previously, to get a series of entries from 'the rest'. The average 'production' in terms of tonkm of these entries can be estimated from the benchmark data for 1636 and 1780, which appears to be almost exactly the same (457.000 tonkm in 1636 and 462.000 tonkm in 1780). We therefore have assumed that this 'production' per entry remained constant. For the period before 1643 we have assumed that the growth of the 'rest' was related to the expansion of the shipping through the Sound, and to the degree of *voorbijlandvaert* that can be found in the data on that source. The idea is that the share of *voorbijlandvaert*, which increased from 1-2% of total shipping in 1557/58, when the first data are available, to sometimes as high as 35% of total shipping in the 1620s and 1630s, reflects the multipolarity of the trading system, in particular the growth of other routes besides the 'mother trade' through the Sound. The expansion of the *voorbijlandvaert* from the mid 1550s onwards is related to the growth of shipping to Spain and Portugal, where the demand for grains from the Sound increases strongly, leading to a rapid expansion of Dutch shipping. The formula for estimating the shipping volume of the 'rest' is chosen in such a way that when *voorbijlandvaert* is zero (as it was in 1557/58), the volume of shipping of 'the rest' is identical to that via the Sound.[15] For 1636 we know from the benchmark estimates mentioned already that the ratio between Sound and 'the rest' is 1.7 (which is also exactly the ratio we get in 1643 when going back in time via the total number of entries, as explained above); before 1557 it was assumed that the shipping volume of 'the rest' was equal to that via the Sound.

Three intermediary factors have to be estimated to arrive at estimates of the value added of the shipping industry:

1. The load factor: the share of the shipping capacity used to transport goods; Horlings estimated these for the 1800-1850 period, and arrived at averages of about 30 to 40%, the result of the unbalanced character of most trade, and

[12] Den Heyer 1997.
[13] Gelderblom 2007.
[14] Welling 1998, Oldewelt 1953.
[15] The assumption, therefore, is that in the 1550s total shipping to 'the rest' was in terms of volume the same as the total shipping through the Sound, which is consistent with Lesger's analysis of the structure of Holland's trade in 1545, see Lesger, *Handel in Amsterdam*, pp. 33-39

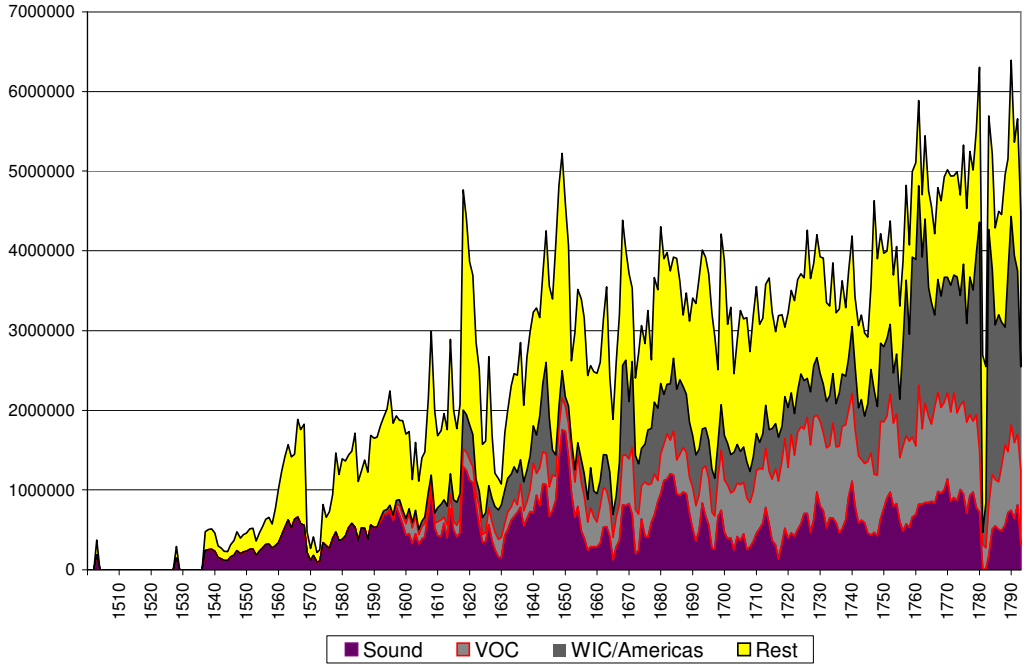
practical limitations of using the shipping capacity; similar (low) shares were estimated for the Sound route, where we know the share of ships that left for the Baltic in ballast (on average about one third), and we actually from 1600 onwards have estimates of the goods transported by the ships going westward; also for the VOC trade a low load factor could be estimated, as it is again known that most ships left for Asia almost empty, which was to some extent also true for the trade with Africa and Latin America; for the shipping on the other routes, it was estimated that the share of ballast was half that of the Baltic (as this trade was generally more balanced); overall, our estimates result in a small decline in the overall load factor from 40-45% in the 16th century to 35-40% in the 18th century, which is mainly the result of the growing importance of long-distance trade with a below-average load factor;[16]

2. The estimates of the long term development of freight rates are presented in a separate paper, which documents the large dataset on which these are based (Van Tielhof and Van Zanden 2008); on the basis of these data the development of average freight rates on shipping via the Sound, on 'the rest' (we estimated the average freight rate per tonkm on routes to Archangel, Bordeaux and Livorno), on Africa/Latin America.[17]

3. Finally, the share of value added in total freight sum had to be estimated; we used the estimates of the structure of the shipping costs discussed previously to estimate this share at 70% for shipping via the Sound and 'the rest', and 60% for long distance routes (Asia and Africa/Latin America), as the later used more inputs from outside, mainly as a result of the higher capital intensity of shipping on these routes, a.o. the use of more cannons and other means of defense as a result of the greater risks at sea, and the much larger size of the ships (Horlings estimated this share at 66%).

[16] Horlings 1995: 393; his estimate for 1807, a year of crisis, is 34%, rising to 45% in 1830.
[17] On the basis of actual freight costs of the Middelburgsche Commercie Compagnie from Reinders Folmer-van Prooijen 2000: 182-211), and estimated the actual costs of shipping by the VOC (from Bruijn 1990 and De Jong 2005.

Figure 1 Volume of shipping 1500-1793 (in 1000 tonkm)



The estimates of the volume of shipping (in tonkm) are presented in Figure 1, which clearly demonstrates the enormous growth of the shipping industry in the Netherlands. The total volume increased by a factor of 17 between the first estimate of 1503 and the absolute peak in 1790. The average annual growth rate between those dates was slightly less than 1% (0.9958%), which is quite high for such a long period. As can be seen from Figure 1, growth was initially rather slow at less than 0.5% per annum between 1503 and 1550; only during the 1550s and 1560s did the rapid expansion began, which is consistent with other studies.[18] The conflicts of the late 1560s and early 1570s were disastrous for shipping, but after 1576 a rapid recovery followed. From the 1590s onwards long distance shipping began to contribute to growth, and a period of extreme fluctuations of shipping followed, with a remarkable boom during the Truce with Spain (1609-1621), during which shipping more than doubled. This was followed by a serious downturn in the late 1620s and early 1630s, after which a very strong increase in activity occurred, peaking in the years before and directly after the Peace of Westphalia (the highest level is reached in 1649). In the next century wars still have quite an impact on the industry – with serious declines during the Anglo-Dutch wars – but the level remained more or less constant at 3 to 4 billion tonkm. Whereas during the previous century growth rates of total output had been in the order of 2.6% (1550-1600) and 2% (1600-1650), between 1650 and 1750 growth rates were barely positive in the long run. Shipping through the Sound declined in these years, as did the trade with the Mediterranean, but this decline was to some extent compensated by the further growth of long-distance routes – on Asia and the Americas. In the second half of the eighteenth century growth resumed (to a rate

[18] De Vries and Van der Woude 1997: 373.

of 1.2% per annum between 1750 and 1790), although it was much less spectacular than during the 1550-1650 period. The Atlantic economy became the most important source of renewed growth. This renewed growth after 1750 is perhaps the most surprising result of these estimates, as the eighteenth century – and in particular its second half – is usually seen as a period of decline.[19] Again the impact of the Fourth Anglo-Dutch war is very clear from the estimates (shipping in 1781 and 1782 is less than half the level before the War), but the recovery after 1783 is surprisingly strong.

A check on these estimates is possible by converting them into the size of the fleet that is needed to producing this shipping volume, which can then be compared with a number or estimates of the size of the Dutch/Holland fleet from contemporary sources.[20] This series at the same time can be used as estimate of the capital input. This can be done in the following way:

- The size of the VOC fleet can be estimated on the basis of the same sources mentioned before (the VOC accounts);

- The size of the fleet via the Sound: the Sound toll tables give, from 1565 (once every ten year) the average number of passages of the same ships via the Sound, a figure that is about 3 in 1565, increases to 4.4 in 1615, and then declines with ups and downs to about 2 in 1710/20, after which it recovers to about 3 between 1730 and 1780; this can be used to estimate the fleet needed to carry out the traffic through the Sound (as we already estimated the average size of the ships);

- The size of the WIC/Americas fleet is estimated on the basis of the benchmark estimates for 1636 and 1780, when the ratio between shipping volume and fleet is known; it appears that the ratio between production and size of the fleet is roughly constant between those years (which also applies to the VOC ships, where we see a similar constancy in this ratio); we estimated the size of this part of the fleet by assuming a constant ratio between fleet and production volume, based on the 1636 and 1780 benchmark years;

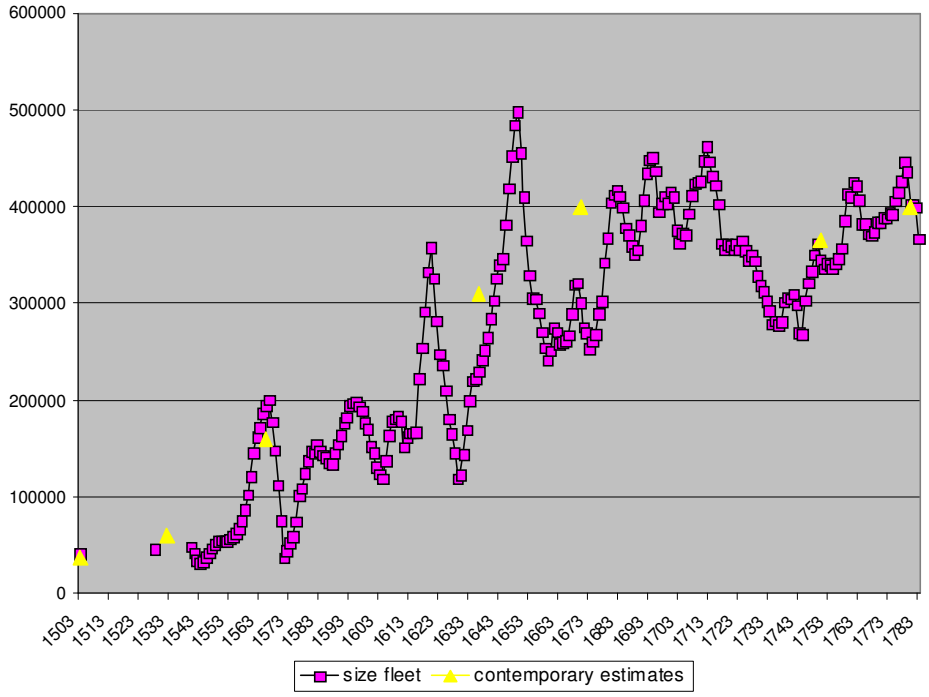
- The size of the rest of the fleet: as already mentioned the benchmark years of 1636 and 1780 show that the production per ship did not increase, and was about 83% of the level of the Sound traffic; this ratio was used to estimate the size of the rest of the fleet;

Adding up the four series leads to the following estimates of the development of the fleet size, which can be compared with data from contemporary sources (see Figure 2). Both series correspond well, which may perhaps increase confidence in these results. The size of the fleet increased from 43.000 tons in 1503 (contemporary estimate: 38.000 tons) to about 400.000 tons in the late 18th century, an increase of 0.9% annually during these three centuries, only slightly lower than the growth of the volume of shipping in the same period. The very large fluctuations in shipping fleet are also evident from Graph 6; in practice, changes in capacity utilization will probably further have dampened these fluctuations.

