Prices and the Growth of the European Knowledge Economy, 1200-2007

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Introduction

Recent research in price history suggests that the European economy gained from declining relative prices of knowledge-intensive goods during the early modern era. Prices of metals, paper, and books, for instance, tended to fall relative to a cost of living index.

This shift in relative prices reflects two aspects of the economies of the time. First, by definition, comparatively large inputs of knowledge were required to produce these goods. Second, these goods were typically used in other knowledge-intensive activities. Books are an obvious example: they had a central place in education and in the distribution of information. This contributed towards lower information costs and stimulated further investment in human capital, which in turn helped creating the necessary prerequisites of the Industrial Revolution.

Early modern Western Europe (henceforth called West) thus acquired a peculiar price structure, characterized by low prices of industrial goods relative to the price of food. This appears to be more or less the reverse of the Chinese pre-industrial price structure, where food prices were low and prices of industrial goods tended to be high.

But did the early modern era really constitute the initial stage of this process? The chronology of the development of relative prices of knowledge-intensive goods is not yet known with any precision. The main question posed in this paper is whether or not any substantial trend towards a relative fall in the prices of such goods can be observed already during the medieval era. If this is the case, the West would have proved capable of efficiently transforming industries relying on applications of practical knowledge well before the advent of early modern era. As a consequence, a view of Western economic development as a very long-term phenomenon would be strengthened. If not, the traditional view of the early modern era as a more dynamic phase than the medieval period would be supported.

Our hypothesis is that the long-term relative price decline of knowledge-intensive goods in the West gained momentum in the century after the Black Death. As is well known, demographic decline led to higher prices of labour, encouraging the use of less labour-intensive methods. It also increased the supply of capital available per capita. Interest rates fell, which stimulated capital-intensive investment, including investment in human capital.2

The outline of the paper is as follows. 1) A new Consumer Price Index for Sweden is described; 2) Long-term trends of the purchasing power of silver and gold are discussed; 3) Relative prices of two knowledge-intensive goods, iron and paper, are presented; 4) Some relative price shifts in Sweden between industrial and non-industrial goods during a period of about 700 years are explored; 5) An index of sea freight prices is developed; and finally 6) Real prices of beer and cloth are analyzed.

The Consumer Price Index of this paper

The Swedish Consumer Price Index for Sweden used in this study covers the whole period 1290-2006.3 For the construction of a consumer price index the general rule should be to follow the currency that was most frequently used in retail trade. The following currencies are followed for different periods for the Swedish Consumer Price Index:

- Mark for the period 1290-1624

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Daler kopparmänt for the period 1624-1776
- Specie riksdaler for the period 1776-1789
- Riksdaler riksgälds for the period 1789-1855
- Riksdaler riksmänt for the period 1855-1873
- Krona (SEK) for the period 1873 onwards.

The data to construct a Consumer Price Index for the period 1290-1539 is based on materials collected by Bo Franzén and Johan Söderberg from various sources. From the early 15th century the data on prices is quite rich for the most important commodities, although not for all years. Before that period only few years and few commodities can be covered. The missing years have been interpolated for various commodities. The price of grain has been interpolated using the price of rye, and vice versa. The interpolations are based on silver prices, and only in the second stage transformed to nominal prices.

The index construction is different for the periods 1290-1330, 1330-1420 and 1420-1539. For the period 1420 ten commodities are covered: grain, rye, beer, butter, iron, copper, oxen, wax, salt and malt. With the exception of 1457, price data exist at least for one commodity in every year of this period. For the period 1330-1420, the price index is based on seven commodities: grain, rye, bear, butter, iron, copper and oxen. For the period 1290-1330 the index is mainly based on the price of grain, complemented with some annual data on the price of butter.

The annual fluctuations of the CPI in the period 1420-1539 should be interpreted carefully since not all years could be covered. For the period 1290-1420, the CPI is not an indicator of annual fluctuations, but should rather be used as an indicator of the long-term trend.

Eli Heckscher constructed a price index for Sweden for the period 1539-1620 based on Stockholm prices. This price index has been improved by Johan Söderberg, with some additional data. Söderberg has constructed a Laspeyre-type cost-of-living-index for Stockholm for the period 1539-1719. This is the basis of the Consumer price index used in this study.

The price index for the period 1719-1732 is based on data presented by Fregert and Gustafsson. For the period 1732-1914 the present Consumer Price Index is based on Lennart Jörberg’s and Gunnar Myrdal’s price data. It has also been complemented with data on salt presented in Stefan Carlén and price indices of various industrial products presented by

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Lennart Schön. The weights are different for the periods 1732-82, 1782-1830, 1830-1870 and 1870-1913. For the period 1914, the CPI is the same as the one presented by Statistics Sweden, whereby July 1914 = 100.

