Harvests, prices and population in early modern Sweden

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Abstract

Today, one of the greatest challenges facing macroeconomic history is to quantify economic growth in the early modern period. This paper presents and discusses a series of total and per capita harvest production in Sweden within present borders for the period 1665-1820. The series is based on three main indices: grain prices, subjective harvest assessments and tithes. To calculate per capita production the size of population must be known. In this paper, population growth in Sweden during the 17th century is revised downwards compared to recent studies. The basic finding is that per capita harvests stagnated during the studied period. The annual fluctuations were substantial. Another finding is that, in the short-run, grain prices were more affected by domestic harvests than foreign prices.

JEL-classification: E30; J11; N13; N53; Q11

Key words: economic history, agriculture, price history, GDP, early modern period, historical demography, Sweden
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1. **Introduction**

Among quantitative historians there is a broad consensus concerning the broad contours of world economic development during the 19th and 20th centuries. The great challenge facing macroeconomic history today is to quantify economic growth in the Early Modern Period. Reliable quantitative data on per capita GDP before 1800 are virtually non-existent. Although Sweden belonged to the periphery of European economy up to the early 20th century, some of Sweden’s data are unique internationally providing the opportunity to test various hypotheses concerning per capita growth during the pre-industrial period.

Maddison (2007) suggests that there are two divergent interpretations of the Merchant Capitalist Epoch (1500-1820), one positive (the Smithian view) and one negative (the Malthusian view). In his approximation of World GDP per capita in 1-2030 AD he assumes that the GDP per capita in Western and Northern Europe increased continually before the pre-industrial period (from 1000 AD onwards). For Sweden within present borders, he makes a guesstimate that the GDP per capita increased by 74 percent in 1000-1500, by 19 percent in the 16th century, by 19 percent in the 17th century and by 23 percent in 1700-1820, in total by 200 percent in 1000-1820.¹ These numbers are most likely overestimations. Maddison’s account of economic growth in peripheral countries before 1800 has been criticized by amongst others Olle Krantz.²

The key activity to be studied is cereal production. In the pre-industrial society, it was largely the growth and fluctuations of harvests that determined the growth and fluctuations of the overall economy.³ There was a strong negative correlation between harvests and grain

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² See Krantz (2004).
³ Edvinsson (2005a) and (2005b).
prices. In his study of grain prices in early modern England, Hoskins (1964) writes that looking at the annual fluctuations of grain prices is to look at the electro-cardiogram of a living organism. The benefit of consumption and price stability was a fundamental theme in pre-industrial political economy.

A fundamental economic variable is population. It is only in relation to the population that other economic phenomena can be interpreted properly. For example, to calculate per capita production when total production is known, the size of population must be known. However, as discussed further below, there are many uncertainties concerning population growth in Sweden before the 18th century.

The purpose of this paper is to construct and analyse an index of total and per capita harvest production in Sweden within present borders for the period 1665-1820. Its findings support the stagnation hypothesis.

The basic method of this study to estimate absolute levels is to extrapolate data backwards by using various annual indicators.

For cereal production, the starting point is the better data that exist for the period 1802-1820. For the period before 1802, the per capita harvest series is based on three main indicators: grain prices, subjective harvest assessments and tithes. Annual changes of these indicators are more reliable than the medium or long-term trends. Long-term growth rates are judged by examining the literature concerning the development of agriculture. The use of annual indicators has made detection easier of any definitional changes that have occurred from one year to another.

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5 Persson (1999).
6 Finland was part of the Swedish-Finnish Kingdom up to 1809. Sweden conquered Jämtland in 1645 and Scania, Halland, Blekinge and Bohus län in 1658.
My basis conclusion is that per capita harvests stagnated during the period 1665-1820, although medium-term fluctuations can be observed. There was a minor decline in the 17th century, and a minor upturn in the early 19th century (probably up to the level of the best decades of the 17th century). Annual fluctuations were very sharp.

There are many sources that can be used to construct economic data for the pre-industrial period. However, the further backward we go, the more unreliable are these sources. Using historical sources, especially tax records, uncritically, there is a clear danger of significantly underestimating the size of the economy. One-sided empiricism should be avoided. The direct sources must be complemented - but not replaced – by reasonable models of how the pre-industrial economy worked. To use several independent source and indicators, which is attempted in this paper, also avoids the biases of a single source.

One consideration concerns the standard deviation. When the included indicators vary over time and individual years, due to change in the availability of data, the theoretical standard deviation also varies depending on the availability of data. Adjustments are, therefore, made so that the theoretical standard deviation is uniform over time (see Appendix 1).

2. Earlier studies concerning long-term changes in per capita grain production and living standards

Various authors have come to somewhat different conclusions concerning the long-term development of per capita harvest production in Sweden during the 17th and 18th centuries. Most authors argue that per capita vegetable production was higher during the Medieval Ages and the 16th century than during the subsequent two centuries, and that it stagnated in the 18th century.

Olle Krantz estimates the size of GDP for Sweden in 1571, and compares it to the level in 1800. Olle Krantz’ conclusion is that Swedish “GDP per capita was about the same in the 16th
century as it was around 1800” and that “Sweden, like other peripheral countries, was characterised by stagnation throughout the period between the 16th and the 19th century”.  

Although Olle Krantz estimate of the GDP per capita in 1571 seems to be reasonable, he most likely underestimates total GDP and population. One problem with comparisons between years of such long distance from each other is that the sources can be fundamentally different. For example, since Krantz uses tithes to calculate total harvests, he probably underestimates actual agricultural production.

Karl Åmark writes that a small increase in per capita consumption of grains probably took place in the second half of the 18th century. 

Carl-Johan Gadd presents a somewhat opposite view, and concludes that the yield ratio (the ratio of harvest to seed) probably did not increase during the 18th century, and could have even decreased somewhat towards the end of the century. According to him, the yield ratio started to climb first after 1810. He also argues that between 1700 and 1800, the growth of cultivated area roughly followed population growth.

At a micro-level, Carl-Johan Gadd (1983) estimates harvests for five parishes in Skaraborg County for the period 1748-1859, which is displayed in Table 1. It clearly shows that per capita harvests were roughly stagnant in the second half of the 18th century, while a substantial increase took place in the first half of the 19th century. However, the yield ratio in the 1820s was not higher than in the 18th century. In the 1850s the yield ratio was only slightly higher than in the 1770s.

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7 Krantz (2004), pp. 119-120.
8 Åmark (1915), p. 10.
Table 1: Harvests in five parishes in Skaraborg County 1748-1859 according to Carl-Johan Gadd.

<table>
<thead>
<tr>
<th>Period</th>
<th>Barrels per inhabitant</th>
<th>Barrels per aged 15-59</th>
<th>Barrels per consumption unit</th>
<th>Yield ratio (harvest/seed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1748-57</td>
<td>7.1</td>
<td>13.1</td>
<td>9.4</td>
<td>4.04</td>
</tr>
<tr>
<td>1770-74</td>
<td>7.0</td>
<td>12.2</td>
<td>8.9</td>
<td>4.23</td>
</tr>
<tr>
<td>1783-90</td>
<td>7.5</td>
<td>12.0</td>
<td>9.3</td>
<td>4.14</td>
</tr>
<tr>
<td>1820-27</td>
<td>8.6</td>
<td>15.3</td>
<td>11.1</td>
<td>4.09</td>
</tr>
<tr>
<td>1850-59</td>
<td>10.2</td>
<td>17.6</td>
<td>13.0</td>
<td>4.32</td>
</tr>
</tbody>
</table>


Janken Myrdal and Johan Söderberg reckon that the yield per sowed grain was higher in the 1550s and 1560s than in the 17th century. The empirical material gives a mixed picture whether the yield per sowed grain was higher or lower in the 16th century than in the 18th century.\(^{11}\) In another work, Janken Myrdal is of the opinion that in Uppland and Södermanland, the yield ratio was probably stagnant during the 17th century, which in turn was lower than in the 16th century, but higher than in the late Middle Ages.\(^{12}\)

In their study of tithes in Scania, Mats Olsson and Patrick Svensson find that per capita tithes were stagnant between 1702 and 1780, but increased by 50 percent between 1780 and 1855.\(^{13}\)

David Hannerberg argues in two publications that in the province of Närke, the per capita harvest increased significantly between the 17th century and late 18th century, while it decreased between the 1630s and 1690s. His calculations are, however, very different between his book in 1941 and in 1971.\(^{14}\) Interestingly, in both books he argues that it was not the cultivated area per inhabitant that declined (the cultivated area rather followed population growth), but that the harvest per unit of cultivated area decreased.

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\(^{13}\) Olsson and Svensson (2007), p. 25.

In his 1941 book, Hannerberg states that the net harvest per capita doubled between the 1630s and the 1790s, and declined by 12 percent between the 1630s and 1690s. While he assumes that the cultivated area per inhabitant did not change between 1630s and 1790s, he concludes that gross harvest per unit of cultivated area increased by 73 percent. The latter can be decomposed in an increase by 32 percent of the seed per unit of cultivated area and a 38 percent increase in the gross yield ratio. The calculations made by Hannerberg in 1941 are largely based on the assumption that the tithes actually taxed the whole or most of the actual harvest. This is especially an unrealistic assumption since, at least in the period 1665-1680, tithes per inhabitant in Närke was only slightly above half the level in Kopparberg County (which, in turn, was a deficiency area in terms of grain production and consumption).15

In his 1971 book, Hannerberg assumes only a 19 percent increase in the net harvest per capita between 1640 and 1780. His estimated total harvest for the 17th century is increased by around 75 percent compared to his investigation in 1941, a quite substantial revision. According to Hannerberg in 1971, between 1640 and 1780, the gross yield ratio and harvest per unit of cultivated area increased by around 30 percent, the seed per unit of cultivated area was stagnant, and the total cultivated area per inhabitant decreased by 16 percent. In fact, if Hannerberg would have assumed a constant yield ratio in the 17th and 18th centuries, which is argued by other authors for other areas, the estimated per capita harvests would have declined between 1640 and 1780, being stagnant between 1690 and 1780. In light of the fact that Sweden was a net exporter of grain around 1640 and a net importer around 1780 that seems to be a more realistic assumption.

Figure 1 presents the real wage in Stockholm during the whole period 1540-1850, which clearly shows a stagnant trend. However, the real wage cannot be completely relied on as an indicator for per capita harvest production or GDP per capita. The wage share can, for

15 Based on Leijonhufvud (2001).
example, change significantly through time. Furthermore, since the wage system in the agrarian society to a large extent practiced payment in kind it is very difficult to calculate the real wage rate and its development for different labour groups.

Various studies of food consumption show that the calorie intake decreased between the 16th and 17th centuries, while being roughly stagnant between the 17th and 18th centuries.\textsuperscript{16}

Mats Morell studies the food consumption patterns from early 17th century to the 19th century by investigating the food intake of institutionally supported paupers in four “hospitals”. His conclusion is that there was a long-term per capita growth of vegetable foodstuffs, while consumption of animal products and beer decreased.\textsuperscript{17} According to Mats Morell,\textsuperscript{18} the per capita calorie intake was lower in the 18th century than in the 16th century. It was especially the consumption of animal products that decreased during the 18th century.\textsuperscript{19}

Another indicator of living standards is the average height of soldiers. Reliable records exist for soldiers born from around 1720 onwards. According to Lars Sandberg and Richard Steckel, the length of Swedish soldiers for the generations of 1720s, 1730s and 1740s displayed an increasing trend, while there was stagnation during the whole period 1750-1800. For soldiers born in 1800-1830 there was once more a substantial increasing trend.\textsuperscript{20} Based on archaeological material, Janken Myrdal draws the conclusion the average height decreased substantially between the Middle Ages and the 17th and the 18th centuries.\textsuperscript{21}

\textsuperscript{16} Morell (1986).
\textsuperscript{17} Morell (1989).
\textsuperscript{18} Morell (1997), pp. 215-216.
\textsuperscript{19} Heckscher (1949), Vol. 2:1, p. 224.
\textsuperscript{20} Sandberg and Steckel (1980).
Figure 1: The real wage index (index of nominal wage deflated by Consumer Price Index) in Stockholm of daily labour, 1540-1850, 1540=100.