[19] De Vries and Van der Woude 1997: 674-683.
[20] Taken from Van Zanden 1987 and Van Lottum 2007.

Figure 2

Estimates of the size of the merchant fleet, 1503-1783 (five year moving averages, in tons)



2.2 Services: international trade

The estimates for the shipping sector are rather robust, and confirmed/checked by more or less independent estimates from contemporary sources. The very large sector of international trade is even more difficult to estimate, although there are again relatively reliable starting points, in particular the estimates by Van der Meulen (for 1780) and the Estates of Holland (for 1634) of the size and value of international trade in these years. Moreover, as with the shipping industry, we have detailed sources of trade with the Baltic and of the activities of the VOC, which make it possible to estimate the development of trade on these routes in detail. It can also be assumed that the income earned from shipping services is a large part of the total value added of this sector; for the trade with Danzig, for example, it can be demonstrated that the freight costs of a last of rye is about one third of the total margin of international trade between Danzig and Amsterdam (measured by the difference in price between the two cities), although this ratio does change a bit over time (it is somewhat lower during the first decades of the 17th century, but returns to the one-third level in the 18th century) (Van Tielhof and Van Zanden 2008). The estimates of the value added of the shipping sector can therefore also be used to check the plausibility of the estimates of the trade sector.

We used the same classification of routes as applied in estimating the shipping industry.

1. VOC: the accounts (published by De Korte 1984) give full details of the sales in the Netherlands, and the commodities bought in the Netherlands to buy those

goods in the Indies (and elsewhere); the gross trade margin is the difference between the two; for the period before 1640 this has to be estimated on the basis of the number of ships sailing to the Indies and arriving from the Indies; the results of the first trips (also of the Voorcompagnieën) are known from a variety of sources (an overview in De Jong 2005).

2. The Baltic: the volume of goods transported through the Sound (in both directions) can be estimated/derived from the published Sound-tables (Bang et al 1906-1953); we also know which share consisted of grains – dominated by rye; we also known the prices of rye in Danzig and in Amsterdam/Holland (from Furtak 1935; Pelc 1937; and the Van Zanden dataset of Holland prices in the 1450-1800 period)[21]; we have assumed that margins on other trades were 30 to 50% smaller than on rye, which was without doubt the main product traded; margins on exports to Danzig were relatively low because of the oversupply of cheap transport capacity (a large part of the ships went out in ballast to the Baltic, because they could not find a suitable export product, which must have depressed margins on export trade to the east) (Van Tielhof and Van Zanden, 2008).The Atlantic trade consisted of a number of trades, of which the slave trade is very well documented (Postma 1990 in combination with the website of David Eltis (http://www.slavevoyages.org) gives the numbers of slaves traded; added to this is the recent information on the illegal trade in slaves from Paesie (2008, p. 361-369); slave prices are from the same sources (and Eltis, Lewis and Richardson, 2005, and Den Heijer, 1997, p. 159); linked to this was the trade in sugar, the main export commodity of the Brazil colony conquered by the WIC in the 1630s (and lost in 1654), and of Surinam, the main Dutch colony in the Americas during the 18th century; Surinam also produced large quantities of coffee and some cotton; different sources make it possible to estimate the size and value of these trade volumes (Den Heijer 1997 for the WIC, and Van Stipriaan 1994 for the exports of Surinam); about the third leg of this trade – to Africa – we are less well informed, but a few sources (Den Heijer 1997) make it possible to estimate the ratio between African trade to the trade in slaves; taken together the annual estimates are consistent with the 1634 and 1780 benchmark estimates, and probably are an accurate reflection of the growth of this part of the trading network between 1640 and 1780 (and after 1780); the weakest part is the period before 1640, for which the data are rather scanty (but we also do know that this trade did only emerge in the 1590s, which creates a handy benchmark of zero trade for the early 1590s).
3. the most difficult to estimate trade is 'the rest', the trade with other European cities and countries, of which we have no detailed information; we basically applied the same method as used for estimating 'the rest' (the same category) of the shipping sector, but it is clear that this is a very rough approximation of the goods being traded and their value added for this important part of the international trade sector.

[21] Price data taken from J. Pelc "Ceny W Gdansku w XVI I XVII Wieku" Lwow, 1937 and Tadeusz Furtak, "Ceny W Gdansku W Latach 1701-1815" Lwow 1935; the Holland price data from http://www.iisg.nl/hpw/brenv.php

For these four groups of routes we could therefore estimate the total value of trade (measured in terms of the export and import prices on the Dutch/Amsterdam market) and, more importantly, the trade margin. In addition, we estimated the international trade with the hinterland (mainly Germany) using the following sources: the master thesis by Verheul (1994) presents data on the size of this trade flow in the 1780s, and a series of yields of toll of Schenkenschans, a strategic toll covering the trade going up and down the Rhine river (just before it split into different branches). The tolls were levied on the amounts of goods transported and therefore reflect the trade flow rather accurately. The series goes back to the 1540s; additional information on the size of trade flows during the middle decades of the 16th century is acquired from Weststrate (2008); for the 1510-1540 period we assumed that Rhine trade increased as fast as overseas trade. The trade margin on this branch was estimated at 15%.

The final problem to solve here was to determine which share of trade and shipping of the Netherlands has to be allocated to Holland? For the VOC this is determined by the shares of the Holland Chambers in its organization, which was 80%; for the WIC this was 78%. We estimated that 95% of Sound trade was carried out by Holland merchants, which may be too optimistic for the 18th century; finally we assumed that 75% of the trade with the rest of Europe, and 80% of trade with the German hinterland, was on account of Holland merchants.

2.3 Services: domestic trade

We follow Horlings (1995, 381) taking the value of agricultural and industrial production as indicative of domestic trade since total net exports had only a small effect. The value of industry and agriculture is taken from sections 3 and 4 below. For 1510 Van Zanden (2002) estimates the share of domestic trade and transport at 519,000 guilders. However, as transport alone is already valued at 380,000 guilders, this leaves 139,000 guilders for trade. Horlings (1995, 381), on the other hand, estimates the value added of domestic trade for the Netherlands in 1804 at 39.4 mln guilders, which, corrected for the population size, results in 14 mln guilders in Holland. This figure is plausible since it is roughly at the same order of magnitude as domestic transport.

Next, we use the series of current price value added in industry and agriculture to interpolate our benchmarks for 1510 and 1804. The weighted price series of industry and agriculture are used to deflate these series.

2.4 Services: banking

During the second half of the 17th century, and even more so during the 18th century, (international) banking activities became increasingly important as a source of income. To a large extent, the service of taking care of the transfer of money from one place to another (via for example bills of exchange), is included in the sector of international trade, because the remuneration for this part of the commercial deal was also included in the margin earned by the merchant. This however began to change during the second half of the 17th century, when – related to the success of the Amsterdam Exchange Bank – Holland merchants increasingly became involved with specialized banking transactions,

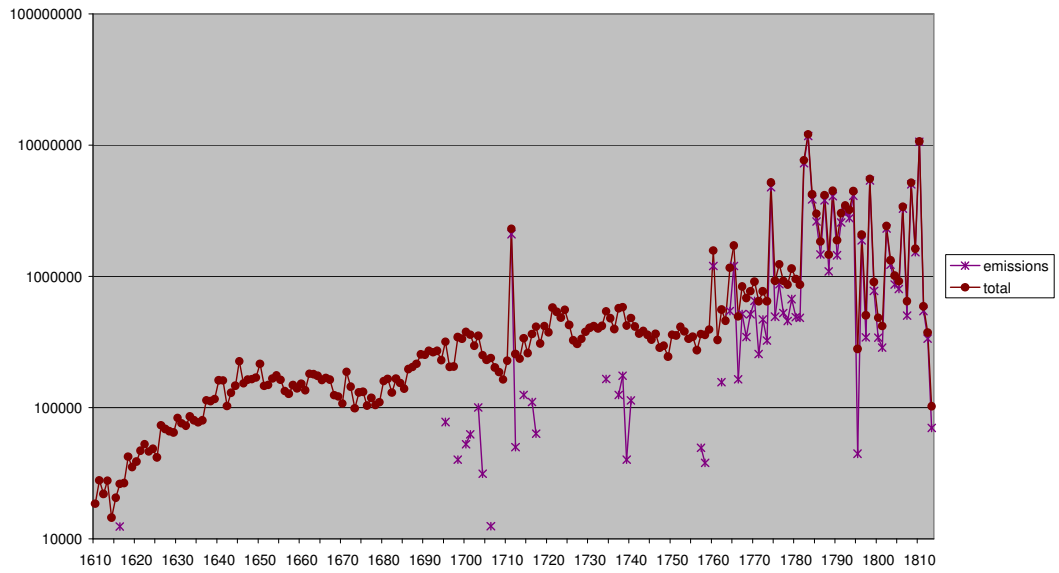
which were not necessarily related anymore with the trade in commodities they undertook. Amsterdam became the clearinghouse of commercial exchange in Western Europe, the Amsterdam Exchange Bank being its central hub. Amsterdam merchants increasingly concentrated on these banking functions, which became an important source of income. A related activity that became quite important during the 18th century was the emission of bonds for foreign governments. The Dutch economy has a large savings surplus, which was channelled abroad, first mainly to Great Britain, later on to almost all European monarchies. The banking firms organizing this trade, earned a share of between 5 and 8% of the capital sum involved (Riley 1980).

To estimate the income earned in this way, we firstly used data from the Amsterdam Exchange Bank as an indicator of the activities in international banking (taken from Van Dillen 1964); it concerns the size of inlays at the end of the year, which is the best measure of the activities carried out via the bank. The second source of information is a dataset of all the IPO's undertaken by Amsterdam bankers in this period, which show an enormous increase during the second half of the 18th century (this dataset was kindly made available to us by Joost Jonker and Peter Koudijs, who have put the dataset together; their main source in Riley (1980), but they added a lot of 'new' IPO's based on detailed archival research). It is estimated that 5% of the sum of the IPO was earned by the bank and its network of distributors (this may be an underestimate, as the available data on this collected by Peter Koudijs suggest that the range may be between 5 and 8%).

Before the middle of the 18th century, the banking sector is rather small, with earning not exceeding half a million guilders; this changes after 1760, when earnings often increase to 2 to 4 million guilders; the peak value is 1783 with more than 12 million guilders, almost as high as the international trade sector in these years.

Figure 3

Figure ... vale added of banking: from emissions and total, 1610-1813



2.5 Services: Education

Primary education:

The number of pupils was calculated using the percentage of people who could set their signature on marriage certificates in Amsterdam, provided by Kuijpers (1997) and Hart (1976). We assumed that those people followed primary education 15 years earlier (average age of marriage varies from 22 to 28 years). From Van Leeuwen and Oeppen (1993: 87-88), we took the number of people living in Amsterdam and the number of people living in Amsterdam who are between age 5-9 (primary school going age). Using the total population of Holland we calculated the total number of people aged 5-9 in Holland under the assumption that the population structure of Holland and Amsterdam are the same. We multiplied the % people that could sign the certificates (in year t+15) with the age class 5-9 for Holland (in year t) and divide that by 5 (as we only want 1 year, not 5). Now we assume that people who can sign followed at least 2 years of primary education (this matches with the average years of education in 1800 estimated by Albers (1997, 6)). The % people who finished the first, second, or third year of the 3-year primary school is taken from De Booy (1977, appendix 24). This allows us to calculate the total number of pupil-years of education followed each year.