The purchasing power of silver and gold

During most of the period studied, Sweden was on a commodity standard. Up to 1873, silver was the main basis of the currency (together with copper for the period 1624-1776), while after 1873 it was gold. It was not until 1971, with the fall of the Bretton Woods system, that the commodity standard was abandoned and a true paper standard established, even though brief periods of credit standard with suspended convertibility were in place before 1971.

Even if silver and gold functioned as the basis of currency, these two metals were also commodities, and their relative price can be studied as well. The relative price of silver to grain is the one that can be studied furthest back in time. The relative price of silver and gold is connected to the production costs of these two metals as well as to the transaction costs of bringing these metals to a country. The relative price of these metals is closely connected with the knowledge economy, of how developed information exchange and communications were. All else being equal, increased integration with international markets decreases the relative price of precious metals, while decreased integration increases the purchasing power of these metals.

Figure 1 presents the purchasing power of silver and gold, which is estimated as the price of silver and gold deflated by the Consumer Price Index. Both series are set equal to 100 for the year 1873, when Sweden changed from silver to a gold standard. The price of silver is based on the exchange rates of the silver mark and riksdaler specie, and the global gold-silver ratio, while the price of gold is calculated as a global average.

Figure 1 shows some important trends. From around 1350 to around 1500 the purchasing power of silver and gold rose substantially. This was the consequence of the population decline following the Black Death and subsequent demographic shocks. The demographic declined increased the transaction costs of bringing silver and gold to Sweden, and marks a decrease in the integration with international markets.

During the course of the 16th century the relative price of silver and gold declined significantly, due to the so-called price revolution. The trade with America opened new supply lines. However, the price revolution only reversed the trend of 1350-1500. The purchasing power of gold in 1600 was only slightly below the level in mid-14th century.

In 1620-1760, the purchasing power of silver and gold was quite stable, showing that production as well as transaction costs must not have changed much. Although the purchasing power of silver and gold declined significantly around 1800, this was more connected to the Napoleonic Wars, which increased the relative price of goods. During the 19th century there was, however, a decline in the relative price of silver and gold. In the late 19th century the

purchasing power of silver declined much more than of gold, as many countries switched from silver to gold standard and the silver reserves were sold out. In the 20th century, when the commodity standard was suspended on several occasions and finally abandoned, the purchasing power of silver as well as of gold fluctuated sharply.

Figure 1: The purchasing power of silver and gold 1290-2006/2007 (1873 = 100).

Figure 2 presents the index of silver’s purchasing power in UK, the Netherlands and Sweden, respectively. The index is set equal to 100 for the OECD in 2005, which implies that it stood at 87.7 in UK, 82.6 in Sweden and 92.6 in Netherlands in that year. The three index series in Figure 2 move closely together during most periods, despite the different methods behind their construction. The correlation between the Swedish and UK indices is the strongest one.

Although the purchasing power of silver was higher in Sweden relative to UK and Netherlands during the Middle Ages than in the 20th century, this should be expected since Sweden belonged to the European periphery in the Middle Ages and was the least knowledge-intensive economy of the three compared countries. During the reign of King Gustav Eriksson Vasa (1521-1560) the purchasing power of silver in Sweden converged with the one in UK. From around 1550 the purchasing power of silver was about the same in Sweden as in the UK. In 1550-2006, the average of both indices stood at 546.

In 1450-1800, the purchasing power of silver in the Netherlands was, on average, 44 percent lower than in Sweden and 24 percent lower than in UK according to the index, while it was, on average, higher than in Sweden and UK in 1850-2006. This reflects the transition of Holland from being the most knowledge-intensive economy in the world to being caught-up by other countries in Western Europe.

Figure 2: Smoothed trend of the index of silver’s purchasing power in Sweden, the Netherlands and UK, respectively (OECD average in 2005 = 100).
Relative price trends of two knowledge-intensive goods: a comparative European view

Iron

Metals, especially iron, is an obvious case of production requiring comparatively large amounts of skilled labour, organization and capital. Thanks to the efforts of Gregory Clark, long price series for a large number of goods in England are now conveniently available. His database includes the price of nails, which is the longest iron price series that exists from any place in the world, to our knowledge. These prices are here deflated by a consumer price index, the construction of which is described by Clark.

Figure 3 reveals that the relative price of nails in England tended to decline in the decades before the Black Death. At that juncture, the price turned sharply upwards, peaking in 1353. This appears to have been a short-term crisis reaction, though. A new downward trend set in almost immediately, accelerating during the 16th century. The downturn continued throughout the 15th century and accelerated during the 16th century (the nail price trebled in 1516, for reasons that are unknown to us).