3. The size of the barrel

One of the main reasons why the period before 1665 has not been included in the analysis of this paper is the difficulty to estimate the size of the barrel ("tunna") before that year. According to Lotta Leijonhufvud, the size of the barrel varied from 101 to 156 litres between various counties in Sweden in the period before 1665.22 There are still many uncertainties. For example, for the Östergötland County, Göran Hansson argues that Leijonhufvud uses a

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too small measure of the barrel for the period 1597-1664.\textsuperscript{23} The barrel contained 101 litres according Leijonhufvud, but 134 litres according to Göran Hansson.

It was also roughly from the late 1660s that various volume measures can be ascertained, after a national standard was decreed by the Crown in 1665 that was more effective than previous decrees. Some differences remained, however.

According to the decree of 1665, one barrel of cereals was to contain 146.6 litres, divided into 32 half-pecks ("kappar"). This was the so-called level barrel ("struken tunna"). However, there was also a custom to add a so-called over-measure ("råga"). Furthermore, the barrel could be shuffled or unshuffled. A shuffled barrel could weigh up to 10 percent more than an unshuffled one. By the decree in 1665, one barrel should contain 2 half-pecks (3 half-pecks for malt) in over-measure and be unshuffled. Thus one barrel was set equal to 155.8 litres.

In practice the decree of 1665 was not completely enforced. For Östergötland County, Göran Hansson shows that the transition from one measure to another was not implemented at once everywhere.\textsuperscript{24} In Östergötland, one barrel was supposed to be equal to 146.6 litres from 1665, but the old measure was used up to the late 1660s by some institutions, while others introduced the change already in 1665.

Astrid Hegardt comes to the conclusion that while the barrel was usually unshuffled in the years following 1665, the shuffled barrel became more common in the late 17\textsuperscript{th} and early 18\textsuperscript{th} centuries.\textsuperscript{25} During the 1730s, three decrees concerning the grain barrels were issued, which attempted to standardize the measure. The decree of 1733 established that the barrel should be shuffled, which was probably in accordance with a widely practiced custom, and that each barrel should contain two half-pecks in over-measure. The decree of 1737 reinstated the

\textsuperscript{23} Hansson (2006), pp. 44-46.
\textsuperscript{24} Hansson (2006), pp. 44-46.
\textsuperscript{25} Hegardt (1975), p. 205.
decree of 1665; the barrel was to be unshuffled and include 2 half-pecks in over-measure. After many complaints, this was followed by the decree of 1739, which established that the grain barrel was to be unshuffled and include 4 half-pecks (6 half-pecks for malt) in over-measure. Such barrel contained 164.9 litres, which was used up to 1855, when the cubic feet was introduced (superseded by the hectolitre in 1889). Some regional difference remained after 1739. For example, in Halland the barrel for wheat, rye, oats and peas included only 2 half-pecks over-measure up to 1763.

For tithes, the assumption in this study is made that the grain barrel increased linearly from 155.8 litres in 1665 to 163 litres in 1695, and that it contained 163 litres in 1695-1736, 155.8 litres in 1737-1738 and 164.9 litres from 1739 onwards (i.e. in litres of unshuffled grain).

The price data is based on Lennart Jörberg (1972) for the period from 1732 onwards. Jörberg has transformed prices expressed in barrels to hectolitres. Since Jörberg’s assumes that the barrel was equal to 155.8 litres in 1732, the assumption in the present study is that the price referred to a barrel of 155.8 litres in the period preceding 1732.

4. The size of population before 1749

For Sweden, there is a continuous official annual series of total population from 1749 onwards. However, before that year estimates of the size of population are less certain.

Concerning the 16th and 17th centuries there are two opposite views, one assuming a low population growth rate (0.2-0.3 percent per annum) and the other assuming a high growth rate (0.5-0.7 percent per annum).

Representing one of the positions, Eli Heckscher, assumes that the population growth for Sweden within present borders was 0.22 percent per year in 1620-1720, implying a growth of

around 25 percent in the 17th century. A similar position is taken by Sigurd Sundquist, a military officer that conducted a major study on the population in Sweden during the 17th century. He comes to the conclusion that the growth of Swedish population excluding the territories conquered in the 17th century, increased from 750000-800000 in 1563 to 900000 in 1630 and to around 1200000 in 1720, implying a population growth of 0.2 percent per annum in 1563-1630 and 0.3 percent per annum in 1630-1720.

Taking an opposite view, Lennart Andersson Palm assumes that the population within the present-borders of Sweden increased by 0.6 percent per annum in the period 1571-1699, implying an increase of around 80 percent during the 17th century. He puts the population in Sweden excluding the territories conquered in the 17th century to only 442569 in 1571 and 620388 in 1630, and the population of Sweden within present borders to 639000 in 1571, 854000 in 1620 and 1363001 in 1699. According to his data there was a clear difference between the population growth in the old territories of Sweden and the conquered territories during the 17th century. While the former had an average population growth rate of 0.7 percent per annum in 1571-1699, the latter had an average growth of only 0.3 percent per annum. He is the only author that presents an annual population series for the whole period from 1630 onwards.

A third position, in-between Andersson Palm and Heckscher, is taken by Janken Myrdal. Janken Myrdal argues against the view of Andersson Palm that the 17th century experienced rapid expansion of agriculture in Eastern Sweden. Janken Myrdal reckons the population of Sweden within present at 1 million in 1600 and at 1.5 million in 1700, and the population growth at 0.7 annually per annum in 1571-1620 and at 0.4-0.5 percent per annum in 1620-

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1700. These figures are not completely consistent. A population increase of 0.7 annually in 1600-1620 and 0.4-0.5 percent 1620-1700 would imply a population increase of 60-70 percent in the 17th century, not 50 percent. With such growth rates, the average population growth for 1571-1699 would be 0.5-0.6 percent per annum, which is very close to Andersson Palm viewpoint.

Internationally, Andersson Palm’s data for Sweden seems to have been accepted. For example, for 1600 Angus Maddison puts the population of Sweden within present borders at 750000.31

The present study roughly follows Sundquist’s estimates for the early 17th century with some minor adjustments downwards, but makes use of Andersson Palm’s data to construct annual population series. The population growth of Andersson Palm is reduced by 0.24 percent per year for the period 1620-1699. Assuming a population growth of 0.5 percent annually in 1600-1620 this would imply a population of 1 million within present borders of Sweden in 1600 (the same as Janken Myrdal) and a 41 percent increase in population between 1600 and 1700. See Figure 2 and Table 2.

For the 1720s, both Heckscher’s and Andersson Palm’s population figures probably overestimate the growth. It is especially the death rates that seem to be underestimated. In 1721 the death rate fell to 19 per 1000 inhabitants according to Andersson Palm. In a study by Widén (1976), based on the composition of age groups in 1750, the population is estimated at 1.54 million in 1720, while Andersson Palm puts the figure at 1.46 million. The present study takes the geometric average of the two estimates. Andersson Palm does not differ from Widén for the population estimate of 1735. In the present study, annual growth is assumed to be the same as according to Andersson Palm for the period 1699-1720, while the annual population in 1721-1734 is interpolated using Andersson Palm’s data as an indicator.

There are several reasons why population in Sweden was most likely at a higher level in 1571 and 1620 than Andersson Palm’s guesstimates, although no certain conclusion can be drawn from the empirical material. Further research is necessary.

Andersson Palm’s account of Swedish population growth in the 17th century deviates from the rest of Europe and other Nordic countries. In Europe the century was a demographically stagnant period. Two countries that had a very positive development were the Netherlands and England. In both these areas population increased by around one third in the 17th century. Only in Ireland did the population double in this century.32 There are also a difference in Andersson Palm’s data between the population growth in the regions belonging to Sweden before 1600 and the regions that were conquered during the 17th century. While according to Palm the size of the population in Scania (Skåne), Blekinge, Halland and Jämtland increased by 16 percent between 1620 and 1699, the size of population of the other parts of Sweden increased by 73 percent.

One of Andersson Palm’s main arguments of a high population growth rate during the 17th century was that the birth rates were much higher in this century compared to the late 18th century. In between these two periods there was a hidden demographic transition. However, the main problem with Palm’s data is not the high birth rates (which for the 1630s and 1640s even seems to be underestimated), but that he seems to significantly underestimate the death rates. Only in the period 1630-1660 more than 100,000 men died due to wars.

According to Andersson Palm’s data the average total death rate in the period 1635-1647 was 20.1 per 1000 inhabitants and the non-war death rate 17 per inhabitant. The minimum non-war death rate was only 13.5 (recorded for 1637). In the period 1670-1699, the minimum non-war death rate was 19.5 per 1000 inhabitants (recorded for 1683). In comparison, according to official population statistics beginning in 1749, it was not until the 1880s that the

10-year average death rate fell to 17 per 1000 inhabitants (the non-war death rate was the same; Sweden has not been at war since 1814). The first time the death rate fell below 14 per 1000 inhabitants was in 1909! The minimum death rate in the period 1749-1820 was 21.6 per 1000 inhabitants (recorded for 1780), which suggests that Andersson Palm most likely underestimates the death rate by at least 8 per 1000 inhabitants for the 1630s and by at least 2 per 1000 inhabitant for the 1680s. Furthermore, it is likely that especially during the demographic crises of 1675-1676, 1697-1698 and 1709-1711 the death toll was more significantly underestimated than during other time periods.

Assumption of higher death rates would reduce the estimated population growth. Although Andersson Palm most likely also underestimates birth rates for the 1630s and 1640s, this underestimation is probably of a lesser magnitude than for the death rates.

According to Lars-Olof Larsson, a demographic expansion took place in 1571-1627, but in the late 1620s there was a decline. The number of nominates was stagnant or declined somewhat between 1627 and 1641 (a small decline in 1627-1632 followed by a small recovery in 1632-1641). According to Andersson Palm, population increased by 0.9 percent per annum in 1629-1641. In Sweden, such high growth rate of population has not been seen until the 1810s, after the rapid expansion of potato production. Even though the number of deaths per annum was 27 percent higher in the period 1630-1633 than in 1634-1641, population increased by two percent between 1630 and 1634, according to the data of Andersson Palm.

According to Lotta Leijonhufvud (2001), the total tithes did not increase substantially in the period 1540-1680, nationally not more than 10 percent. Assuming the size of population within the old territories of Sweden more than doubled in this period, it would imply that the per capita tithe collection was halved. On the other hand, real wages only declined marginally

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33 Larsson (1972), p. 162.
in this period, and were actually at quite high levels in the 1680s (see Figure 1). One explanation of this could be that the ratio of the tithes to the actual harvest declined. Although this is probable, it seems somewhat unlikely that the latter ratio would have decreased as much as 50 percent (at least not at the national level).