The salary of schoolmasters is that which the Leiden guesthouse paid to the schoolmaster.[22] Gaps in the data were interpolated using the journeyman wage from De Vries and Van der. Woude (1997). From De Booy (1977, appendix 23), we took the ratio of pupils to teachers. Hence, we arrived at the total wage expenditure of teachers per pupil.
Multiplying this with the wage per pupil, gives the total VA in primary education

Secondary education:
The development of wages of teachers are taken from primary education, but, following the *quotisatie of 1742* (an income tax for this year), their level was estimated at three times the level of teachers in primary schools.[23] The total number of pupils was taken for Latin schools from Frijhof (1985). We assume 7 year education per pupil. Therefore we take 2 years from the age group 5-9 and 5 from the age group 10-14. From benchmark year from Frijhof (1985) we can calculate benchmark percentage of relevant age group following Latin education and extend these percentages using interpolation.

To this, we have to add children in French schools which started in the mid-17th century and overtook Latin schools in the 18th century. The ratio with Latin schools is available from Frijhof for the early nineteenth century and is assumed to go linearly to 0 in 1620.

The sum of pupils in Latin and French schools is argued to be equal to the total number of secondary school pupils in Holland. Multiplying the wage per pupil with the total number of pupils results in total VA in secondary education.

Higher education
The number of professors and their wages at Leiden University (the only university in Holland) is given in Sluiter (2004, appendix 2). Herewith we have to add the Atheneum

[22] NEHA: Posthumus archief no. 407, box I.
[23] Sources of Quotisatie of 1742: Oldewelt 1945, 1950 and 1951.

of Amsterdam. Amsterdam increased from 2 to around 6 professors between 1575 and 1810. In addition we know that in 1810 the number of students in Amsterdam was 80% of that of Leiden. The number of pupils from Leiden is taken from Frijhoff (1981) and from Amsterdam from Van der Byll *et al.* (1932, 3). Using this information we can interpolate the share of students in Amsterdam versus Leiden between 1810 and 1575. Multiplying this ratio with the total wage sum in Leiden results in the total VA in Higher education in Holland.

The educational sector increased rapidly between 1500 and 1800, but from very small beginnings (about 6 thousand guilders in 1510/14); in 1807 it contributes 490 thousand guilders to GDP. This corresponds with an increase in average years of education (see

Figure 4
Average years of education in Holland

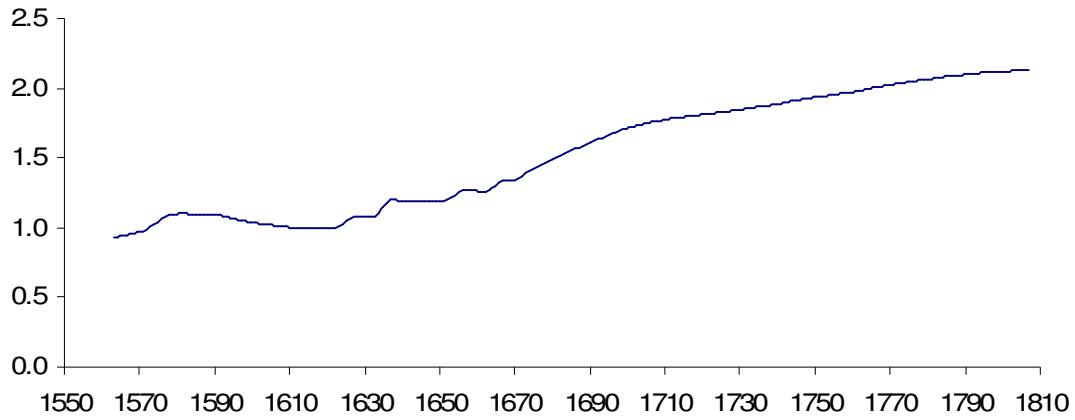


Figure 4) from about 1 in the middle decades of the 16th century to about 2 in 1800.

2.6 Services: Army and Navy (including production of inputs for this branch)
This is a very rapidly growing sector, because it was close to zero during the 16th century (only during the middle decades of that century there was a certain expenditure on the establishment of a standing navy), but grew enormously during the Revolt of 1572-1648, and remained quite high during the rest of the period, with sharp ups and downs. The data are available thanks to the important work done by Liesker and Fritschy (2004, 390, 392, 394, 406) on public expenditure of Holland in this period. Next, the number of soldiers was calculated using Zwitzer (1991, 190-191) and wages were taken from Van Zanden (2002b, 624). On this basis, we assume that 90% of the expenditure calculated by Liesker and Fritschy is value added: wages and salaries of soldiers and sailors, and the domestic value added of industries supplying military equipment, including ships.

Another source of finance of government expenditure, specifically for the navy, were the convooyen and licenten, from which the expenditure of the Admiralties on the navy was financed. We do not know the actual expenditure of these institutions, but do know their income (from these convooyen and licenten), which is given by Becht (1908) and, from 1707 onwards, by Johan de Vries (1968, pp.186-192). For the expenditure on the navy prior to 1589 we used the data from Sicking (1998, p. 184). For 1799-1807 the

data could be obtained from Van Zanden and Van Riel (2004, p. 45 and 49). We assume that 60% was contributed by Holland. The period 1795-1799 was interpolated.

The deflator is based for 50% on the military wage data from Van Zanden (2002b) and the unskilled wage index from De Vries and Van der Woude (1997). The other 50% consist of 35 percentage points iron and copper and 25% CPI.

2.7 Services: Housing

The starting point is the house rents index from Eichholtz and Theebe (1998). The missing years were extrapolated using the CPI from Van Zanden (2005: see www.iisg.nl/hpw). This house rent index was for Amsterdam only, and therefore not necessarily representative for Holland as a whole. Fortunately, we have the rent per house for 1632, 1732 and 1832 from the tax registers of these years (see Van Zanden 1987). We interpolated and extrapolated these points using the Amsterdam rent index to get a modified rent index.

This rent index was multiplied with the number of households in Holland (based on its population of Holland and an average household size). Multiplying the number of houses with the average rent index results in an index of the VA in current prices of housing. This is linked to the 1510 estimate of housing. The resulting series is deflated using the house rent index.

2.8 Services: Government

Fritschy (2004, p. 446) gives the wage sum of provincial civil servants in Holland for several benchmark years. These are interpolated using the categories of expenditure that cover these wages or are otherwise linked to it (*huislasten, collectlonen* and *inningskosten*, taken from Fritschy (2004, p. 160 and 430)). This results in a series of provincial government VA between 1575-1795.

These data, however, only cover the provincial wages. Therefore, we still have to add the wage sum of local government. Before 1575 local government must have been small while it increased strongly during the Revolt. For the period after 1620, when local government must have been relatively extensive, Fritschy (2004, p. 383-384) estimates the total *ambtgeld* (a tax on civil servant wages), which was equal to half all the total value of all government salaries. These estimates are, however, only comparable for the years 1717 and 1725. Using these years as benchmarks and assuming that the ratio between total salaries and salaries paid out by the central government remained constant during this period, we can estimate total government expenditure on wages between 1620 and 1795.

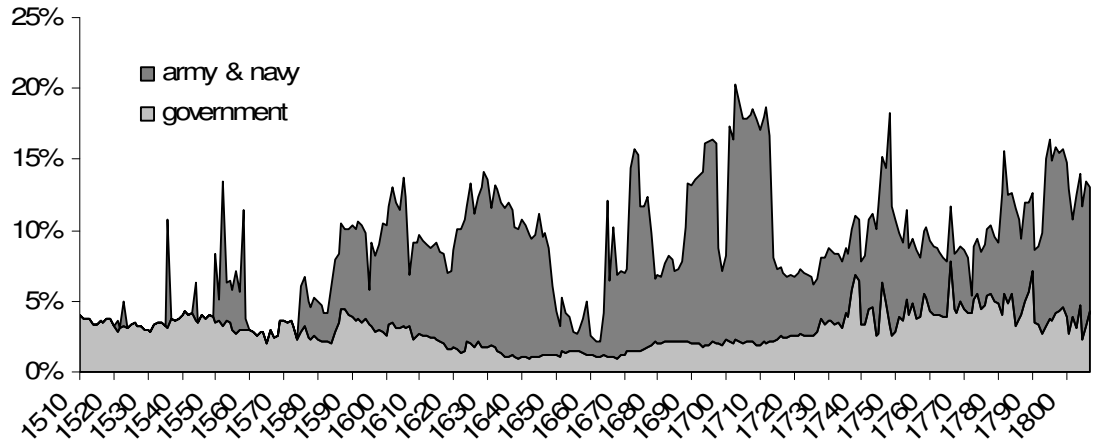
Unlike the period 1620-1795 where we directly estimate the total wage sum, we have to build up the wage sum prior to 1620 from individual wage data. To proxy civil servant wages, we used a wage index that consists of 50% schoolmaster wages and 50% skilled labour. Of course, population (and therefore the number of civil servants) also increased during this period. Hence, we multiplied this wage index with population size in order to create an index of civil servant wage sum. This index was linked to a base estimate of total civil servant wages in 1510/14. As the 1510/14 figures also included religious and educational professions, we subtracted from the 1510/14 estimate the value

added of education and clergy, the latter assumed to be 0.5% of the population and having a yearly wage equal to that of 50% schoolmaster and 50% skilled labourer. Linking the index with the modified 1510 benchmark results in a series of total government value added for 1510-1575.

Between 1575 and 1620, when local government increased relative to provincial government, we have the earlier estimate of provincial government expenditure. Also, we have the ratio between local and provincial government VA in 1575 and 1620. So, assuming a gradual increase in local civil servants, we linearly interpolated the ratio between local and provincial VA between 1575 and 1620. This resulted in an estimated of total value added for government for this period.

Finally, for 1799, the government expenditure is taken from Van Zanden and Van Riel (2004, p. 45 and 49) where we assumed 90% of government expenditure (exclusive military) is value added while the share of Holland is this value added is 60%. The years 1800-1807 is taken from Horlings (1995) under the assumption that 60% of the expenditure is for Holland. Finally, the years 1796-1798 are interpolated.

Figure 5
Share of government (including army and navy) in GDP, 1510-1807



Note: The share of the army and navy is taken from section 2.6

2.9 Services: Domestic servants

We took the percentage urban population in Holland from De Vries and Van der Woude (1997, p. 58; 61). These data were interpolated. Next, we multiplied it with the total population of Holland in order to get the share of the population living in towns. Under the assumption that most of the domestic servants were living in cities, multiplying with the unskilled wage index by De Vries and Van der Woude (1997) results in an index of the nominal wage sum of domestic servants.

This index is linked to an 1807 VA benchmark obtained from Gogel (1844, p. 482-485). Gogel reported the domestic servants in the departments of Maasland and Amstelland (roughly Northern Holland, Southern Holland and Utrecht). In order to remove the share of Utrecht in domestic servants, we multiplied this figure with the share of the population of Holland in the total population of Holland and Utrecht (ca. 90%).

The resulting number of domestic servants was multiplied with the unskilled daily wage where we assumed the wage to be 20% higher than in the rest of the Netherlands. This, in turn, was multiplied with 150 days worked as there was a lot of part-time work among domestic servants. In addition, this made the results fit good to the 1807 benchmark calculated by Horlings (1995).

2.10 Services: Domestic transport

Domestic transport consists of the "trekschuit" (inland barges) and "other transport".

Trekschuit:

De Vries (1981, 68) estimates the total passenger km capacity by trekschuiten in Holland-Utrecht in 1660. In addition, De Vries (1981, 69) estimates that only 50% of this capacity was actually used. Combining this information gives the total used passenger km for trekschuiten in 1660. Assuming that intercity trekschuiten developed in line with over-all trekschuiten, this benchmark figure was extended back and forward using an index of passenger km of the trekschuit for intercity purposes only (De Vries 1981, 246).

Next, we calculate the tariff per passenger per km on the basis of De Vries (1981, 76-78). This number of passenger km, multiplied with the tariff, results in the total value added for Utrecht and Holland. Just as we did for domestic servants, in order to remove the share of Utrecht, we multiplied this figure with the share of the population of Holland in the total population of Holland and Utrecht (ca. 90%).

Other domestic transport

We have data for two important transport routes. The most important route was through Holland, connecting Amsterdam/IJsselmeer, with the south; all ships had to go through Gouda, where as tax was levied on using the sluce. The yield of this *sluisgeld* reflects a large part of the domestic transport of Holland (see Van Zanden 1993 for this source).[24] The second series is linked to the trade of peat from Northern Netherlands to Amsterdam – according to Horlings (1995) this was the most important transport route in the early 19th century. We know the development of the production of peat in the Northern Netherlands (from Gerding 1995) and have assumed that exports were a constant percentage of output; consequently, we could use the output of 'northern' peat index also as an index of transport activity via the IJsselmeer. It was assumed that in 1807 both trades were equally important (see Horlings 1995). The resulting index of "other transport" was reflated using a price index of 75% skilled wage and 25% peat prices.

The resulting nominal index has to be linked to total domestic transport in 1807. Horlings (1995, 85-87) estimates domestic transport at 30.8+12.9=43.7 mln (inland navigation and "other transport"). We assume that Holland's share in inland transport was equal to its share in Dutch population. Next, we subtract the value added of the *trekschuiten*; the remainder (15.6 mln) is used as a benchmark estimate of the value added of other domestic transport (without trekschuiten).

Next we add trekschuiten and "other domestic" transport together to obtain all inland transport. The price index is a weighted average of the price indices of both series.

[24] Data for the sluisgeld for the period 1570-1800 were collected by Christiaan van der Spek.

2.11 Services: Other services (notaries and book traders)

Because the notaries are, from the 1520s onwards, a strictly regulated profession, we know the number of new entries into this business; in combination with the estimate of an average career of 20 years (this could be based on the 18th century data related to Amsterdam, when it is known that the number of notaries was frozen at 60). Before the 1520 we assume that the number of notaries increased with the population.[25]

The number of book traders is known from Gruys and De Wolf (1989). Their numbers shows a strong correlation with book production in the Netherlands (see under industry). The relative wage of book traders and notaries is derived from the Quotisatie of 1742 (Oldewelt 1945, 1950 and 1951), and the index of salaries estimated in section 2.5 is applied to this level to get a series of incomes of book traders and notaries.

3. Industry

3.1 Industry: Wool

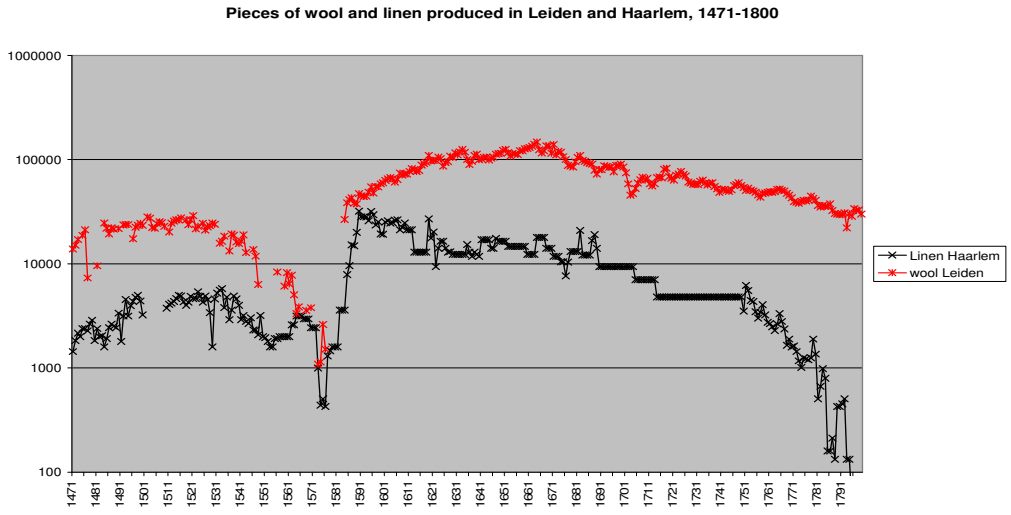
The total wool production in Leiden is given by Posthumus (1908-39) and Jansen (1999, 328). Weighted average prices of all sorts of woolens for benchmark years were obtained from Posthumus (1908-39, Vol. 3, 941). These prices were interpolated using the price index for textiles from Van Zanden (2005). These series were extended after 1800 by the series of Van Riel (see http://www.iisg.nl/hpw/prijzen19earthur.xls). Multiplying prices with volumes results in the total value of output of woollens in Leyden. Following Van Zanden (2002, p. 145), who took the data from Posthumus (1908, 276), we put the value added-output ratio at 0.7. This gives the total value added for woolens in Leyden. The share of Leiden in Total output of Holland was calculated in Posthumus (1908, vol. 1, p. 368) as 51% for 1514. Jansen (1999, 280-81) estimates the share of Leiden in 1807 at 61%. The intermediate years were interpolated and the VA of Leiden modified accordingly.

3.2 Linen

Holland also had an important linen industry, which was concentrated around Haarlem. Kaptein (1998) shows that the yield of the tax on the 'reep and ellemaat' reflects the development of this industry in Haarlem. Fortunately, this series is available for the whole period (Kaptein (1998, 256-7), and ****; the latter source also gives information about the changes in the tax rate happening after the 1570s). This could be used to estimate gross output and value added (estimated at an unchanging 70% of gross output). It was assumed that Haarlem's linen industry accounted for 50% of total production of linen in Holland (see Jansen, 1999). (moeten we nog aanpassen***)

[25] Data on the number of entries into the profession of the notaries in Holland between 1520 and 1800 were kindly made available by dr. F. Snapper.

Figure 6
Pieces of wool and linen produced at Leiden and Haarlem, 1471-1800



3.3 Clothing

Van Zanden (2002a, 163) estimates value added at 138,000 guilders in 1510 for clothing. For 1807, we have an estimate of 15.45 million based on Janssen (1999) under the assumption that 50% took place in Holland. The in between years were interpolated using the urban population growth (see domestic servants), reflated with an index of 50% wages of journeymen and 50% school masters.

3.4 Paper

The number of paper mills since the 16th century is given in Voorn (1960; 1973). For calculating total productivity, the number of "kuipen" per mill must be calculated. Fortunately, for almost all mills in Northern Holland, the personal archive of Voorn (Coda Apeldoorn, Collectie Voorn) contains estimates per mill of the number of "kuipen wit en grauwpapier". Following Jansen (1999, 192) we assume a production of 25000 kg per kuip in Northern Holland, meaning 2000 riem witpapier or 1200 riem grauwpapier.

For Southern Holland the no. of "kuipen wit en grauwpapier" is not recorded. We assume that the no. of kuipen per mill is equal to the average of Northern Holland for the respective year. In addition, we assume, following Jansen (1999, 399) that the no. of produced riemen paper per mill in Southern Holland in 1800 is equal to 31000. That figure thus declines together with the average no. of kuipen per mill.

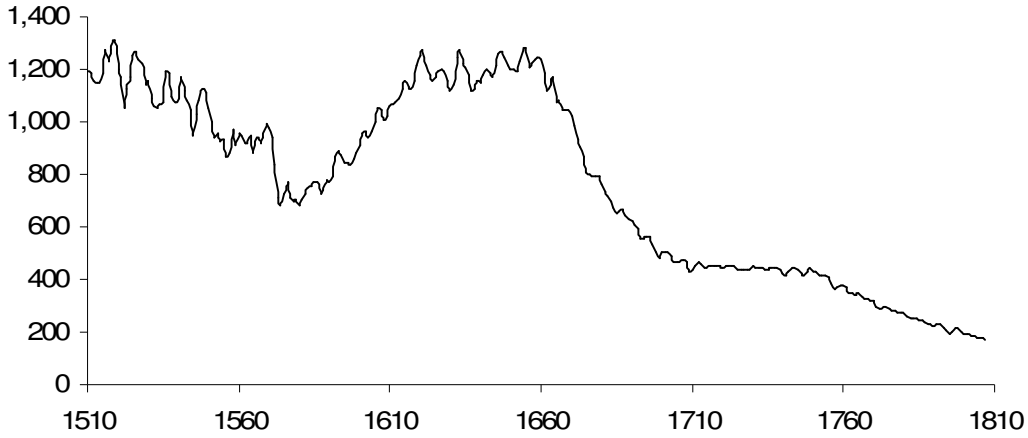
Thus having derived at the total no. of paper produced in Northern and Southern Holland, we use the price index of paper from Van Zanden (2005) and benchmark that with the price of "grauwpapier and "witpapier" for Northern Holland (Jansen 1999, 394-395) and to an average price of paper of fl 3.48 for Southern Holland. For the period after 1800 the prices were extended using the price data from Jansen (1999, 399). Thus having arrived at the total value of output, we arrive at the value added by assuming, following Jansen (1999), that the Value Added is 65% of gross output.

3.5 Beer

Benchmark estimates of beer consumption and production (and of exports) are taken from Yntema (1992); additional time series for the large producer cities are derived from the work by Unger (2001). In addition, the post 1650 decline of beer production can also be read from the decline in the excise on beer available from Liesker and Fritschy (2004). Beer production was multiplied with the price of beer. The index of the beer price is taken from Van Zanden (2005) and is benchmarked with the price of beer taken from Yntema (1992). After 1800, the resulting series was extended using beer prices from Van Riel (http://www.iisg.nl/hpw/prijzen19earthur.xls).

Multiplying the price and volume results in the total value of output. To obtain the value added, we follow Jansen (1999, 357) in assuming that 20% of output is equal to the Value Added. Because of different sorts of beer in the sixteenth century, Van Zanden (2002a) takes a ratio of 28% in 1510. The intermediate years are interpolated to obtain the complete series of value added.

Figure 7
Beer production (1000 ton)



3.6 Jenever

Dobbelaar (1930) gives information of the number of gin distilleries and the average output per distillery, as well as estimates of the input of grains. The price data for gin and brandy were taken from Posthumus (1964) from the Holy Ghost Children's Hospital. The remaining years are extrapolated using barley prices. From 1800 the price data were taken from Van Riel (http://www.iisg.nl/hpw/prijzen19earthur.xls). Multiplying the price and volume of gin results in the total value of output.

From the total value of output we have to subtract the total costs. A big part of these costs is the grain used for brewing. Following Jansen (1999, 175) we assume that gin consists of 30% barley and 70% rye. The price of barley is taken from Posthumus (1946) (Frisian Winter barley and Groningen Winter barley) and (1964) (St. Catherijnen-gasthuis). Rye prices are taken from Van Zanden (2005). Both series after 1800 are extended by Van Riel (http://www.iisg.nl/hpw/prijzen19earthur.xls). Subtracting the

costs of grain results in the gross value added. Following Jansen (1999) we multiply this with 0.125 in order to get the net value added.

3.7 Bread

The amount of grain for the production of bread has been estimated in the following way. Van Zanden (2002) estimates grain consumption (excluding beer) in the early 16th century at 200 liter per capita (see also VandenBroeke 1975); this is kept constant until the second half of the 18th century, when potatoes become increasingly important, leading to a decline ofconsumption of bread by 15% in the 1750-1807 period (Van Zanden 2005). This is converted in kg of bread using the conversion factor from Van Zanden and Van Riel (2004, 146). However, this amount of bread needs to be divided in wheaten and rye bread since the latter has a much lower value added than the former while there was a strong shift over time towards wheaten bread. From the study of Liesker and Fritschy (2004) we know the different excise tariffs for wheat and rye and we know the total amount of excise as well as the total amount of grain used for bread. Equalizing these values results in the share of rye and wheaten bread for benchmarks years. This is confirmed by a separate benchmark observation for 1760 and by an estimate for 1808 by Vries (1994, 202). These observations show a long-term decline in the share of rye bread in total consumption from 90% to 30% (wheat increases from 10% to 70%).