One of the main arguments put forward by Sigurd Sundquist that the size of population in 1630 could not be much larger than in 1563 is that the size of the army did not change much between those two years.\textsuperscript{34}

One of the few objective sources that could be used to estimate the size of the population in the second half of the 17\textsuperscript{th} century is the size of the age groups born in this period that were still living in mid-18\textsuperscript{th} century, at the time when the first censuses were conducted. Gustav Sundbärg notes that the age groups born in the period 1661-1690 were overrepresented in the censuses from 1750 onwards.\textsuperscript{35} However, the number of 90 plus year-olds seems to be too high in the census of 1750 compared to later censuses, which most likely can be explained by the overestimation of the age of many older persons. It is possible that some of the other older age groups were exaggerated as well in the censuses of the 1750-1770,\textsuperscript{36} which could partly explain the overrepresentation of the age groups born in the period 1661-1690 in these censuses. For example, the death rate of some of these age groups seems to be too low when compared to the censuses of the late 18\textsuperscript{th} century.

\textsuperscript{34} Sundquist (1938), pp. 264-274. The army in Sweden excluding Finland and the conquered territories of the 17\textsuperscript{th} century consisted of 21364 men in 1563, while it consisted of 26494 men in 1630 (the total size of the army of King Gustavus (II) Adolphus was much larger, but consisted mostly of soldiers from other areas).

\textsuperscript{35} Sundbärg (1903).

Palm’s conclusion of a high population growth is to a large extent not based on empirical data for the 17th century, but on the number of taxed households in 1571 later published by Hans Forssell.37

In 1571, a special tax was then levied to redeem the Älvsborg fortress the first time it was captured by Denmark-Norway. The tax lists from 1571 only records the number of taxed households, numbering 83900, not the actual size of the population. Hans Forssell estimated that the average tax household represented 5-7 inhabitants. Andersson Palm’s population figure of 442569 for 1571 implies that the average taxed household represented 5.3 inhabitants. His estimated annual population growth rate between the two benchmark years 1571 and 1620 is about the same as between the two benchmark years 1620 and 1699 (0.6 percent per annum).

Eli Heckscher’s main argument not to accept too low population figures for 1571 is that Forssell’s estimates are based on taxation material, and taxation materials always underestimates their subject matters because of attempts to evade taxation.38 The effectiveness of the taxing authorities in this period was very low.

In international historical demographic research it is generally recognized that censuses are much more reliable than tax records. Whenever money it is to be collected, it is the pecuniary interest that is the first consideration of officials, not the count as such. Poor households were commonly excluded.39

An interesting example is the special tax in 1613-1618 to redeem the Älvsborg fortress the second time it was captured by Denmark-Norway. The taxation lists were recorded six times, and each time the number of persons included in the taxation was reduced.40

37 Forssell (1872) and (1883).
38 Heckscher (1935), pp. 29-30.
40 Hannerberg (1941), p. 81.
Andersson Palm’s assumption of the average size of household is most likely realistic, but the actual number of households should not be equalled to the number of taxed households. For example, Sigurd Sundquist points out that two or more households could be taxed as one.\textsuperscript{41}

According to cadastral records, the number of farms ("jordeboksmantals") in Sweden within its old borders in 1571 was 71,892.\textsuperscript{42} Assuming that this is a rough estimate of the number of peasants at the time, it can provide a basis for estimating the total population. According to the census in 1751 the number of peasants stood for 11.6 percent of total population in the countryside.\textsuperscript{43} Assuming the same proportion in 1571, and a town population of 30,000, this would imply that the size of population was around 650,000 in Sweden within its old borders.\textsuperscript{44}

One of the most important sources concerning the size of population for the first half of the 17\textsuperscript{th} century are the so-called Mill Tax Lists (“kvarntullsmantalslängd”), which formally counted all over 12-years old. Children up to 11 years old were not included, which could constitute one third of the population. In practice, many other groups were excluded as well. For example, most 12-15 years were not counted.

According to Nils and Inga Friberg, the number of persons in the Mill Tax Lists amounted to between 20 and 50 percent of the total population, which could vary between parishes as

\textsuperscript{41} Sundquist (1938), p. 54.
\textsuperscript{42} The estimate is based on Forssell (1872) and (1883).
\textsuperscript{43} Based on Statistics Sweden (1949).
\textsuperscript{44} This calculation is, of course, based on quite shaky assumptions. In 1571, 10-11 percent of the farms in the cadastral records were described as desterted. However, this was mostly because of the temporary effects of the war. Many farms that were recorded as deserted were probably inhabited. Furthermore, the cadastral records could have underestimated the number of farms. There is also an uncertainty concerning the ratio of total population to the number of peasants in the countryside. It is possible that this ratio decreased between 1571 and 1751. On the other hand, in 1751, the ratio was somewhat lower in the “old” counties of Sweden (the counties belonging to Sweden in 1571) than the national average.
well as between time periods for the same parish. It was probably higher when the first tax lists were set up in the late 1620s. In their investigation of Björkskog in Västmanland, where an early household examination roll (“husförhörslängd”) exist for 1643, they come to the conclusion that the ratio was at its highest, 45 percent, in 1628, but dropped to below 30 percent in 1652. The ratio was probably even lower since the household examination roll most likely also left out some groups. The assumption made in the present study is that a probable minimum at a provincial or county level was 50 percent (which does not preclude that the ratio could be higher for individual parishes).

Sundquist estimates the total number of persons in the Mill Tax Lists to 336701 for 1628 in Sweden without the conquered territories. This could be increased to 338451, with adjustments made to Närke and Uppland including Södertörn (see notes in Table 2). For 1620, Lennart Andersson Palms assumes that the population was 620388, which could be increased to 646000 for 1628 based on his assumption of a population growth of 0.6 percent per annum. The ratio of the number of persons in the Mill Tax Lists to population would then have been 52 percent, compared to 38 percent if Sundquist’s population of 900000 would be accepted. In this respect, Sundquist’s number seems more plausible than Palm’s. For the areas of Södermanland and Uppland, Palm’s population estimate would imply a ratio close to 70 percent, on average, which must be ruled out (even Sundquist’s population estimates for this area seems to be too low, as he himself admits). In Värmland, Dalsland, Östergötland, Hälsingland and Medelpad, Palm’s population estimates would imply a ratio of around 60 percent, which is also extremely high.

Table 2 presents different population estimates of Swedish regions in the period 1620-1630. Sundquist’s “probable maximum”, summing to 851500, is according to him actually a

45 Friberg and Friberg (1971).
46 Friberg and Friberg (1971), p. 64.
minimum figure of the population during the reign of Gustavus (II) Adolphus. For the year 1630 he, therefore, increases this figure to 900000 (which probably also allows for some population growth).

In this study, the minimum population in 1620 based on the Mill Tax Lists is calculated by assuming that the Mill Tax Lists in 1628 at maximum represented 50 percent of the total population and that the population growth in 1620-1628 was 0.4 percent per year.

The nobility is distributed to the regions in accordance to their size of population. For this purpose the relative size of nobility in various regions is based on Forssell’s study for 1571.

The present study estimate for the year 1620 is the maximum of three population estimates: Sundquist’s “probable minimum” (with the addition of the nobility), the probable minimum in 1620 based on Mill Tax Lists in 1628 (including the nobility) and Andersson Palm’s estimate for 1620. However, it is only for two regions (Södermanland excluding Södertörn and Västmanland) that this study differs from Sundquist’s “probable minimum”.

The present study puts the size of the population within Sweden excluding the conquered territories in the 17th century at 821,000 in 1620, which is 32 percent above Andersson Palm’s estimate. With the assumption of a population growth rate of 0.4-0.6 percent per annum in 1571-1620, it would put the population within the old borders of Sweden (excluding Finland) at 600,000-680,000 in 1571.
Table 2: The population in Swedish regions during the reign of Gustavus (II) Adolphus according to different estimates.

<table>
<thead>
<tr>
<th>Region</th>
<th>Mill Tax Lists (MTL)</th>
<th>Sundquist, &quot;probable maximum&quot; + nobility</th>
<th>Sundquist, &quot;probable minimum&quot; + nobility</th>
<th>Andersson Palm</th>
<th>Present study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1628</td>
<td>1611-1632</td>
<td>1611-1632</td>
<td>1620</td>
<td>1620</td>
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<tr>
<td>Södermanland excluding Södertörn</td>
<td>27874</td>
<td>53663</td>
<td>52963</td>
<td>37978</td>
<td>55159</td>
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<tr>
<td>Uppland including Södertörn</td>
<td>58820*</td>
<td>117526</td>
<td>117526</td>
<td>83446</td>
<td>117526</td>
</tr>
<tr>
<td>Västmanland</td>
<td>13108</td>
<td>37504</td>
<td>34704</td>
<td>40456</td>
<td>40456</td>
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<tr>
<td>Närke</td>
<td>11466**</td>
<td>23465</td>
<td>22665</td>
<td>20201</td>
<td>22677</td>
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<tr>
<td>Värmland</td>
<td>13036</td>
<td>40000</td>
<td>34000</td>
<td>21082</td>
<td>34000</td>
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<tr>
<td>Dalecarlia (Dalarna)</td>
<td>21252</td>
<td>46403</td>
<td>42803</td>
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<td>42803</td>
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<td>149513</td>
<td>124821</td>
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<tr>
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<td>181588</td>
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<tr>
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<td>81542</td>
<td>53404</td>
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<tr>
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<td>9700</td>
<td>7493</td>
<td>9700</td>
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<tr>
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<td>25500</td>
<td>24700</td>
<td>18296</td>
<td>24700</td>
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<tr>
<td>Medelpad</td>
<td>2596</td>
<td>6600</td>
<td>6000</td>
<td>4850</td>
<td>6000</td>
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<tr>
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<td>17500</td>
<td>13900</td>
<td>11365</td>
<td>13900</td>
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<tr>
<td>Västerbotten</td>
<td>6864</td>
<td>26600</td>
<td>23600</td>
<td>14800</td>
<td>23600</td>
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<td>Addition (by Sundquist) for the year 1630</td>
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<td></td>
<td></td>
<td>48500</td>
<td></td>
</tr>
<tr>
<td>Sweden excluding conquered territories in the 17th century</td>
<td>338451</td>
<td>90000***</td>
<td>813100</td>
<td>620388</td>
<td>821059</td>
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<td>Conquered territories in the 17th century</td>
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<td></td>
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<td>240055</td>
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<tr>
<td>Sweden within present borders</td>
<td></td>
<td></td>
<td></td>
<td>854000</td>
<td>1061114</td>
</tr>
</tbody>
</table>

Sources: Sundquist (1938) and Andersson Palm (2000).

* For Närke Sundquist seems to use the data for 1629 (10113) instead of 1628 (11466). See Friberg and Friberg (1971), p. 60.

** For Uppland including Södertörn Sundquist presents the figure 58423. Since the Mill Tax Lists for parts of this region refer to the years 1630-1631, which are generally lower than for 1628, Sundquist increases the number to 58820 (based on earlier tax records).

*** Sundquist’s estimate for the year 1630.
Figure 2: The size of the population in Sweden within present borders (in millions) 1630-1750 according to Andersson Palm and the present study.

Sources: Andersson Palm (2001) and the present study.

5. The per capita tithe index

Tithes are probably the most direct quantitative evidence concerning harvest fluctuations before 1802. The tithe is traditionally a tax representing 10 percent of the harvest. After the Reformation in the 16th century, the Crown took 2/3 of the tithe, while 1/3 was retained for the vicar. Thus the Crown tithes were supposed to represent 1/15 of the harvest (although in the counties previously belonging to Denmark and Norway tithes were supposed to represent 1/30 of the harvest).
There has been a long debate about whether the tithes can be used as an indicator for harvest production and its fluctuations. While the tithes has been shown to be unreliable concerning the absolute level of harvest, they seem to more reliable when determining annual fluctuations. In my view, they should also be quite reliable to identify stable periods when per capita harvest production did not change much and some medium-term cyclical patterns.