The total output can now be calculated, as well as the costs of grain. The price of rye bread is taken from Van Zanden (2005) and modified for Van Riel (http://www.iisg.nl/hpw/prijzen19earthur.xls) after 1800. The ratio of rye-to wheatbread after 1800 is known. Before 1800 the price of wheaten bread must be 250% higher than that of rye bread. The price of wheat is taken from Posthumus (1946) (Zeeland wheat and Koningsberg wheat) and (1964) (St Catharijnengasthuis, p. 449-550). The price of rye is obtained from Van Zanden (2005) and updated after 1800 with Van Riel's estimates for the 19th century.

Unfortunately, simply subtracting the costs of grain from the total value of bread does not result in the value added since we also have to subtract the costs for oil, salt, and excise. The excise data are obtained from Liesker and Fritschy (2004). Oil and salt as a percentage of the wage sum is known for benchmark years from De Vries (forthcoming). Any remaining years were interpolated with the CPI (Van Zanden 2005).

3.8 Sugar

Most of the sugar estimates are taken from Oscar Gelderblom (2004). He estimated the costs of sugar refineries, had the amount of Atlantic trade, prices, and the loss of sugar in the refining process. The data from Gelderblom needed to be updated with the imports from Surinam which was an average of Van Stipriaan (1994) and Postma and Enthoven (2003). Further, we added the Dutch East Indies Company (VOC) sales in Holland; the VOC archives contain detailed statistics of sales in Amsterdam, which have been processed for this research (source; National Archives, VOC, ****), which is exactly half the total sales in Holland. Hence, the Amsterdam sales were multiplied with 2. Prices were updated with Posthumus (1946).

3.9 Other food

Not much information is available fro the category "other food". Van Zanden (2002, 163) estimates this category at 271,000 in 1510/14 while The National Accounts project estimated the total food production in the Netherlands in 1807 at 41 million guilders. Subtracting the food produced and accounted for in Holland (sugar, beer, gin, and bread) and assuming that this was 60% of the Netherlands (since all products where either overwhelmingly produced in Holland or had a higher value added in Holland) we are left with a category of other food (e.g. meat) in the Netherlands of 13.4 million. Under the assumption that the per capita production was equal in all the Netherlands, the Value added for "other food" in Holland becomes in 1807 4.9 million.

Assuming that the consumption grew in line with population, we interpolate these two years using the population growth, reflated with an index of 50% wages of journeymen and 50% school masters.

3.10 Building

Building industry consists of "polderlasten" (the costs of maintaining polders), drainage (the costs of reclaiming new land), creating and maintaining waterways for "trekschuiten", and house building.

The "polderlasten" were calculated based on the expenditure per *morgen* of land as given in Van Tielhof (2006, 328, appendix 5). This series was multiplied with estimates of the cultivated area (see agricultural sector). As these series do not cover all costs, we used the 1832 benchmark of all "polderlasten" (based on the cadastral survey of that year) and used the index to bring this series back in time. Following Van Tielhof (2006, 327, appendix 4) we assume that 80% of this amount was value added. This series can be deflated using an index with 1/3 sand, 1/3 skilled and 1/3 unskilled wage obtained from Posthumus (1964) and De Vries and Van der Woude (1997).

Reclaiming of new lands was based on Van der Woude (1983, 50) who estimated the cost of reclaiming land at 690 guilders per hectare around 1600. Just as for "polderlasten", we brought this series back and forward using a price index of 1/3 sand, 1/3 skilled and 1/3 unskilled wages. The resulting index is multiplied with the annual increase in the cultivated area (almost all increase was due to reclamations).

The building of waterways for "trekschuiten" was also an important source of value added. De Vries (1981, 105) estimates the average costs of maintenance of these waterways per km. De Vries (1981, 99) also gives an overview of the increase in he total length of these waterways over time. Multiplying these two series results in the total costs of maintenance. This is multiplied with 0.95 to correct for a small management. Finally, just as above, the series is deflated using an index of 1/3 sand, 1/3 skilled and 1/3 unskilled labour.

Another major component was house building. For the period 1651-1806 this could be based on the excise for "grove waren", i.e. all sorts of building materials obtained from Liesker and Fritschy (2004). These series were back and forward extended using multiple imputation and a simple regression with household size. These resulting series were reflated (as it was in constant prices) using a price index consisting of 25% skilled wage, 25% unskilled wage, 23% bricks, 13% wood, 4.5% lime, 4.5% sand, and 5% lead. These weights are based O'Brien (1985) and were taken from Posthumus (1946-

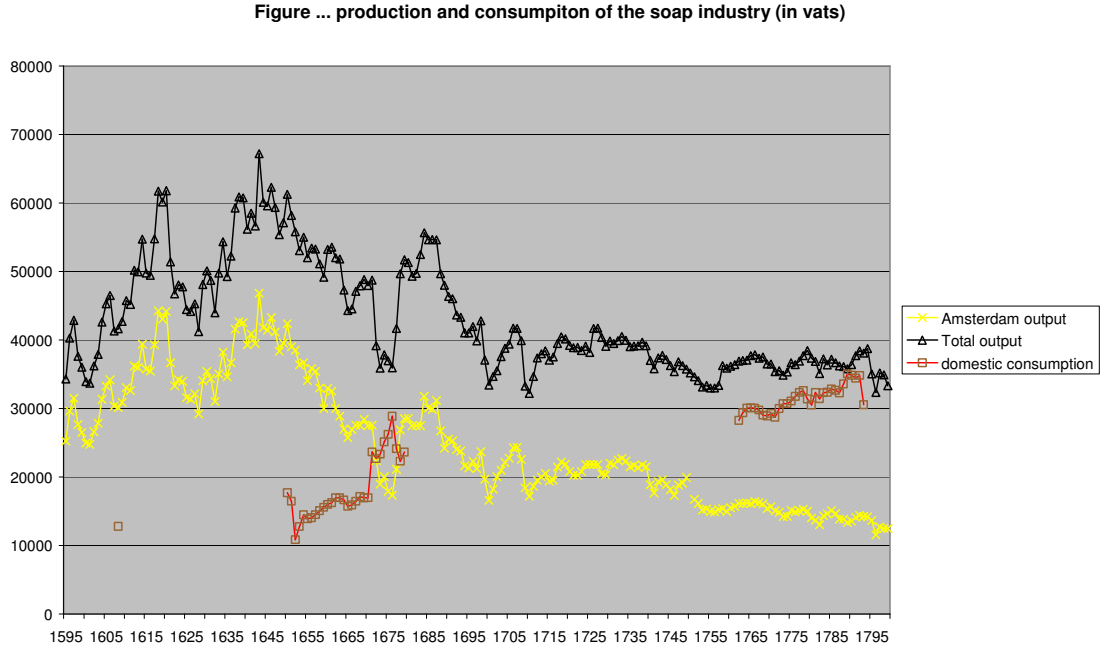
64) and Van Riel (http://www.iisg.nl/hpw/prijzen19earthur.xls) Van Zanden (2005). Since house building is an index, we still need to benchmark it in 1807. Therefore, we take the no. of builders in the Netherlands and assume this is in Holland equal to the ratio of the population of Holland versus the rest of the Netherlands. We add 10% to this figure (assuming more building in Holland) and 20% higher wages. This figure is multiplied with 300 days worked and 50% skilled and 50% unskilled wages. To this we add 10% capital. This results in a total value added for construction of 9.77 mln. From this figure we subtract polderlasten, droogleggingen (land reclamation) and trekschuiten. The resulting figure is brought back in time using the reflated and extended series of "grove waren".

3.11 Soap

There is a wealth of information about the soap industry, in particular that of Amsterdam. The guild of soap makers (zeepziedersgilde) of Amsterdam has left a large archive available at the Amsterdam Gemeentearchief, containing amongst others data on the production of soap in Amsterdam from 1595 onwards (with only a few small gaps in the data). In addition, Holland collected a tax on soap production, the proceeds of which are known for 1590, 1608, and from 1650 onwards (Liesker and Fritschy 2004). Amsterdam's share in total production was 75% in 1590, 72% in 1608 and 73% in 1650, making it possible to estimate output of the Holland industry using the 'inflated' Amsterdam figures for the intermediate years. For the period between 1650 and 1750 we have corrected for the fact that there is a growing gap between the estimated production based on the amount of tax paid by the Amsterdam soap makers, and the actual production known from the sources collected by the guild; the guild became the sole buyer of the tax (which was rented out), but used its power to pay much less than they were expected to do. On a much smaller scale the same happened with soap makers outside Amsterdam, as can be inferred from the differences between the yield of the tax before 1750 and after 1750; from 1750 onwards, the tax was actually collected by the government, and not leased out anymore, which lead to an important upward correction.

Because there was a separate tax on the consumption of soap (again derived from Liesker and Fritschy 2004), we can also estimate the internal market and the share of exports in production (see Figure 8). The estimates of soap production before 1590 are based on a constant consumption per capita (between 1608 and the 1660s per capita consumption also did not change much, but it doubled in the 18th century), and the assumption that the share of exports in total output increased from 50% in 1510/14 (when already large exports to the Baltic occurred) to 80% in 1590. The prices of soap are derived from Van Zanden (2005). The share of value added in total production is derived from Emeis (1954) and refers to the year 1699.

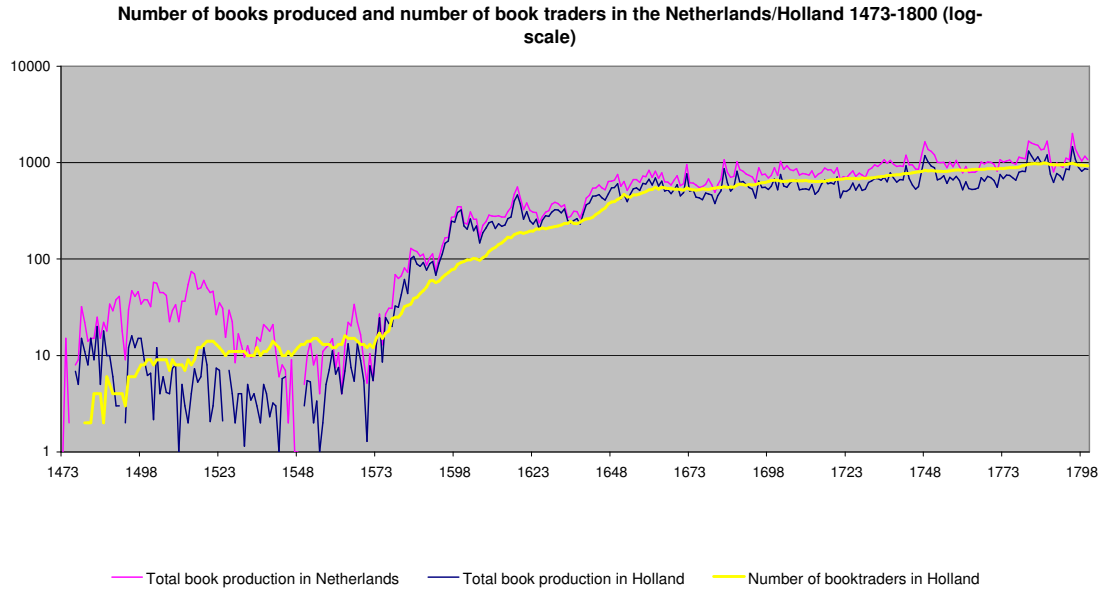
Figure 8
Production and consumption of the soap industry (in vats)



3.12 Books/printing industry

A dataset of the number of new books published in the Netherlands (and in Holland), including estimates of the development of the average price of books, has been put together in previous research (Van Zanden 2004b). For the post 1780 series use is also made of the tax on 'printed wares' (*geprinte waren*) collected by the Estates of Holland (Liesker and Fritschy, 2004), which is based on a broader definition of output of the printing industry, and therefore preferred. Estimates of the share of value added in output are from Cuijpers (1998).

Figure 9
Number of books produced and number of book traders in the Netherlands/Holland 1473-1800 (log-scale)



3.13 Shipbuilding

Elsewhere we discussed how we estimated the development of the merchant fleet (as part of the estimates of the shipping industry). The output of shipbuilding consisted of two parts:

- The maintenance of the fleet, which required expenditure to the tune of 10% of the fleet itself per year;
- The net increase of the fleet from year *T* to year *T +1*.

In principle, the output of the shipping industry was the sum of the two (maintenance and net growth of the fleet); in years in which the fleet declined, however, this could lead to negative output levels. In those cases it was assumed that the output of the industry was the maintenance of the fleet only (and the effect of a decrease of the fleet size was ignored).

We did some work on estimating a price series for ships, consisting of the weighted average of the prices of inputs (see Van Tielhof and Van Zanden 2008 for details). The different series used are:

- Wages of skilled labourers taken from De Vries and Van der Woude;[26]
- Prices of copper and iron, taken from Posthumus, which are from fifteenth and sixteenth century Utrecht and Leiden institutions and from the Amsterdam exchange for the seventeenth and eighteenth centuries[27]; additional data from De

[26] De Vries and Van der Woude, *The first modern economy*. 1997pages??
[27] N.W. Posthumus, (1943-1964), *Nederlandsche prijsgeschiedenis*, 2 Vols., Leiden, Vol 1.

Moor[28] for the fifteenth and sixteenth centuries, and from De Jong for the period 1585-1620;[29]

- Timber prices were derived from ongoing research by Christiaan van Bochove into the timber market in the seventeenth and eighteenth centuries, the data being linked to similar numbers from the abbey of Leeuwenhorst published by De Moor.[30]

The long term development of these prices was rather similar, as it was dominated by the price revolution of the sixteenth century. Only the price of iron changed much in relation to the other price series. Prices of timber and copper more or less moved with the general price level. In order to convert these individual series into one set of estimates of the development of total factor costs, they have to be weighted with their share in total costs of the shipping industry. It is not easy to find data on the structure of costs in shipbuilding. Based on nineteenth century data the costs of shipbuilding have been distributed as follows: timber 40 per cent, wages 30 per cent, iron 15 per cent and copper also 15 per cent (see for all details Van Tielhof and Van Zanden 2008).[31]

3.14 Peat

A lot has been written about the importance of the peat industry to Holland's economic development (De Zeeuw 1978; Unger 1984; Van Zanden 1997). The best recent survey is Cornelisse (2008), confirms previous estimates by Van Zanden (1997) about the level of peat consumption per capita, derived from tax yields from the early 16th century, 1608 and 1650-1800. The 1608 yield showed a somewhat higher level of peat consumption than the post 1650 estimates; Van Tielhof found in the Zeeland archives more details about the 1608 yield of the tax on peat, which made clear that 73% of the yield is related to the actual consumption of peat, the remaining 27 being levies on exports and actual production.[32] This makes it possible to estimate production (and exports) directly for this year, and makes it necessary to lower the previously published consumption estimates. This also implies that the decline of consumption per capita that did occur was more concentrated in the 16th century; it was probably related to the relative decline of the brewing industry, and to the switching of this industry to coal (which happened during the first half of the 17th century). The estimates are based on a constant estimate of per capita consumption of 12 ton, plus the estimated consumption of the brewing industry (see the sources there).

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[28] T. de Moor, *Prijzen en lonen in het cistercienzerinnenklooster bij Noordwijkerhout tussen 1410/11 en 1570/71* (Amsterdam: Historisch seminarium 2000).

[29] De Jong, '*Staat van oorlog'*.

[30] De Moor, *Prijzen en lonen*.

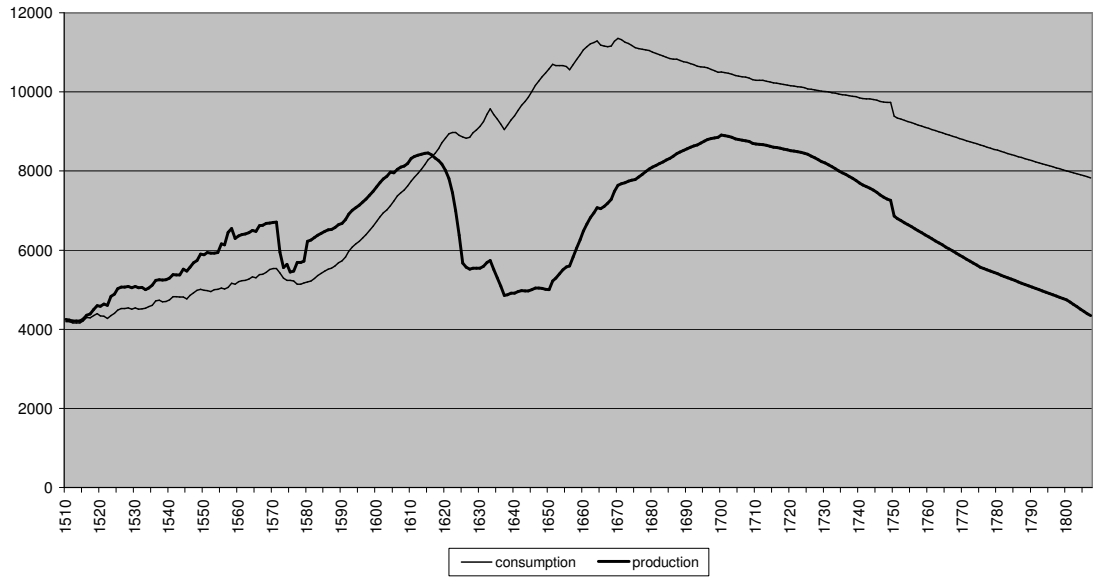
[31] Michael Jansen, *De industriële ontwikkeling in Nederland 1800-1850* (Amsterdam 1999) 288, 292-293; The most important price series that could not be included, is the price of hemp or canvas – our series of total factor costs therefore does not cover the costs of sails and ropes. We do know the long term development of the price of linnen, which was produced under more or elss the same circumstances as hemp and canvas; linnen prices declined compared to almost all other prices (with the exception of iron prices).[31] Assuming that hemp knew a similar price curve, the addition of hemp and canvaes to the index of total factor costs would have lowered its long term increase, and by implication also lowered the increase in total factor productivity.

[32] Zeeuws archief, Staten van Zeeland, inv.nr. 1894.

To get from consumption to production, two additional series of estimates are necessary. Exports are known for the 1560s (Diepeveen 1950) and 1608; for the 16th century we assumed that the series of the traffic through Gouda (see the section on inland transport) can be used to link the various estimates. At the beginning of the 16th century, exports were limited, the real export boom occurred in the middle decades of the 16th century (Diepeveen 1950). From about 1600 onwards, imports from northern Netherlands (Overijssel, Drenthe, Friesland and Groningen) became increasingly important. Gerding (1995) has estimates the long term trends of the production in these regions; we assume that 60% of it was being exported to Holland.

Figure 10
The long term trends in the production and consumption of peat in Holland 1510-1807 (in 1000 peat-tons)

Figure The long term trends in the production and consumption of peat in Holland 1510-1807 (in 1000 peat-tons)



4. Agriculture and fisheries

4.1 Fisheries and whaling

The value added of fisheries and whaling is calculated by Van Bochove and Van Zanden (2006) for 1600-1795. These estimates need to be extended both prior 1600 and after 1795. Van Bochove (2004) also made calculations of the catch of herring for years prior to 1600. Since whaling only emerged in the first half of the 17th century, this does not cause a distortion. We calculated the average value added per last for 1600-1610. These were used to modify the linear interpolated catches between 1500-1600 to constant 1600 prices value added. Next, these constant price series was reflated using the herring prices. For the period 1795-1807 we took the same approach with the catch data for herring from Poulson (2008) and assumed whaling to move in line.

We used herring prices to reflate these value added series. These prices were taken from Van Zanden (2005) and from Posthumus (1946) (full herring and matie) and (1964) (Holy Ghost, Municipal Orphanage, and St. Catherine).

4.2 Agriculture

For 1812/13 and 1510/14 two benchmark estimates were put together on the basis of the sources used in previous studies (Van Zanden 1985 and 2002); for these years we could also estimate the share of rents and of labour in value added in agriculture.

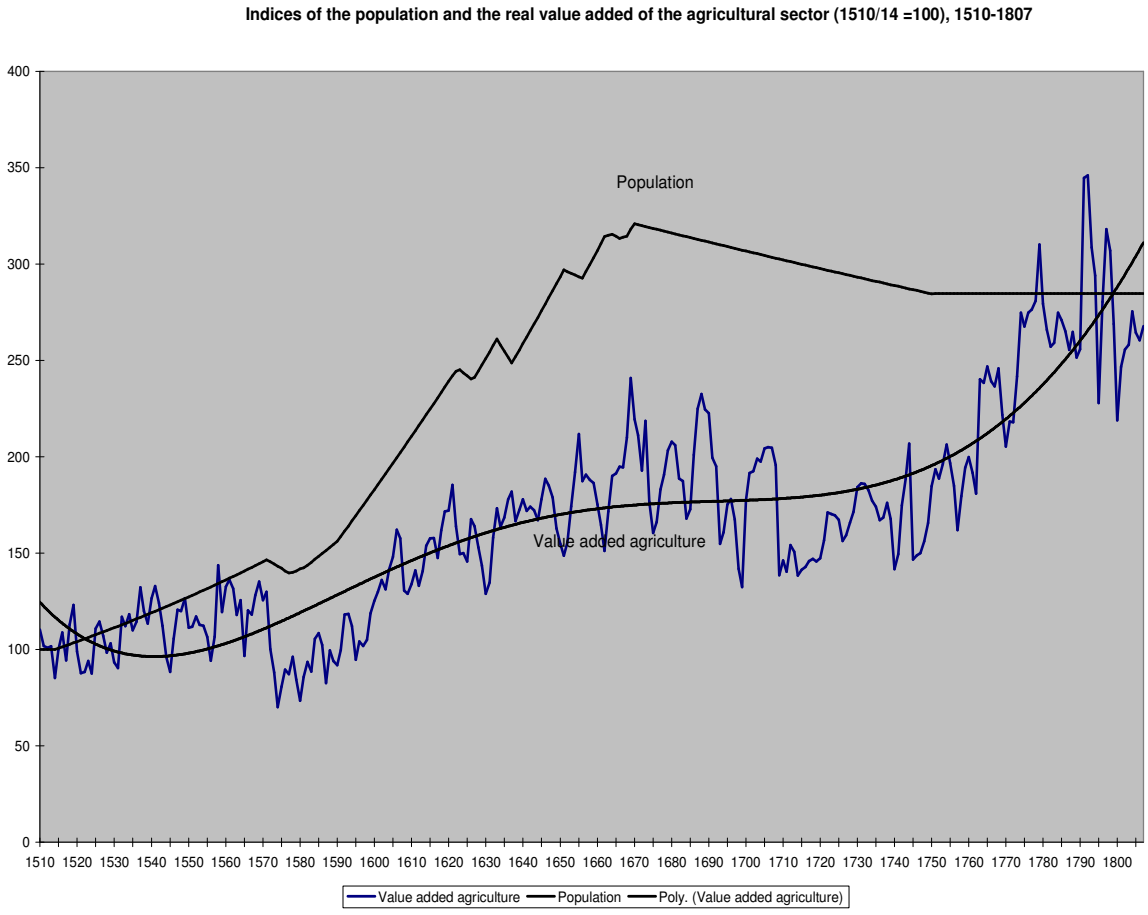
The cultivated land is known from the kadaster of 1832 (Van Zanden 1985), and the different reclamations (mainly newly created polders) are known from De Vries and Van der Woude, 1997, 32); the estimate of the cultivated land is based on the 1832 benchmark, and the different reclamations are subtracted from it; this gives an estimate for 1510 that is consistent with the data from the Informacie of 1514 estimated by Van Zanden (2002).