Lotta Leijonhufvud uses tithe accounts to estimate harvest production in the period 1539-1680. One problem is that after 1680, many areas fixed the tithes; they no longer reflected annual harvest fluctuations. After 1730 most areas went over to fixed accounts. That is why Leijonhufvud stops at 1680 in her investigation.

To present a per capita tithe index, the present study uses Leijonhufvud tithes for the period 1665-1680. For the period 1680-1753, the per capita tithe index is based on the following sources:

1. The collection of tithes and rents (“avrad”) by the Uppsala Akademi in Uppland (40 % weight), Västmanland (40 percent weight) and Hälsingland (20 percent weight) per inhabitant in the respective region in the period 1680-1760.

2. Tithes per payer of the tithe in Östra Eneby in Östergötland, presented by Björn Helmfrid for the period 1691-1753.

References:

47 See Berg (2007), Leijonhufvud (2001), Helmfrid, (1949), Hannerberg (1941) and Heckscher (1935).
49 Missing data for various counties are estimated by using nearby or similar tithe accounts as indicators for interpolation.
50 The growth of population in the different areas is based on Palm (2000), the national population growth and the estimates for the different regions presented in Table 2.
51 Found in Hegardt (1975) for the period up to 1719 and Lindgren (1971) from 1720 onwards.
52 Helmfrid (1949), diagram 1. The data has been estimated from the figures, since no table is presented for the underlying data. The missing values are interpolated by using the tithe series of Ståthöga by, and when the latter is missing the tithes of Uppsala Akademi (series (5)), as indicators.
(3) Per capita tithes in the county of Kopparberg (the Dalecarlia province), which, in turn, is based on two series, one on the parish of By presented by Maths Isacson,53 and one on the parishes of Mora and Venjan collected by Johan Söderberg.54

(4) Per capita tithes in Närke, based on David Hannerberg’s study. Hannerberg does not present any total sums of the tithes, but only the distribution of tithe values in 40 parishes for the period 1652-1727 in the upper and lower quartiles.55 The difference between the number of parishes in the upper and lower quartile have been transformed to an estimated index of the total sum in the whole county, under the assumption of a normal distribution of the index.56

(5) Per capita tithes in Scania from 1702 onwards.57 This is probably the best series for any region.

54 Söderberg (1999), pp. 112-120. Johan Söderberg has been generous in giving me access to his excerpts. The correlation between the absolute level of tithes in Kopparberg and in the parish of By was +0.65 in the period 1666-1680, and between tithes in Kopparberg and in the parish of Mora (including Venjan) +0.64 for the period 1634-1680 and +0.82 for the period 1666-1680. Correlating the tithes in Kopparberg and the geometric average of the tithes in the parishes of By and Mora gives a correlation of +0.93. The correlation of the absolute tithe level in Mora and subjective harvest accounts for Kopparberg County according to Utterström for the period 1740-1785 and according to Hellstenius for the period 1774-1799 (see the section on subjective harvest account of this paper) is close to +0.6 in both cases. Henceforth, combining By and Mora should give reasonably good estimates of harvest fluctuations in Kopparberg County as a whole.
55 Hannerberg (1941), pp. 202-204
56 The coefficient of variation of the index has been adjusted so that it would be the same as for the tithes in Örebro County according to Leijonhufvud (2001) for the overlapping years (covering the period 1652-1679). The correlation between the estimated index for the period 1652-1679 and tithes in barrels according to Leijonhufvud (2001) is as high as +0.96.
57 Olsson and Svensson (2007). Based on figure 2 (p. 15) since no table is presented with the exact data. The figure shows harvest in hectolitres per mantal. To estimate production per capita, the size of population per mantal must be estimated. Table 6 (Olsson and Svensson (2007), p. 25) provides information on the growth of population and production of grains between three benchmark years: 1702, 1780 and 1855, indirectly also population per mantal. To interpolate population per mantal between 1702 and 1780, data on the growth of population of the concerned parishes has been used as an indicator.
(6) Tithes for the parishes of Kävlinge and Hög.\textsuperscript{58} This series is included in (5), but has been used since it has been published in a table-form.

(7) In addition a series of subjective harvest assessments for the period 1690-1724 on Gotland presented by Gunnar Kellgren is used,\textsuperscript{59} which is not based on any direct tithe data. The series is transformed to an index by assuming a normal distribution and a coefficient of variation of equal magnitude as the per capita tithe indexes for the other counties.

The seven series covers 9 counties. These counties stood for nearly half of the harvest in the early 19\textsuperscript{th} century, and should reasonably represent the overall harvest fluctuations in Sweden as a whole, provided that tithes did so generally before they became fixed.

The national tithe index is calculated as the weighted average of these series. Series (1) is given the weight 0.3 and series (4) the weight 0.2, while the other five series are each given the weight 0.1. Since not all series covers the whole period under investigation adjustments are made to the estimated standard deviation (see Appendix 1).

One important question is the relation between the taxed harvest, i.e. the tithe multiplied by 15, and the actual harvest.

The evasion from taxation in the pre-modern era could be quite substantial. One of the few items in the tax lists for 1571 that are known from more reliable sources is the size of the monetary stock of silver coins. The preserved records shows that during the period 1559-1570 silver coins were minted to the face value of 11.45 million marks and 0.16 million dalet.\textsuperscript{60} Some additional silver coins were minted during this period for which no minting data exist. The amount of coins minted before 1559 was quite small in comparison. Considering that some silver coins were exported (most notably, to Finland) or were withdrawn from

\textsuperscript{58} Olsson (2005), p. 201.
\textsuperscript{59} Kellgren (1931), p. 39.
\textsuperscript{60} Wallroth (1918).
circulation (for example, to be reminted), the total stock of silver coins could be reasonably estimated at 5-10 million marks in 1571. However, the taxation records for 1571 shows that the total stock of silver coins was only 0.5 million marks. Thus only 5-10 percent of the actual stock of silver coins was recorded by the tax authorities, while 90-95 percent escaped taxation. Although harvests were not as easy to hide from the tax authorities as silver coins, a substantial tax evasion must be almost presupposed for the tithe series.

For the Finnish part of Sweden-Finland Marti Rantanen uses two different methods to calculate harvests, one based on tithes and one based on yield ratios combined with quantities of seeds. He comes to the conclusion that the estimates based on tithes are less than half of the estimates from the other method.

In Sweden, official statistics on crops at a county level has been gathered since 1802. Annual data exist for 1802-1820 and from 1860 onwards. At present, there is a general consensus that the official harvest estimates for the early 19th century must be increased by around 100 percent. However, the annual fluctuations of these series should be quite reliable.

The following question could be asked: why would priests underestimate the harvest production by around 50 percent in the early 19th century, but have almost complete knowledge in the 16th and 17th century when tithes were determined? Priests could have hardly been better informed in the 16th and 17th century than in the early 19th century. A reasonable assumption would be that the underestimation of harvest production was at least as large in the 16th and 17th century as in the early 19th century.

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61 Forssell (1883), p. 348.
Figure 3 presents the taxed harvest in barrels per inhabitant in Mora and Venjan in the period 1634-1807. It shows that tithes cannot be used uncritically concerning the long-term development. In the period 1690-1760 it was stable, which seems reasonable, but the much lower level in the early 19th century is most likely explained by the lowering of the tax rate rather than a decline in per capita harvests. In 1802, the taxed harvest in Mora and Venjan was around 75 kg of grains per inhabitant. According to the official statistics that year, the harvest in the Kopparberg County was 162 kg per inhabitant.\textsuperscript{65} The actual harvest was probably almost twice that amount, i.e. around 300-350 kg. This implies that in early 19th century the taxed harvest of Mora stood for only around 50 percent of the reported harvest and less than 25 percent of the actual harvest. In the period 1634-1680, the taxed harvest most likely stood for 50 percent of the actual harvest.

Figure 4 presents the taxed harvest in the Uppsala and Kopparberg counties in barrels per inhabitant 1620-1680, based on the work of Lotta Leijonhufvud. In Uppsala County, the taxed harvest almost halved between 1620-1640 and 1660-1680, from 1.75 to 0.89 barrels per inhabitant. The decline would be even greater if Andersson Palm’s population estimates would be used. In comparison, the taxed harvest in the Kopparberg County was stable during the period, at 1.57 barrels per inhabitant in 1620-1640 and at 1.51 barrels per inhabitant in 1660-1680. That the Kopparberg County would have a much higher per capita harvest than the Uppsala County in the second half of the 17th century is very doubtful, since the Kopparberg County was a deficiency area in terms of grain production, while the Uppsala County was a surplus area.

Since the Uppsala County supplied other regions with grains, my guess is that the actual harvest should have been around five barrels per inhabitant in that county in the 17th century (although a somewhat downward trend could be reasonable to assume). This would imply that

\textsuperscript{65} Statistics Sweden (1949).
in the Uppsala County tithes taxed around one third of harvests in 1620-1640 and around one sixth in 1660-1680.

In conclusion, taxed harvest probably stood for between 15 and 60 percent of the actual harvest. It was probably around 50 percent in the 16th century, but declined in many counties during the course of the 17th and 18th centuries, because of the introduction of other taxes and the fixation of the tithes. The ratio was most likely higher during good harvests and lower during harvest failures.

For the period 1665-1753, the per capita tithe index of this study is quite stable and seems to reasonably reflect changes in actual per capita harvests, although somewhat exaggerating annual fluctuations.

Figure 3: Taxed harvest (tithes x 15) in Mora Venjan, in barrels per inhabitant 1634-1807.

Figure 4: Taxed harvest (tithes x 15) in Uppsala and Kopparberg counties in barrels per inhabitant 1620-1680.

Source: Leijonhufvud (2001). For population data, see section of this paper on population before 1749.

6. Subjective harvest assessments

In Sweden, subjective harvest assessments exist back to the 16th century, and have been gathered systematically since 1799. Several authors present subjective harvest assessments. Such accounts exist at the national as well as at county or provincial level. Mats Olsson and Patrick Svensson (2007) find that subjective harvest assessments of Scania are well correlated with fluctuations in tithes. However, as discussed by Lennart Jörberg, and more recently Bengt-Åke Berg, there are many difficulties to transform the qualitative assessments into quantitative data.

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67 Olsson and Svensson (2007).
68 Jörberg (1972), pp. 69-75.
In 1783, Emanuel Ekman published an account of Swedish harvests for the whole period 1523 to 1781, a kind of chronology of economic cycles. Ekman assigns different years as experiencing crop failure, average harvest, weak harvest, abundant harvests or some other categorisation. This categorisation is based both on the movements of the price of grains and on written statements. Although Ekman’s methodology could be partly questioned (for example, he assumes a periodic ten-year economic cycle), according Utterström his accounts has certain value.

Official accounts of harvests can be obtained from Emigrationsutredningen, which are, in turn, based on earlier material. The figures are given from 0 to 9 for the whole period 1748-1912. The number 6 represents average harvests and the number 9 rich harvests. The lower numbers have not been used since the year 1841. Over time, the quality of the official accounts of harvests improved. For the period 1748-1780, Ekman’s accounts of harvests almost entirely correspond to the later official accounts of harvests. It may therefore be suspected that for this period the official accounts of harvests are originally based on Ekman’s accounts.

Various authors have criticized both the official harvest assessments, and more specifically Ekman's accounts. Most agree that only from the year 1799 are the official accounts based on direct observations of harvests at a national level.

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70 Ekman (1783).
72 According to David Hannerberg (1971), p. 71, the official accounts of harvests have been reconstructed later in time based on different sources of varying quality.
73 This could in itself reflect that the fluctuations in harvests were larger for earlier times, but is most likely explained by a change in methodology.
74 Brolin (1954), Hedqvist (1999), and Berg (2003).
In a previous attempt to construct a GDP-series before 1800, the official harvest accounts and Ekman’s series have been used. In the present study, other works have been used instead (especially since Ekman’s account is based on price material, which is a separate indicator in the present study). However, when Ekman’s account is compared to the harvest index estimated in this study, it seems that some of the criticism levelled against him may have been somewhat unfair, especially considering he wrote in the late 18th century.

To transform qualitative accounts to a quantitative measure of harvest fluctuations is problematic. When numbers have been used to describe the harvest result, it is very difficult to determined whether the difference between “total harvest failure” and “bad harvest” is of a similar magnitude as, for example, the difference between ”average harvest” and ”rich harvest”. There is also a discrepancy between taking an average at the county level and the general observation at the national level. It must be considered that fluctuations at the national level are not as sharp as the fluctuations at the county or provincial level. Henceforth, if the subjective assessment records a harvest failure at the national level it most likely involves a smaller percentage decline in actual harvest than when the subjective assessment records a harvest failure at the county or provincial level.

To construct subjective harvest assessment indices for various counties, four main works are used in the present study, which in many ways complement each other:

(1) An extensive account has been collected by Hellstenius (1871) for 24 counties in 1749-1870. For the period 1816-1870 all counties are covered by Hellstenius. No data are given for the period 1800-1815. For the period 1774-1789 and 1791-1799 at least 10 counties are covered.

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75 Edvinsson (2005b).
(2) Gustav Utterström presents written accounts of data for the period 1721-1819. At least 10 counties are covered for 1726, 1739-1749, 1756-1770, 1772, 1775, 1780-1781, 1785-1786, 1798, 1801, 1804, 1808-1808, 1811-1813 and 1815-1819.

(3) Imhof covers the period 1721-1750. The best coverage at the county level is for 1737, 1740-1746 and 1748-1750.

(4) Gustaf Axelson covers the period 1695-1718. The best coverage at the county level is for 1696-1698 and 1708-1718.

Some complementary works are also used.

The following scale is applied to transform the qualitative subjective assessments into quantitative numbers:

- Total harvest failure ("missväxt") – 0
- Nearly harvest failure ("nära missväxt") - 1.5
- Bad harvest ("svag/klen skörd") – 3
- Below average harvest ("under medelmåttig skörd") – 5

77 Imhof (1976), pp. 715-754.
78 When some new research has revised earlier research, this has been taken into account. For example, according to Hallerman (1916, p. 243), the harvest in Blekinge in 1717 was not as bad as implied by Axelson. Axelson argues that Jönköping County experienced crop failure during the whole period 1706-1709, but Schartau (1915, p. 222) draws the conclusion that no crop failure occurred in this period.
79 For Uppsala county 1695-1718 in Hallerman (1919), p. 256; for Östergötland County 1691-1753 in Helmfrid (1949), pp. 19-20; for Jönköping County 1695-1709 in Schartau (1915), p. 209; for Gotland 1690-1724 in Kellgren (1931), p. 39; for Bleking County 1696-1717 in Hallerman (1916); for Skåne province 1693-1727 in Enghoff (1889), pp. 86-89 and Weibull (1923), pp. 114-115; for Älvsborgs County 1695-1716 in Schartau (1912) p. 262; for Skaraborgs County 1712-1715 in Olander (1946), pp. 78-79; for Närke province 1728-1801 in Hannerberg (1941), pp. 207-214; for Kopparberg County 1695-1720 in Schartau (1918), pp. 278-280; and for northern Sweden 1695-1791 in Nordberg (1928). Some additional information has been gathered from Ilmoni (1849) and Hannerberg (1941). In her diaries, Christina Juliana Wargentin (1771-1824) also recorded the harvest outcome for the period 1771-1824 for the area around Stockholm, which in the present study is used as an indicator for the harvest of the Stockholm County.
- Average harvest ("medelmåttig skörd") – 6
- Above average harvest ("över medelmåttig skörd") – 7
- Good harvest ("god skörd") – 8
- Rich harvest ("ymnig skörd") - 9

Hellstenius uses the scale of 0 to 6, but his data has been transformed back to the scale of 0 to 9.

Fluctuations in the per capita tithes in various counties, based on the 11-year moving average, have also been transformed to generate a number between 0 and 9. This implies that the same source material has partly been used both to construct the per capita tithe index as well as the subjective harvest assessment index.

In addition for providing subjective harvest assessments at a county or province level, Utterström, Axelson and Imhof also provide assessments of harvests at the national level. Hannerberg also provides national assessments for the period 1695-1698.80

The division into 24 counties follows the one presented by Hellstenius, even though the boundaries between counties changed over time. Some counties were merged and other subdivided during the investigated period.

For each county, a weighted median value is computed. Hellstenius subjective assessments are given three times the weight of the subjective assessments presented by other authors. This implies that when only the data of Hellstenius and Utterström exist, Hellstenius is chosen over Utterström. The median has been chosen rather than a weighted arithmetic average, since the scale of the subjective harvest assessments does not necessarily reflect proportional differences (although, an arithmetic average would not seem to distort the result).

80 Hannerberg (1941).
The national subjective assessment index of the present is calculated in several steps. First two national series are constructed: (1) one calculated as the weighted average of the county accounts and (2) one directly based on the national assessments.

Series (1) is calculated as the weighted average of the estimated subjective assessment values for the various counties, where the weights are set equal to each county’s share in total national harvest in 1802 and 1820 (average share in the two years). Since not all counties are represented for most years, a further adjustment is made to take this into consideration.\(^{81}\)

Series (2) is calculated first as a median of the accounts provided by Utterström, Axelsson, Imhof and Hannerberg, and then adjusted so that the average and standard deviation is the same as for series (1).

While series (1) can be estimated for all years in 1695-1802, series (2) only exists for 58 years in this period. The final national series is set equal to series (1) when series (2) is missing, to series (2) if the latter exist and the series (1) covers 35 percent or less of the estimated harvest (using the share of each county in 1802 and 1820 in total national harvest for this purpose), and as the average of series (1) and (2) if both series exist and series (1) covers more than 35 percent of the counties.\(^{82}\) The finally estimated national subjective assessment index is presented in Figure 5 for the period 1737-1802.

For the period 1695-1737, the correlation between the annual change in the subjective harvest assessment index (without the data that is the same as for the per capita tithe index) and the annual change in the per capita tithe index is +0.72. For the period 1738-1802, when the per capita tithe index is less reliable, the correlation is +0.62. Thus, even if much criticism

\(^{81}\) A theoretical standard deviation is calculated when all 24 counties are included, which is compared to the theoretical standard deviation when only the counties are included in one year that are assigned values for that year. A correlation matrix of the subjective harvest assessment for the counties is estimated for the whole period 1695-1802.

\(^{82}\) Further adjustments are made to take into consideration that the theoretical standard deviation (without such adjustments) is different if only one of the series is used instead of the median value of the two series.
can be levelled against the subjective harvest assessments, when transformed into quantitative variables, they seem to be reasonable indicators of harvest fluctuations.

Figure 5: The estimated national subjective assessment index (0 – lowest possible value, 9 – highest possible value) of the present study for the period 1737-1802.

7. The price as an indicator for harvest fluctuations

One important indicator of harvest fluctuations is the grain price. The latter tended to be high when harvests failed and low in times of abundant harvests.

For the period 1732-1820 the nominal price of the present study is calculated as a weighted geometric average of the prices of wheat, rye, barley, oats, peas and malt. The geometric average is chosen over the arithmetic since it automatically adjusts for the fact that consumption of a cereal is decreased if its price is increased relative to other cereals, and vice versa. Malt has been given the weight 0.05, while the weights for the other grains are based
on the value shares of these grains in total cereal production in 1802 and 1820. Since the prices of various grains are highly correlated with each other, variously constructed price indices will not differ much from each other. For the period 1665-1732, the grain price is largely based on estimates of rye and barley prices in various regions, which is spliced to the grain price from 1732 onwards.\(^83\) The price refers to the late autumn or winter price, i.e. it is the price connected to the harvest year rather than the calendar year.

Several authors have argued against using the price as an indicator for harvest fluctuations.\(^84\) Lennart Jörberg writes that “the uncomplicated conception of a strong correlation between price and estimated yield is not borne out by a closer analysis”.\(^85\) Two of the most forceful arguments are that domestic prices were more substantially affected by inflationary policies and foreign prices than domestic harvests.

While the monetary conditions after the 1820s were quite stable, the period 1665-1820 experienced several serious inflationary episodes. To counter this effect, the nominal price of grain has been transformed to a so-called silver price, which is presented in Figure 6. The exchange rates of the Swedish riksdaler specie in mark kopparmynt up to 1776, the Swedish riksdaler banco in riksdaler riksgälds 1789-1808 and Hamburger reichstaler banco in riksdaler riksgälds from 1790 onwards have been used for this purpose.\(^86\)


\(^{84}\) See Brolin (1954), Berg (2003), Jörberg (1972) and Leijonhufvud (2001).


\(^{86}\) Based on the data of the Riksbank project “Historical monetary statistics for Sweden 1668-2008” (www.riksbank.se). The price of grain in grams silver can be calculated in several ways, mostly by first transforming the price to a currency based on a stable silver content. The fine silver content of the Swedish riksdaler specie is assumed to have been 25.2739 grams up to 1718, and 25.6973 grams in 1719-1830. From 1790 the Hamburg reichstaler banco contained 25.28 grams fine silver. In the period 1665-1776 the exchange rate of the Swedish riksdaler specie in mark kopparmynt is used to transform nominal prices to silver prices. In 1777-1788 all prices were expressed in riksdaler specie. From 1789 the price was expressed in riksdaler riksgälds. The riksdaler banco was convertible into riksdaler specie, at least up to 1808. Sometimes during the
Karl Gunnar Persson (1999) argues that price volatility is the combination of supply shock (harvest failure) and poor market integration.

Bengt-Åke Berg criticizes neo-classical theory of a simple relation between price and output. He points out that due to the availability of imports, the domestic price should not be used as an indicator for domestic harvests. There is maximum price, which is the international price plus the transaction margin. His argument goes as follows:87

“Import matters even when it is small. According to neo-classical theory, prices are determined by the cost of supply, but not the cost of the average but the marginal quantity supplied. And the marginal quantity is just what the import is. Whenever there is an opportunity for import this real or potential import will have a fundamental impact.”

Berg’s alternative model is in itself a modified neo-classical model, since he puts forward a marginalist explanation and assumes quite efficient markets. At the theoretical level Berg’s model does not take into account that transaction costs most likely increased with increased imports. Average price for freights, insurance, trade marginal, etc, can not in itself be used. It is the marginal costs that are interesting. Assuming increasing marginal costs, the increase in import will be dampened by bad harvests. Profits can also be highly variable. A higher profit rate in one market does not immediately induce a movement towards that market, since it can be expected that the increased profit rate may be temporary. This implies that it can take up to several years for the domestic price to fully adjust in response to the international price.

course of 1809, the riksdaler banco became inconvertible. A silver price can, therefore, be estimated from 1789 by using the agio on riksdaler banco relative to riksdaler riksgälds (which was fixed at 50 percent in 1803). The estimated silver price is, however, different when based on the exchange rate of the Hamburg reichstaler banco in riksdaler riksgälds. For the period 1790-1808, the silver price is, therefore, calculated as the geometric average of the two methods. For the period from 1809 onwards the exchange rate of the Hamburg reichstaler banco is the only one used to transform nominal prices to silver prices.