The development of the rent per morgen (.87 hectare) for the period 1500-1650 can be derived from Kuys and Schoenmakers (1981); for the 1650-1832 we have a benchmark estimate for the 1820s (based on the cadastral survey), and various estimates of the development of the level of rents by Van der Woude (1983), Prak (1985) and Baars (1973) for the intervening period.

Next, we assumed that the total rental value of the land was a certain percentage of total value added; in 1510/14 this was 65%, in 1807 61%, in between this percentage was intrapolated. Prices were derived from Van Zanden (2005).

As the figures below demonstrate, the growth of agriculture did not keep pace with population growth during the 1560-1700 period (and Holland was already a large importer of agricultural commodities in 1510); this changed during the second half of the 18th century, when agriculture grew relatively strongly, whereas the population stagnated. Land productivity more or less doubled during these three centuries; the growth of labour productivity was much more modest, and concentrated in the 17th century.

Figure 11
Indices of the population and the real value added of the agricultural sector (1510/14=100), 1510-1807

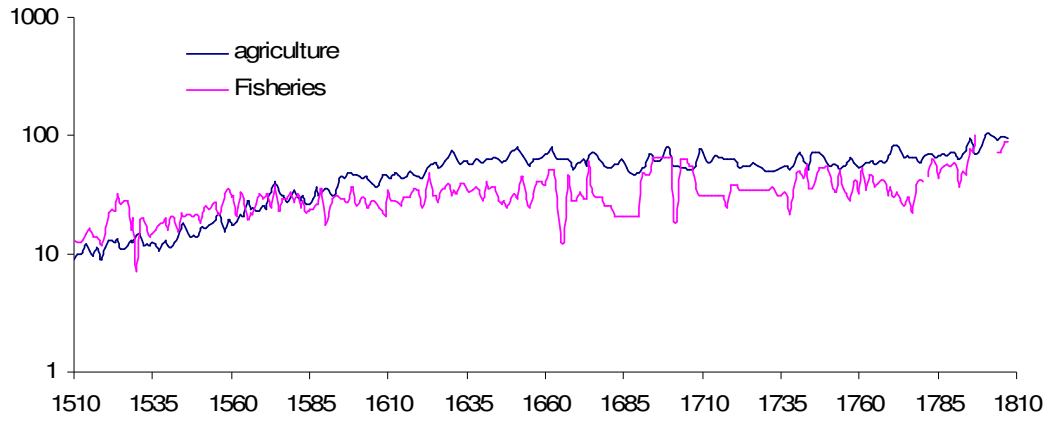


5. Prices and deflators

In the previous sections we discussed both current and constant prices with their deflators. Most series were reflated with the price of the most common product, e.g. herring prices for fisheries, sugar prices for sugar refining. Other series consist of weighted index of several prices and/or wages. For example, the building deflator consists of 25% skilled wage, 25% unskilled wage, 23% bricks, 13% wood, 4.5% lime, 4.5% sand, and 5% lead. Reflators in services were, however, by necessity largely based on wages, most commonly on a weighted average of the wages of skilled labourers and schoolmasters.

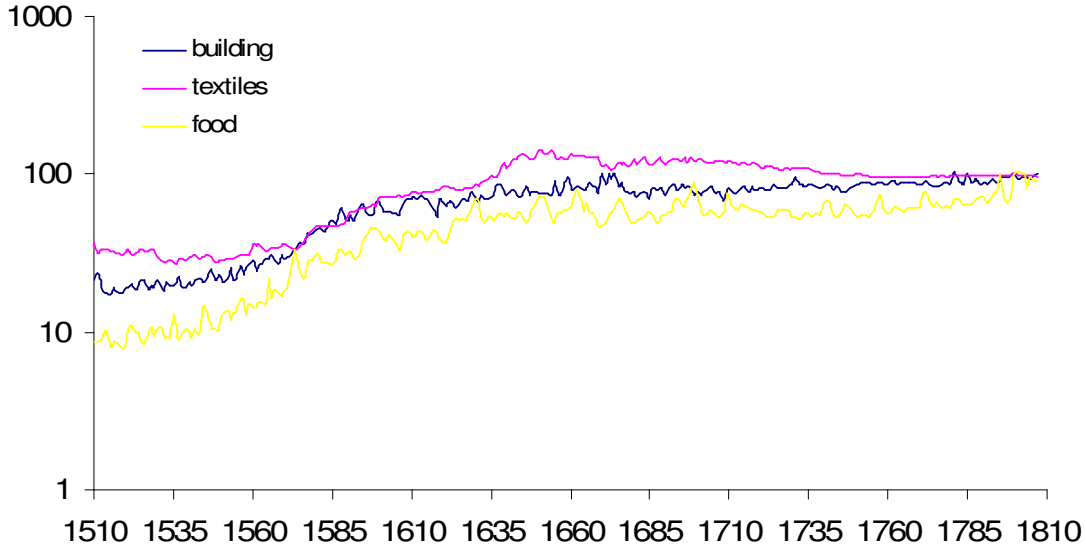
A comparison of price indices in agriculture is given in below figure. Both

Figure 12
Price indices in agriculture (1800=100), on a log-scale



fisheries and agriculture show a strong increase in prices from 1510 onwards; the prices of agriculture in particular increase a lot during the 80 years war. This strong growth in agricultural prices can also be found in the food sector in industry (see Figure 13). Food prices increased fastest, largely driven by the price increase in agriculture,

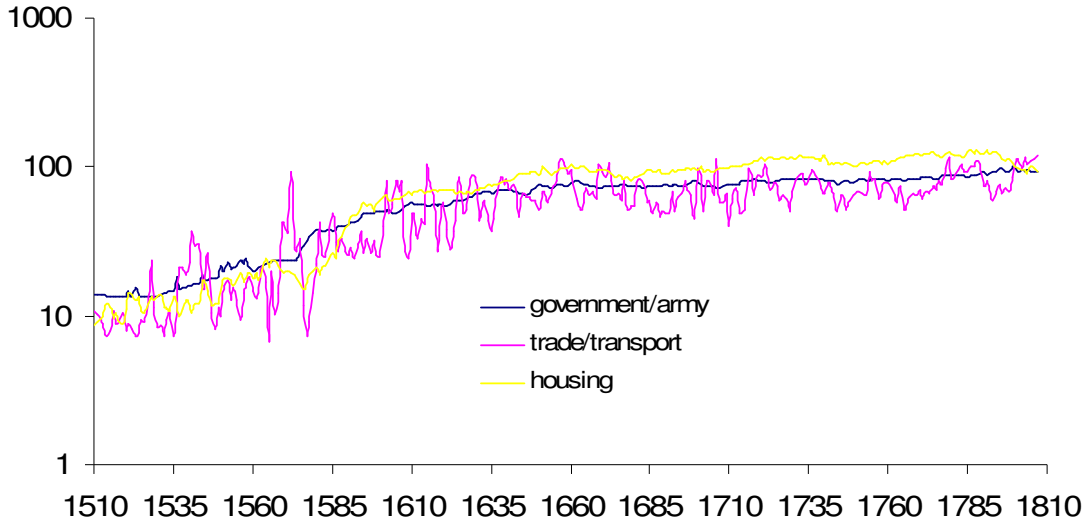
Figure 13
Price indices in industry (1800=100), on a log-scale



followed by a much slower growth in building and textiles. The relative decline of prices of textiles suggests a marked improvement in (labour) productivity vis-a vis the other

sectors. Since most of the service sector is based on wages, we do not expect much variation here.

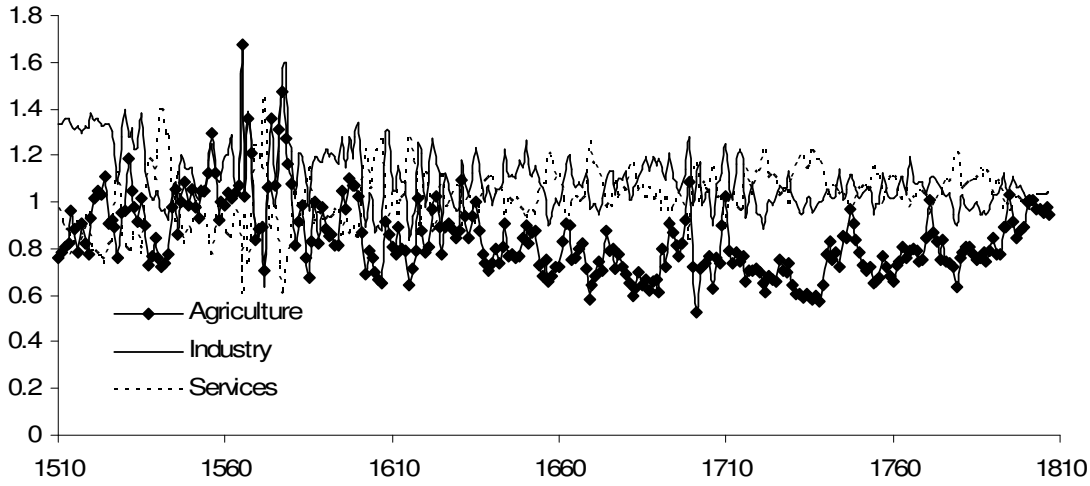
Figure 14
Price indices in services (1800=100), on a log-scale



Indeed, we can see that, although house rents clearly show the fastest growth, especially during the 1580s, all series move more or less in line.

If we now compare price developments in agriculture, industry, and services, we find the same pattern: agricultural prices on average grew faster than those in other

Figure 15
Price indices in the aggregate economy (1800=100) relative to the GDP deflator



sectors, suggesting a relative increase in labour productivity in services and industry (assuming no massive growth of the urban population and no decrease in per capita GDP). Another interesting development is the decline of agricultural prices vis-à-vis the other sectors between 1650 and 1750.

6. A comparison with other estimates

We can make a preliminary comparison for 1510 and 1807. This is given in below table:

		1510		1807		
		Van Zanden Holland	This text Holland	This text Holland	estimate based on Netherlands Holland	GDP project Netherlands
Agriculture		**1,882**	**1,543**	**33,093**	**30,016**	**120,700**
of which:	agriculture	1,282	1,281	32,908	28,790	119,300
	fisheries	600	262	185	1,226	1,400
Industry		**2,577**	**2,152**	**56,719**	**72,673**	**134,148**
of which:	building	942*	564.3*	14,184	11,840	21,300
	textiles	603	576	463	5,587	6,984
	clothing	138	138	15,450	15,450	30,900
	food	618	542	21,944	25,000	41,948
	paper	0	0	674	800	1,000
	mining	195	322	2,979	2,840	3,100
	other	81	10	1,025	11,156	28,916
Services		**2,026**	**2,022**	**84,193**	**112,590**	**209,200**
of which:	international trade/transport	930	515	9,305	42,460	60,200
	domestic trade/transport	519	519	31,525	25,194	69,600
	housing	275	275	9,707	7,844	19,700
	other services	302	713	33,656	37,092	59,700
GDP		**6,485**	**5,717**	**174,005**	**215,279**	**464,048**

*Inlcudes shipbuilding, metals and wood.

** Excludes metals and wood. Shipbuilding is largely included in the navy.

These results have to be taken with a grain of salt as there is a large margin of error. The main problems are in international trade and transport, and in the food sector.

7. Factors of production

7.1 Land

See under Agriculture (estimates of cultivated area)

7.2 Population

There are three more or less reliable benchmark estimates of the population of Holland, in 1514, 1622, and 1795; on this basis, and additional data, De Vries and Van der Woude have in a number of publications also made estimates for 1670 (when Holland's population probably peaked) and 1750 (when its decline, which began after 1670, came to a stop) (see for example De Vries 1974, and De Vries and Van der Woude 2001). Moreover, we know from a number of papers that Holland was a couple of times struck by epidemics (of the plague), which led to strong declines of population levels (Noordegraaf and Valk 1996, Rommes 1990). Moreover, it is also known that during the 1580s and 1590s population growth must have accelerated as a result of massive immigration from Flanders (but this followed a probable set back of the population during the 1570s as a result of the civil war and emigration of Catholics to the south). To create a time series, we have tried to take these demographic developments into account; firstly we intrapolated the point estimates available for 1514, 1622, 1670, 1750 and 1795; next, we included a number of corrections to take into account 1) decline during the 1572-1576 period; 2) accelerated growth after 1580, and 3) declines during the epidemics of the 1630-1670 period. The resulting time series is very tentative.