87 Berg (2003), p. 44.
Under such circumstances annual harvest fluctuations in harvest retain a great impact on annual fluctuations of prices.

In fact, in the short term import was not very responsive to price changes. For the period 1731-1820, the correlation between annual change in the silver price of grain and annual change in the per capita import of grain the next year was +0.4.\textsuperscript{88}

The impact of foreign prices and domestic harvests on domestic prices can be analysed by relating rye prices in Gdańsk to domestic (Swedish) grain prices and harvests. The price of grain in Sweden fluctuated sharply relative the price of rye in Gdańsk.

$\Delta X_t$ measures the change in the indicator $X$ from year $t-1$ to year $t$. Let $\Delta P_{L,N,\text{standardized rye in Gdańsk, silver},t}$ be the standardized logarithmic change in the silver price of rye in Gdańsk from the 4\textsuperscript{th} quarter in year $t-1$ to the 4\textsuperscript{th} quarter in year $t$, $\Delta P_{L,N,\text{standardized silver},t}$ the standardized logarithmic change in the domestic silver price of grain, $\Delta S_{t,\text{standardized}}$ the change in the standardized subjective harvest assessment index and $\Delta T_{L,N,\text{standardized per capita},t}$ the standardized logarithmic change in the per capita tithe index. Since all the variables are standardized, the standard deviation of these variables fluctuates around 1. A combined harvest index is constructed (not based on the price fluctuations, which, therefore, should not be confused with the per capita harvest index presented in the next section), by using the per capita tithe index for the period 1666-1737 and the subjective harvest assessment index for the period 1738-1802.

Although domestic and foreign grain prices were correlated, this correlation was not very strong. In the period 1666-1802, the correlation between changes in the silver price of rye in Gdańsk and silver price of grain in Sweden, respectively, was +0.57, implying that only 33 percent of the variance of domestic price fluctuations in Sweden can be explained by the

\textsuperscript{88} Data on import is based on Åmark (1915).
\textsuperscript{89} Based on Furtak (1935) and Pelc (1937).
fluctuation in foreign price. In the same period, the correlation between changes in the silver price of grain in Sweden and in the combined harvest index, respectively, was -0.75, implying that 57 percent of the variance of domestic price fluctuations can be explained by the fluctuation in domestic harvests.

The correlation between changes in the silver price of rye in Gdańsk and in the combined harvest index, respectively, was -0.3 in the period 1666-1802. Part of the correlation between domestic and foreign prices can be explained by the correlation between domestic and foreign harvests. For example, for the period 1820-1842, the correlation between annual changes in the subjective harvest assessment index in Sweden and of the average yield of wheat, oats, barley, potatoes, hay and flax in Ireland, respectively, was as high as +0.66. The correlation between annual changes in wheat yields in Ireland and England, respectively, was for the same period +0.68. In comparison, during the same period the median pairwise correlation between the annual changes of the subjective harvest assessment indices in Swedish 24 counties was only +0.4. This is simply the statistical effect of the condition that correlations between harvests of various areas are weaker at the more disaggregated level.

Table 3 and Table 4 present two multiple regression models where the dependent variable is the change in grain price and the independent variables are change in rye price in Gdańsk and change in two different harvest indicators. Table 3 is a model for the period 1666-1737 and Table 4 for the period 1737-1802. While in Table 3 the harvest indicator is the per capita tithe index \((\Delta T_{1,\text{standardized}}^{\text{LN, per capita}})\), the indicator in Table 4 is the subjective harvest assessment index \((\Delta S_{1}\text{standardized})\). Despite of this difference, the beta-coefficients are almost identical in the two models. The two models explain more than 65 percent of the variance of the dependent variable, and confirm that the price of grain was affected by the foreign price as well as

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domestic harvests. However, the effect of domestic harvests clearly had a bigger impact on domestic prices than foreign grain prices. The relation between the variables was quite stable during the whole period 1665-1802. There was no tendency for improved international market integration during the course of the period (the impact of foreign price even decreased somewhat relative domestic harvests).

Table 3: Multiple regression for the period 1666-1737 where the standardized, logarithmic change in the silver price of grain in Sweden ($\Delta P_{\text{silver},t}^{\text{LN,standardized}}$) is the dependent variable.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beta-coefficient</th>
<th>t-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.371</td>
<td>0.719</td>
<td></td>
</tr>
<tr>
<td>Change in the per capita tithe index ( $\Delta T_{\text{percapita},t}^{\text{LN,standardized}}$ )</td>
<td>-0.622</td>
<td>-8.649</td>
<td>0.000</td>
</tr>
<tr>
<td>Change in the silver price of rye in Gdańsk ( $\Delta P_{\text{rye in Gdańsk,silver},t}^{\text{LN,standardized}}$ )</td>
<td>0.396</td>
<td>5.505</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Model summary: $R = 0.815; R^2 = 0.664; \text{adjusterad } R^2 = 0.655; \text{degrees of freedom: 69; significance: 0.000.}$

Table 4: Multiple regression for the period 1738-1802 where the standardized, logarithmic change in the silver price of grain in Sweden ($\Delta P_{\text{silver},t}^{\text{LN,standardized}}$) is the dependent variable.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beta-coefficient</th>
<th>t-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.029</td>
<td>0.308</td>
<td></td>
</tr>
<tr>
<td>Change in the subjective harvest assessment index ( $\Delta S_{\text{subjective harvest assessment index},t}^{\text{standardized}}$ )</td>
<td>-0.662</td>
<td>-9.505</td>
<td>0.000</td>
</tr>
<tr>
<td>Change in the silver price of rye in Gdańsk ( $\Delta P_{\text{rye in Gdańsk,silver},t}^{\text{LN,standardized}}$ )</td>
<td>0.357</td>
<td>5.129</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Model summary: $R = 0.861; R^2 = 0.741; \text{adjusterad } R^2 = 0.732; \text{degrees of freedom: 62; significance: 0.000.}$

Table 5 presents a regression model for the period 1666-1802 where the change in the combined harvest index (the per capita tithe index 1666-1737 and the subjective harvest assessment index in 1738-1802) is the dependent variable and changes in grain price in Sweden and rye price Gdańsk, respectively, are the independent variables. The table shows that the beta-coefficient of the change in the silver price of rye in Gdańsk is slightly positive (0.19), instead of being negative. This implies that, when harvests are to be predicted from the
movements of prices, the change in foreign price counteracts somewhat the change in
domestic price provided that the two latter change roughly at the same rate. However, if the
changes in domestic and foreign prices are of different signs the estimated change in the
harvest index is strengthened.

Table 5: Multiple regression for the period 1666-1802 where the standardized, logarithmic
change in the combined harvest index (the per capita tithe index 1666-1737 and subjective
harvest assessment index in 1738-1802) is the dependent variable.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beta-coefficient</th>
<th>t-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.255</td>
<td>0.799</td>
<td></td>
</tr>
<tr>
<td>Change in the silver price of grain in Sweden (ΔP_{silver}^{LN,standardized})</td>
<td>-0.861</td>
<td>-12.769</td>
<td>0.000</td>
</tr>
<tr>
<td>Change in the silver price of rye in Gdańsk (ΔP_{rye in Gdańsk,silver}^{LN,standardized})</td>
<td>0.190</td>
<td>2.815</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Model summary: R = 0.768; R^2 = 0.590; adjusterad R^2 = 0.584; degrees of freedom: 134; significance: 0.000.

Henceforth, even if the existence of foreign markets makes the relation between domestic
price and domestic production more complicated, the usefulness of domestic grain price as an
indicator of domestic harvests should not be discarded. The existence of foreign markets
weakens the correlation between changes in domestic price and domestic harvest, but the
correlation is still very high, and would be even higher in a closed economy.

Lennart Jörberg points out that trade led to more uniform prices between regions. In that
case the correlation between price and harvest should be better the larger the area is under
study.

This is borne out by a simple correlation analysis. The average correlation between the
subjective harvest assessment index and silver price is weaker at the county level than at the
national level. For example, in 1732-1775,\textsuperscript{92} the correlation between the rye price in grams

\textsuperscript{92} This period is chosen to avoid the spike in the silver price of grain in the late 18\textsuperscript{th} and early 19\textsuperscript{th} centuries.
silver and the subjective harvest assessment index (for absolute values, not annual changes) ranged from -0.02 (for the county of Västerbotten) to -0.82 (for the county of Älvsborg). The median correlation was -0.47 (about the same correlation coefficient is found by Lennart Jörberg). In contrast, the correlation between the weighted national rye price in grams of silver and the weighted subjective harvest assessment index (the weights being determined by the total harvest production of the counties) was -0.64 in the same period. There is an even better correlation, -0.74, between the national rye price and the estimated national subjective harvest assessment index of the present study.

Furthermore, the correlation between the absolute price and harvest is weaker than the correlation between the changes in price and harvests. For example, in 1732-1775, while the correlation between the absolute rye price in grams of silver and the national subjective harvest assessment index was -0.74, the correlation between the annual changes of the rye silver price and the national subjective harvest assessment index, respectively, was -0.80.

The opposite is true of the relation between domestic and foreign price. The correlation between the absolute foreign and domestic price is stronger than the correlation between the changes in domestic and foreign prices. While in the short run, the grain price was to a larger extent determined by domestic harvests, in the long-run it was to a larger extent determined by the foreign price level.
Figure 6: The estimated silver price of grain (gram silver per hectolitre) of this study for the period 1665-1840.

8. The per capita harvest index

To construct a volume index for the gross harvest production (without deduction of seed), a model is constructed based on the annual changes of various indicators. In this way autocorrelation should be avoided (although one degree of freedom is then lost for the model). Except for the subjective harvest assessment index, all calculations are based on the logarithmic change (the logarithm of the absolute value in year t less the logarithm of the absolute value in year t-1). Furthermore, the annual changes of all variables have been standardized, i.e. transformed to changes measured in standard deviations. Marriage rates, yield ratios, foreign prices and net import have also been considered but do not seem to contribute significantly to the regression model compared to the other indicators.
\[ \Delta H_{\text{per capita}, t}^{\text{LN, standardized}} \] is the logarithmic change, measured in standard deviations, of the per capita volume value of gross harvest production from year \( t-1 \) to \( t \). For the period 1803-1820\textsuperscript{93} it is based on official harvest estimates for wheat, rye, barley, oats, peas and mixed grain.\textsuperscript{94} Although the official harvest estimates are too low, this should not affect the logarithmic change of the variable. The value of 1 kg of mixed grain is assumed to be the same as the value of 1/2 kg of barley and 1/2 kg of oats. The volume value has been calculated as an annual Fisher chain index. In the first step, the production of potatoes is excluded.

A per capita volume index including potatoes is also calculated for the period 1802-1820 by using the official estimates of potato harvest, assuming that the volume value per kg potatoes was one third of the volume value per kg of grain. For the period 1780-1802, the volume ratio of potato to cereal production is assumed to grow geometrically at the same rate as in 1802-1820 (7.6 percent annually), and in 1750-1780 at 15 percent annually. The production of other types of vegetables is not considered here.

The price the preceding year \( (\Delta P_{\text{silver}, t-1}^{\text{LN, standardized}}) \) is also included in the model. Storage dampens the impact of harvest on price. If bad harvest occurs, the price tends to be lower if the price is lower than normal the preceding year. Vice versa, if good harvest occurs, the price tends to be higher if the price is higher than normal the preceding year. There also seems to be a direct positive correlation between the change in price the preceding year and the change in per capita harvest production the next year. This is the effect of the negative autocorrelation between two subsequent changes in per capita harvest production. Per capita production is stagnant in the long-term (i.e. extreme harvests tend to bounce back to more normal levels the next year). Both these effects imply that the partial correlation between the annual change in

\textsuperscript{93} Including the annual change from 1802 to 1803.
\textsuperscript{94} Statistics Sweden (1949).
the grain price of the preceding year and annual change in harvest is positive, holding
constant for the annual change in the grain price of the present year.

Table 6 presents a regression model for the period 1803-1820 (including the annual change
from 1802 to 1803), where the change in the official per capita harvest \((\Delta H_{\text{per capita},t}^{\text{LN,standardized}})\) is the
dependent variable.

Table 6: Multiple regression for the period 1803-1820 where the standardized, logarithmic
change of the per capita volume value of official gross harvest production \((\Delta H_{\text{per capita},t}^{\text{LN,standardized}})\) is
the dependent variable.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beta-coefficient</th>
<th>t-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.818</td>
<td>0.427</td>
<td></td>
</tr>
<tr>
<td>Change in the subjective harvest assessment index ((\Delta S_t^{\text{standardized}}))</td>
<td>0.502</td>
<td>4.500</td>
<td>0.000</td>
</tr>
<tr>
<td>Change in the silver grain price ((\Delta P_{\text{silver,t}}^{\text{LN,standardized}}))</td>
<td>-0.522</td>
<td>-5.065</td>
<td>0.000</td>
</tr>
<tr>
<td>Change in the silver grain price the preceding year ((\Delta P_{\text{silver,t-1}}^{\text{LN,standardized}}))</td>
<td>0.272</td>
<td>2.624</td>
<td>0.020</td>
</tr>
</tbody>
</table>

Model summary: \(R = 0.938\); \(R^2 = 0.880\); adjusted \(R^2 = 0.855\); degrees of freedom: 14; significance: 0.000.

The unadjusted R-value of the model in Table 6 is 0.938. The model explains around 85
percent of the variance of \((\Delta H_{\text{per capita},t}^{\text{LN,standardized}})\), a quite high predictive power.\(^{95}\) All coefficients are
significant at a 5 percent level (two-tail test), even considering that there are only 14 degrees
of freedom and that the period was characterized by monetary instability. The constant does
not deviate significantly from zero, although the positive sign of the constant is an indication
that there was an underlying long-term positive growth of per capita cereal production in
1802-1820.

\(^{95}\) It may be suspected that Hellstenius subjective harvest accounts for 1816-1820 (they are missing for 1802-
1815) could partly be based on the same source material as the official statistics. However, if Hellstenius
subjective harvest accounts are eliminated from \((\Delta S_t^{\text{standardized}})\), the R-square, in fact, increases somewhat.
To construct a per capita harvest index for the period before 1802, the beta-coefficients of Table 6 are not used straightforward. The coefficients and the indicators included are different for different periods. Change in per capita tithes is not included in Table 6, but is used to estimate $\Delta H_{\text{per capita}}^{\text{standardized}}$ up to 1753.

The ratio of the coefficient of the annual change in price the preceding year and the coefficient of the annual change in price the estimated year is set equal to -0.5 (roughly in line with the model of Table 6) for the whole period 1666-1802.

During the 18th century and early 19th century Sweden experienced several periods of monetary instability. During the late 18th century and early 19th century there was also a long-term increase in the silver price of grain, which was felt internationally as well (see Figure 6). Using the silver price of grain straightforward would lead to the conclusion that there was a significant decline in per capita harvest production in 1790-1820, while, in fact, it was towards the end of this period that Sweden became self-sufficient on grain. For the period 1737-1802 the annual change in an adjusted silver price is used instead, which is calculated as the deviation from an 11-year moving geometric average of the actual silver price. For the period up to 1730s the silver price of grain was more stable in the long-term, and the price is not adjusted.

Although real wages declined significantly towards the late 18th century (see Figure 1), this was more connected to monetary conditions and the proletarisation of large parts of the population rather than a decline in per capita production. The 1790s are generally considered to have experienced good harvests. The height of soldiers born in the late 1790s reached the highest level hitherto. Rather than being a reflection of low per capita harvests, it is likely

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96 A small adjustment is also made to synchronize the moving average of the silver price and the moving average of the subjective harvest account index.

97 Sandberg and Steckel (1980).
that the high silver price of grain and the low real wages induced significant investments to expand the production of vegetables (not least of potatoes) in the early 19th century.

The subjective harvest assessment index is used as indicator only for the period 1737-1802, since the per capita tithe index is sufficiently good up to the 1730s. In the period 1754-1802 only the subjective harvest assessment index is used, since the quality and coverage of the per capita tithe index declines significantly after the 1750s.

The constant is set to zero for all periods, although this is not a necessary assumption.

The coefficients of the equations are adjusted so that the theoretical standard deviation of \( \Delta H_{N,\text{standardized}}^{\text{per capita}} \) equals 1 (see Appendix 2 and Appendix 3). To calculate actual logarithmic growth, the standardized logarithmic growth is multiplied by the standard deviation of the logarithmic change in the national per capita harvest in the period 1803-1820. The procedure rests on the assumption that the volatility of national harvests did not display a significant long-term change in the period 1665-1820. This is based on the study of Bengt-Åke Berg, who finds that the coefficient of variation of harvests for selected parishes was the same in the periods 1655-1689 and 1802-1820. According to Berg, the period 1690-1725 experienced higher volatility, but this was due to the major crop failures in this period.\(^98\) The standard deviation of the present study series of the logarithmic change of per capita harvest production is also somewhat higher for the period 1690-1725 than for other periods.

Since neither the change in the subjective harvest assessment index nor the change in the adjusted silver price can increase in the long-term, the per capita harvest production is basically assumed to have fluctuated around a stagnant trend in the period 1754-1802. This is in line with other studies. The trend line of per capita import of grain also seems to be quite flat in this period (see Figure 7).

There are more uncertainties concerning the long-term development of the per capita cereal production before 1750, and especially before the 1730s. However, for this period the silver price of grain and the per capita tithe index are used as indicators also for the long-term changes in per capita harvest production.

Figure 7: The net import of grain per inhabitant (kg) in Sweden 1732-1830.

Source: Åmark (1915).

9. **A periodisation pattern**

Figure 8 presents the per capita harvest index excluding potatoes for the period 1665-1820. The index is set equal to 100 for the year 1665.

Figure 10 presents total harvest production in tons of cereal for Sweden within present borders, which is based on the estimates of per capita harvest index and the size of population.
For the period 1802-1805 it is assumed that the harvest production was 1,069,974 tons per annum, in accordance with a preliminary result by Carl-Johan Gadd.\(^{99}\)

The per capita harvest index displays a long-term stagnation. However, there are some significant medium-term fluctuations, while the annual fluctuations are quite sharp.

Up to the early 1690s the per capita index was on a higher level than during the subsequent century. The 1680s were one of the better decades.

The 1680s were followed by the great agrarian crisis of the 1690s. The whole period 1693-1726 was a crisis period. On average, while the per capita harvest index stood at 93 in 1665-1820, it stood at 88 in 1693-1726. Four of the five most severe crop failure years belonged to this period – 1697, 1709, 1719 and 1726 (see Table 7). This is in line with earlier research. According to Carl-Johan Gadd, the per capita production during the first two decades of the 18\(^{th}\) century was significantly below the level during the rest of the century.\(^{100}\) Mats Morell demonstrates that there was a lower than normal level of calorie intake in Swedish “hospitals” in the period 1690-1730, while it stabilised at a higher level from the 1740s onward.\(^{101}\) Swedish soldiers born in the 1720s were shorter than during any subsequent period.\(^{102}\)

The 1730s experienced higher per capita harvests, but the 1740s was a shorter crisis period. During the 1750s, 1760s and 1770s per capita harvest production followed a stable trend, despite of the severe crop failures occurring in this period, most notably the crop failure of the early 1770s.

The 1780s experienced severe crop failures. The average length of Swedish soldiers born in the 1780s decreased almost to the levels 60 years earlier.\(^{103}\) The per capita import increased to

\(^{102}\) Sandberg and Steckel (1980).
\(^{103}\) Sandberg and Steckel (1980).
the highest level hitherto experienced (see Figure 7). The 1790s experienced better harvests. This was followed by worsening conditions at the turn of the century.

During the first two decades of the 19th century, per capita harvest increased substantially. The year 1820 was the best crop year of the whole period 1665-1820. There was an expansion both in per capita production of cereals as well as potatoes. Sweden went from being a net importer of grains up to the 1810s to a net exporter in the 1820s (see Figure 7).

While the correlation between annual changes in net import and in the per capita harvest the preceding year, respectively, is quite weak, it becomes stronger if decades are correlated instead of years. A regression equation for the period 1731-1830 (which includes 10 decades) results in a R-value of +0.8. The regression is significant at the 1-percent level (one-tail test), despite there being only 8 degrees of freedom. The regression equation can be rewritten as follows:

\[
\text{\text{grains}}_{\text{perc}} = (H_{\text{perc}} - 496) \times 0.44
\]  

(1)

The equation implies that if the per capita harvest \( (H_{\text{perc}}) \) is below 496 kg there would be negative net export of grains \( (\text{grains}_{\text{perc}}) \), i.e. a net import. Thus, to be self-sufficient Sweden would have to produce around 500 kg of grains per inhabitant, amounting to the human consumption of around 350 kg if deductions are to be made for seeds (around 100 kg), storage loss and animal consumption. In the 1820s, this was accomplished. However, during the whole 18th century and the first 20 years of the 19th century, Sweden was a net importer of grains.

---

104 To estimate per capita harvest in the 1820s, the subjective harvest assessment index is used to extrapolate the series up to 1820 forwards.
Roughly, if during a longer term period (say 3-5 years), per capita net harvests (after the deduction of seeds and assuming a yield ratio of around 5) decreased by 1 kg, the per capita import of grains increased by around ½ kg. Henceforth, only half of the fall in net harvest production was covered by import. The other half was substituted by other food items or the living standard decreased.

This can be illustrated by taking the example of Gotland. Gunnar Kellgren writes that according to official reports, the seed productivity of the agriculture in Gotland was extremely low in the early 18th century, not more than 3-4, but that in reality this was most likely a huge underestimation. Gotland was most likely self-sufficient. Kjellerman estimates that the cultivated area in Gotland was 18000 Swedish acres (“tunnland”). With a yield ratio of 4, this would give a harvest of 72000 barrels, consisting of 37800 barrels of rye, 30600 barrels of barley and 3600 barrels of oats. With an estimated population of 18000 this would result in a per capita production of 405 to 435 kg, depending on the size of the barrel. The average per capita production in the whole of Sweden according to the present study was 420 kg in 1700-1720. Kjellerman assumes that the yield ratio of 4 was probably a minimum. Assuming a yield ratio of 5, would give a per capita harvest production of well over 500 kg in Gotland during good years. That would imply that Gotland had a higher harvest per capita than the rest of the country, which was also the case in the early 19th century.

While the general picture is of stagnating per capita harvests up to the early 19th century, the story is somewhat different for total harvest production.