Finally, we estimated Holland's population after 1795. First, we took the population of Holland from Oomens (1989, p. 16) for 1795 and 1814. From this, we subtracted the population of Amsterdam from Van Leeuwen and Oeppen (1993) because the population of Amsterdam moved differently from population in general). Next we took the population from *200 jaar statistiek in tijdreeksen* for the Netherlands 1804-1814. We calculated the ratio with the population in Holland (minus Amsterdam) in 1814 and brought the series back to 1804. Next, we interpolated the remaining years (1796-1803) for the population of Holland without Amsterdam. Finally, we added the interpolated population of Amsterdam (1795-1814) to the population of Holland minus Amsterdam to obtain the total population of Holland.

7.3 Human capital

See under education.

7.4 Physical Capital

No estimates of the development of the capital stock have been made so far, except for estimates of the size of the merchant fleet.

Appendix 2: A scenario for growth between 1348 and 1514

It is not possible to estimate the national accounts of Holland for the period before 1514 in the same, relatively detailed way, via the estimation of the value added in constant and current prices for different (27) branches of industry. The necessary data and time series are simply not available to do this in the same way. What can be done, is to develop a 'scenario' of the most likely development of real GDP per capita, using the detailed benchmark of 1510/1514 as a starting point. What do we know for the period 1348-1514 is the following (this overview is largely based on Van Bavel and Van Zanden 2004):

- In contrast to large parts of Western Europe, the population of Holland recovered quickly from the Black Death of 1347/48 and its aftershocks; the total population in 1400 was 'only' about 10% smaller than in 1348, and increased continuously after 1400 to a level that in 1514was 17% larger than before the Black Death (275 thousand versus 235); moreover, population growth was concentrated in the cities, who saw their share in total population increase from 23% in 1348 to 45% in 1500; the rural population in 1500 was still somewhat smaller than in 1348;[33]
- Due to ecological problems (rising water levels, storm surges etc.) agricultural went through a crisis between about 1390 and the middle of the 1420s (when large parts of the countryside became inundated by the Saint Elisabethflood of 1421); there are a number of tithe series that probably closely reflect the development of cereal output in these years; they show a recovery after the mid 1420s, another crisis in the 1480s (which is also documented well by other sources: the Enqueste of 1494), and another recovery afterwards (for details see Van Bavel and Van Zanden 2004); because the cultivation of grains became much more difficult, the agricultural output mix shifted towards livestock products, made possible by the growing demand from the cities, and from abroad; from the 15th century onwards, Holland becomes a net exporter of butter, cheese, livestock etc.; whereas at about 1350 Holland was more or less self –sufficient in foodstuffs, in 1514 it was a large importer of grains from northern France and the Baltic, and a net exporter of livestock products; this change can be estimated in the following way: we assumed that Holland was indeed self sufficient in 1348, and that consumption per capita was the same as in 1510/14, which gives us a set of estimates of agricultural output in 1348; the gap between 1348 and 1514 has been filled by assuming that the available tithe series represent the evolution of grain production, and that the output of livestock products grew with the expansion of cities (which we estimate below); Figure 1 presents the two series of grain production and total production; between 1348 and 1390, agricultural output goes up somewhat, and there is almost no structural change; the rising trend in output in this period is remarkable, as population went down somewhat in these years; output per capita seems to have increased by about 40% in the four decades after the Black Death; the ecological crisis between 1390 and 1425 leads to a diversification of agricultural output, a process that continues during the rest of the 15th century;
- The rest of the economy is much more difficult to measure; we do know something about the growth of the urban population, and can follow the annual evolution of the population of the relatively new and fast growing city of Leiden from 1365 to 1514 (thanks to information on the immigration of new citizens in

[33] The years in which the population of Holland decline due to epidemics of the Plague are derived from De Boer (1978: 40-91).

these years, which make it possible to estimate its growth – see Van Bavel and Van Zanden 2004); the example of Leiden is important, because it represented the new growth industries – textiles, brewing, herring fisheries and shipping– that hardly existed at all in 1350, and were the most dynamic parts of the Holland economy in the 1350-1500 period; we have therefore assumed that output in these new industries (with a share of 37,5% of GDP in 1510/14, half the non-agricultural part of the economy) increased at the same rate as the population curve of Leiden; this assumes that labour productivity was stagnant, which is a strong assumption leading to an underestimation of GDP growth in this period; the rest of the non-agricultural economy, the other 37,5%, consists of activities which also increased rapidly in the 1350-1514 period, but were of some importance already in 1348: commerce, other services, and industrial activities linked to the domestic market (foodstuffs – apart from brewing – etc…); here we assumed that output increased with the number of urban inhabitants – again assuming that labour productivity did not increase;

- The combination of these estimates result in the following structure of the economy at about 1350: 50-55% of GDP is earned in agriculture (in prices of 1510/14), which seems consistent with a rate of urbanization of 23%; in 1510/14 the share of agriculture had dropped to 24%, and the urbanization ratio was 44%; both estimates are more or less consistent with the assumption that each urban citizen gives rise to the employment of one non-agricultural worker outside the cities.

The rising urbanization ratio illustrates that there was substantial economic growth in the period 1348-1514. We estimate that GDP per capita almost doubled. The long term rate of economic growth was 0.18% per year (which is, by the way, very similar for per capita growth during the 1514-1806 period). There was rapid growth in the decades immediately following the Black Death – part of the increase in GDP per capita was the Black Death bonus of a decreased population. The period 1390-1425 was quite difficult, and income per capita probably fell quite a bit. Then followed, from 1430 to 1477, a period of expansion – the golden years of the Burgundian economy. The 1480s were difficult again (this time mainly due to political conflicts), but followed by recovery and further growth after about 1490. Figure A.2 makes a comparison with completely independent estimates of real wages in this period, based on price and wage data (again, see Van Bavel and Van Zanden 2004). We present two series: of the nominal wages of unskilled labourers expressed in liters of wheat, and deflated by a CPI representing a basket of consumption goods (following the methodology set out by Allen 2001). It is reassuring that these estimates show the same rhythm: (growing) prosperity until the 1390s, a deep crisis until the mid 1420s, followed by the golden years between 1430 and 1477; the final decades of the 15th century were again rather difficult for wage labourers: the recovery after 1477 was

only partial. Clearly, real wages fluctuate much more strongly than real incomes per capita, but the underlying trends were very similar.

Figure A.1 The output of grains and the agricultural sector as a whole, 1348-1514 (1348 =100)

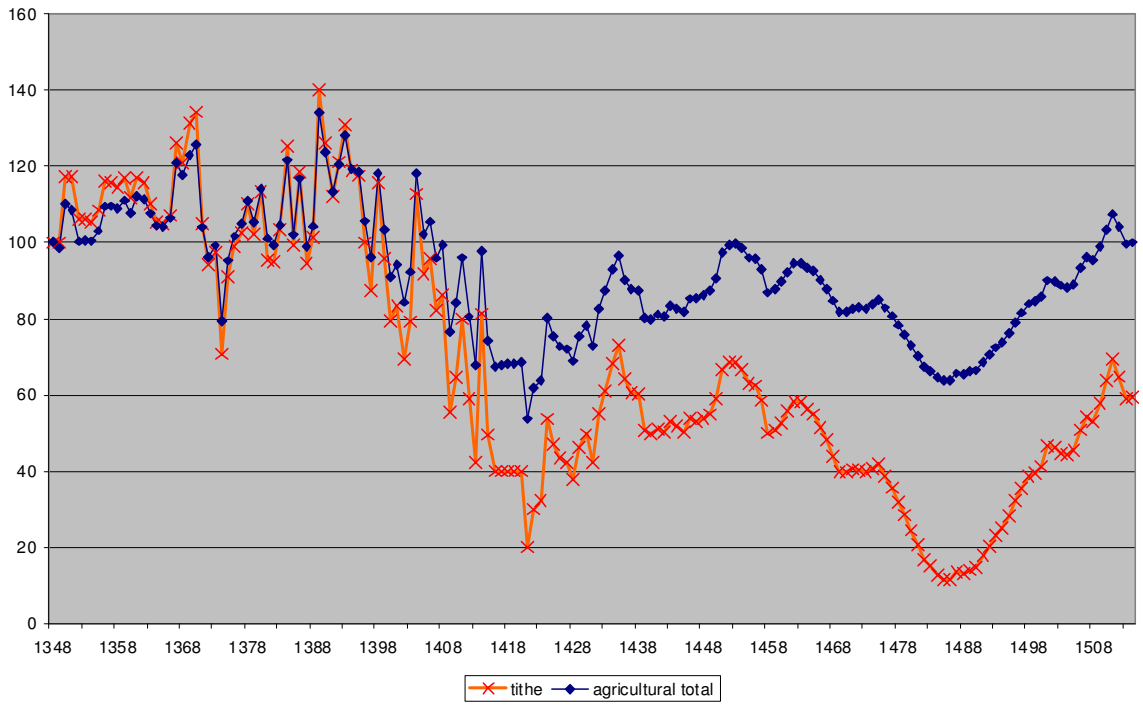
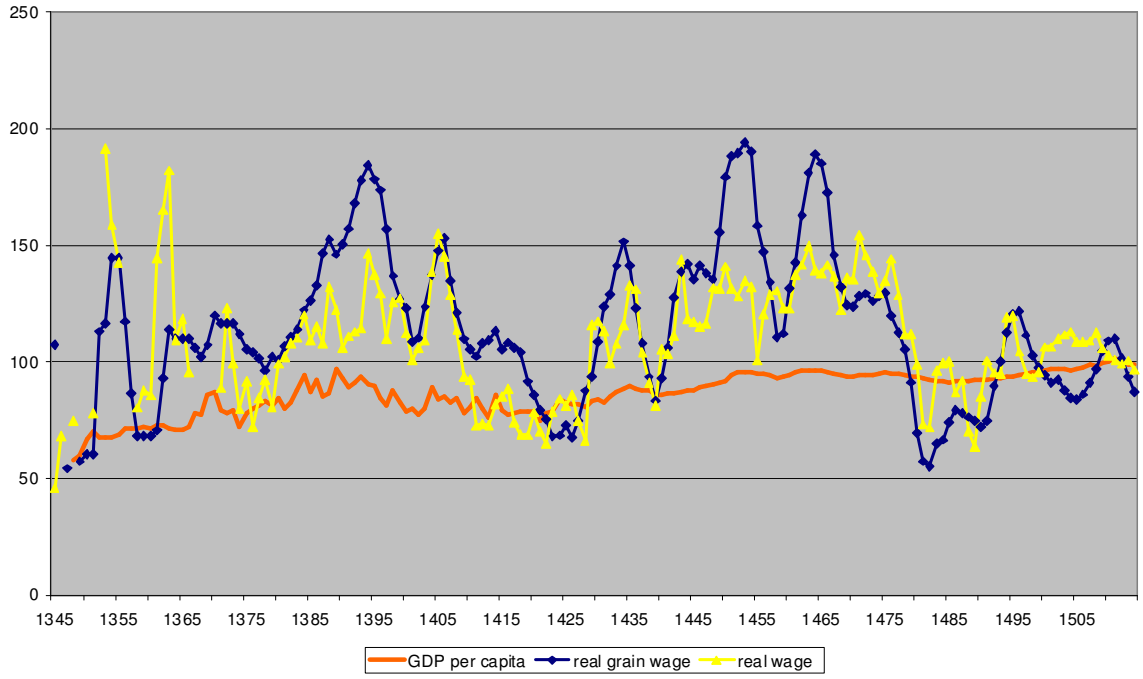


Figure A.2 Estimated GDP per capita and real wages in Holland, 1348-1514 (indices 1510/14=100)



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