---

106 Kjellerman (1941), p. 128.
107 The lower estimate is based on the size of barrel of 151.8 litres, while the higher estimate assumes a size of 163 litre. According to the present study, the population was probably larger, but for simplicity it may be assumed that the cultivated area is underestimated by Kjellerman to the same degree as the size of population.
From the 1660s to the 1720s there was, in fact, stagnation in total harvest production, hovering around 600,000 tons (see Figure 10). During the harvest failure of 1726, the total grain production was four percent below the level attained in 1665 (which was a good harvest year), while population was 26 percent above the level in 1665.

Whether there was a long-term stagnation before 1660s is an open question. According to Lotta Leijonhufvud (2001), the tithes did not increase substantially in the 16th and 17th centuries, despite an increase in population. Assuming the population of Sweden within present borders was over 1 million before the Black Death,108 and the per capita harvest production around 500 kg per inhabitant, the total harvest production before the mid-14th century was not far below the level in the early 18th century. This would imply that in the four centuries preceding the early 1720s cereal production increased by at most 0.1 per year, on average. There seems to have been a ceiling on the total harvest production at around 600,000 tons, which the old society had sever difficulties to move beyond.

From the late 1720s something happened. In the next century total harvest production doubled. Thus the Malthusian trap was avoided. Therefore, the 18th century must be seen as quite dynamic. The term agricultural revolution, as used by, for example, Carl-Johan Gadd to describe the 18th and 19th centuries,109 should be quite adequate.

In the first stage of the agricultural revolution, from the late 1720s to around 1810, total production increased. Although per capita production continued to stagnate, stagnation in per capita production must not be confused with technological stagnation. The significant growth in the size of population during the 18th century was in itself a manifestation of a dynamic economy. Furthermore, stagnation or even decline in the largest part of the economy does not preclude that there was a small dynamic sector that could exhibit significant advances in

productivity. However, before the industrial revolution this sector was too small to generate substantial increases in the living standards of the majority of the population.

The second stage of the agricultural revolution, from the early 19th century onwards also per capita production increased substantially, coinciding with a wider spread of the potato.

From around 1870 a third stage in the agricultural revolution began, when the share of the agricultural sector in total GDP for the first time started to decline substantially.\(^{110}\) This was preceded by important political changes in the 1850s and 1860s.

The empirical result of this paper needs to be put into the context of an ongoing debate internationally on pre-industrial economic growth. The state of international empirical research is unsatisfactory. Together with improved data for other countries, Swedish data can make significant contributions to a better understanding of economic growth in Early Modern Europe.

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\(^{110}\) Edvinsson (2005a).
Figure 8: The per capita harvest index (excluding potatoes) of Sweden within present borders in 1665-1820.
Figure 9: Nine-year moving average of the per capita harvest index including and excluding potatoes in 1665-1820.
Figure 10: The cereal production (excluding potatoes) in Sweden within present borders in 1000s of tons 1665-1820.
Table 7: The 20 years experiencing the most severe harvest failures in the period 1665-1820, ranked by the per capita harvest index.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Year</th>
<th>Per capita harvest index, 1665 = 100</th>
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<tr>
<td>1</td>
<td>1709</td>
<td>68.8</td>
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<tr>
<td>2</td>
<td>1697</td>
<td>72.1</td>
</tr>
<tr>
<td>3</td>
<td>1719</td>
<td>75.1</td>
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<td>4</td>
<td>1771</td>
<td>75.9</td>
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<td>1726</td>
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<tr>
<td>6</td>
<td>1674</td>
<td>77.0</td>
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<tr>
<td>7</td>
<td>1696</td>
<td>77.4</td>
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<td>1783</td>
<td>78.0</td>
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<td>78.6</td>
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<td>79.5</td>
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<td>1762</td>
<td>80.2</td>
</tr>
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<td>16</td>
<td>1800</td>
<td>81.5</td>
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<td>1723</td>
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<td>18</td>
<td>1745</td>
<td>82.5</td>
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<td>19</td>
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<td>82.6</td>
</tr>
<tr>
<td>20</td>
<td>1785</td>
<td>83.4</td>
</tr>
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</table>

Appendix 1: Adjusting the standard deviation of the various indices constructed in this paper

The indices are constructed in two steps. Let the first index be named Index1, and the finally constructed index be named Index2.

The theoretical standard deviation (SD) of the constructed index in the first step (this index is here either an absolute index or an index of annual changes) - can be calculated as follows:111

111 See, for example, Ross (1994), p. 323.
Theoretical standard deviation of Index1 in year t =

\[ SD\left( \sum_{i=1}^{n} c_{i,t}X_{i} + k \right) = \sqrt{\sum_{i=1}^{n} c_{i,t}^2 \text{Var}(X_i) + 2 \sum_{i<j} \sum_{i,t} \sum_{j,t} c_{i,t}c_{j,t} \text{Cov}(X_i,X_j)} \]

where \( c_{i,t} = \frac{\sum a_i}{\sum b_{i,t}} b_{i,t} \),

and \( b_i = 0 \) if information on \( X_i \) is missing in year t and \( b_i = a_i \) when information on \( X_i \) exist in year t

(2)

\( n \) is the number of independent variables (indicators) from which the index is constructed, \( X_i \) is the \( i^{th} \) independent variable, \( a_i \) is the \( i^{th} \) coefficient if information exist on all independent variables, \( c_{i,t} \) is the actual \( i^{th} \) coefficient in year t, and \( k \) is a constant.

The desired theoretical standard deviation can be defined in various ways, but is usually the same as the standard deviation if information on all independent variables exists. Index2 in year t is then calculated as:

\[ \text{Index2}_{\text{year} t} = \]

\[ = \text{Average} + \frac{\text{Desired theoretical SD}}{\text{Theoretical SD of Index1 in year t}} \times (\text{Index1}_{\text{year} t} - \text{Average of Index1}) \]

(3)

**Appendix 2: Adjusting the standard deviation of the index of logarithmic change in per capita harvest production**

As explained in Appendix 1, the coefficients have been determined in two steps. First coefficients are assigned based on the relative weight given to the various indicators. In the next step a theoretical standard deviation is calculated based on the correlation between these indicators and the assumption that the standard deviation of all indicators is 1.

Since the standard deviation (SD) and variance (Var) of the independent variables are standardized to 1, the covariance of each pair of the independent variables (Cov\((X_i,X_j)\)) equals
the correlation between the two ($\rho(X_i,X_j)$). The theoretical standard deviation (SD) of the regression expression $a_iX_i+k$ is calculated as follows (where $n$ is the number of independent variables in the regression equation, $X_i$ is the $i^{th}$ independent variable, $a_i$ is the $i^{th}$ coefficient, and $k$ is the constant):

$$SD\left(\sum_{i=1}^{n} a_i X_i + k\right) = \sqrt{\sum_{i=1}^{n} Var(a_i X_i) + 2 \sum_{i<j} Cov(a_i X_i, a_j X_j)} = \text{[since $Var(X_i) = 1$] = }$$

$$\sqrt{\sum_{i=1}^{n} a_i^2 + 2 \sum_{i<j} a_i a_j \rho(X_i, X_j)}$$

(4)

New coefficients are then calculated by dividing the original coefficients by the theoretical standard deviation of the first regression equation. This procedure guarantees that the standard deviation of the estimated annual change in harvest production is also standardized, i.e. that its standard deviation is around 1 in the long-run, although it can vary somewhat between different periods.

**Appendix 3: Coefficients used to estimate annual fluctuations of per capita harvest production 1666-1802**

For the period 1666-1737, the price is given only half the weight of the per capita tithe index. The following equation is applied for this period:

$$\Delta H^{L,N,standardized}_{per capita,t} = 0.67 \Delta T^{standardized}_{per capita,t} - 0.335 \Delta p^{L,N,standardized}_{silver,t} + 0.167 \Delta p^{L,N,standardized}_{silver,t-1}$$

(5)

For the period 1738-1753, equal weight is given to the adjusted price, the per capita tithe index and the subjective harvest assessment index. Both the subjective harvest assessment
index and the per capita tithe indices are used, despite the fact that these two are partly based on the same source material. The following equation is applied for this period:

\[ \Delta H_{\text{N, standardized}}^{\text{per capita},t} = 0.364 \Delta S_t^{\text{standardized}} + 0.364 \Delta T_{\text{per capita},t}^{\text{standardized}} - 0.364 \Delta P_{\text{silver},t}^{\text{N, standardized}} + 0.182 \Delta P_{\text{silver},t-1}^{\text{N, standardized}} \] (6)

For the period 1754-1779 the adjusted price is given the same weight as the subjective harvest assessment index. The following equation is applied for this period:

\[ \Delta H_{\text{N, standardized}}^{\text{per capita},t} = 0.499 \Delta S_t^{\text{standardized}} - 0.499 \Delta P_{\text{N, standardized silver, adjusted},t}^{\text{L,N, standardized silver, adjusted},t-1} + 0.249 \Delta P_{\text{N, standardized silver, adjusted},t-1}^{\text{L,N, standardized silver, adjusted},t-1} \] (7)

For the period 1780-1801 adjusted price is given only one third of the weight of the subjective harvest assessment index. Because of the monetary disarray of the period due to the existence of two currency units, the riksdaler banco and the riksdaler riksgälds, and the confused state of exchange markets, the price is a less reliable indicator, even when estimated as a deviation from a periodic average. The following equation is applied for this period:

\[ \Delta H_{\text{N, standardized}}^{\text{per capita},t} = 0.748 \Delta S_t^{\text{standardized}} - 0.249 \Delta P_{\text{N, standardized silver, adjusted},t}^{\text{L,N, standardized silver, adjusted},t-1} + 0.125 \Delta P_{\text{N, standardized silver, adjusted},t-1}^{\text{L,N, standardized silver, adjusted},t-1} \] (8)

Special care has been taken to estimate \( \Delta H_{\text{N, standardized per capita},t}^{\text{L,N, standardized}} \) for 1802. Certain problems are created when different weights are given for the indicators for different periods, and when these series are linked with each other. According to the estimates for 1802-1820, harvest production increased by five percent between 1802 and 1803. However, using equation (8) the per capita harvest production fell instead. Using equation (8) up to 1803 instead of up to 1802,
therefore, results in a much lower estimate of per capita harvest production in the period 1665-1801 as compared to the period 1802-1820. In the present study a middle ground has been sought when the series up to 1802 has been linked up to the series in 1803-1820. 

$\Delta H_{\text{LN, standardized per capita, 1802}}$, the annual change in per capita harvest production, has been estimated as the average of the change according to equation (8) and the change between 1801 and 1803 according to equation (8) less the actual change between 1802 and 1803.
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One of the greatest challenges facing macroeconomic history is to quantify economic growth in the early modern period. The key activity to be studied is grain production. In the pre-industrial society, it was largely the growth and fluctuations of harvests that determined the growth and fluctuations of the overall economy. Domestic grain prices were affected by domestic harvests as well as foreign prices. In this paper, to estimate fluctuations in grain production, three indicators are used: grain prices, subjective harvest assessments and tithes. To calculate per capita production the size of population must be known. In this paper, population growth during the 17th century is revised downwards compared to recent studies. The basic finding is that per capita harvests stagnated during the studied period, although annual fluctuations were substantial, which is in line with several other studies for various European countries. Up to the 1720s, there was even stagnation in total grain production. Total harvest within the present borders of Sweden before the mid-14th century was not far below the level in the early 18th century. There seems to have been a ceiling on total production, which the old society had sever difficulties to move beyond. From the late 1720s something happened. In the next century, total harvest production doubled. Thus the Malthusian trap was avoided. From this perspective, the 18th century must be seen as quite dynamic, despite of the stagnating per capita production.

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