Figure 3: Price of nails in England and broad nails at Munich relative to CPI, 1250-1700 (index 1500/1524 = 100).
Note. Before 1427, the price of oats is used as a deflator, since the CPI is not available.

12 The Clark database also provides prices of manufactured iron, the relative price of which rose in the 14th century. After peaking in the 1380s, a secular decline set in, lasting up to 1700. Clark, Gregory, England_1209-1914_(Clark).xls, http://gpih.ucdavis.edu/.
Figure 4: Price of iron in Sweden relative to CPI, 1340-1900 (index 1500/1524 = 100).
Source: Edvinsson–Söderberg database.
Note. Missing data have been interpolated.

Similar series are available for some other parts of Europe as well. The general downward trend in nail prices at Munich during the 15th and 16th centuries, which is also shown in Figure 3, is quite similar to the one observed for England. Obviously we are dealing with prices on a European rather than a national market.

Figure 4 presents the price of iron in Sweden, deflated by the new CPI index described in the previous section. Prices refer to osmond iron before 1540 and to bar iron thereafter. Bar iron was a more refined product which cost twice as much per weight unit as osmond iron. In Figure 4, however, the two price curves have been linked at 1540 in order to give a clearer view of the long term trend.

Sweden emerged as an iron-exporting country during the medieval era. The strong decline in the relative prices of iron may be attributed to advances in technology as well as in capital markets and transports. Many ironworks were founded in central Sweden. Technological transformation included the increased use of water power and the evolution of larger furnaces. Capital was mobilized from German merchants as well as from the upper layers of Swedish society. Sea transports apparently became cheaper, particularly long distance shipping.\(^{13}\)

Table 1. Relative price shifts of iron in England, Munich, and Sweden, 1350-1699

<table>
<thead>
<tr>
<th>Series</th>
<th>Period</th>
<th>Mean annual change, %</th>
<th>t</th>
<th>Sign.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>England, nails/CPI</td>
<td>1353-1499</td>
<td>-0.13</td>
<td>-3.29</td>
<td>0.001</td>
<td>143</td>
</tr>
<tr>
<td></td>
<td>1500-1599</td>
<td>-0.67</td>
<td>-8.39</td>
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<td>1600-1699</td>
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<td>-4.90</td>
<td>0.000</td>
<td>81</td>
</tr>
<tr>
<td>Munich, broad nails/CPI</td>
<td>1399-1499</td>
<td>-0.15</td>
<td>-4.02</td>
<td>0.000</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>1500-1569</td>
<td>-0.69</td>
<td>-13.83</td>
<td>0.000</td>
<td>65</td>
</tr>
<tr>
<td>Sweden, iron/CPI</td>
<td>1340-1499</td>
<td>-0.63</td>
<td>-6.46</td>
<td>0.000</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>1500-1599</td>
<td>-0.60</td>
<td>-8.51</td>
<td>0.000</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>1600-1699</td>
<td>-0.20</td>
<td>-5.85</td>
<td>0.000</td>
<td>92</td>
</tr>
</tbody>
</table>

Table 1 summarizes the trends of the iron price series presented above. Before 1500, the time trend is negative and statistically significant on a high level for all three series. The downward pressure on iron prices during the late medieval era (before 1500) was clearly stronger in Sweden, about 0.6 percent a year, than in England and Munich. In all three series the price decline was quite strong during the 16th century at 0.6 to 0.7 percent a year. During the 17th century the decline in prices slowed down in England.

Swedish iron prices exhibit a remarkably even rate of price reduction over nearly four centuries, from about 1350 up to about 1720. As osmond iron and bar iron in Sweden probably were more capital-intensive products compared to nails in England and Munich, it is not surprising that the scope for technological improvement and economies of scale was larger in the former case.

**Paper**

Paper has a particular interest in the economic history of production and dissemination of knowledge. There are at least two reasons for this. First and foremost, paper was part of the infrastructure of knowledge dissemination. It was a prerequisite of the new information technology associated with the introduction of the printing press during the 15th century. Vellum and parchment were not viable for mass production. A well-known example is the Gutenberg Bible, of which 30 copies were printed on parchment. Each parchment copy required the skins of more than 300 sheep. As editions of printed books could run into a thousand copies in the 16th century, it is obvious that the printing industry could not have expanded without a growing paper industry.\[14\]

Second, paper production is by itself a good example of the dynamics of medieval technology. As is well known, paper is not a European invention. Paper was used in China and other parts of East Asia long before it was brought to Europe by the Muslims, who improved the technique of making paper from rags. From the 12th century paper was produced in Spain, and during the subsequent centuries manufacturing was extended to Italy, France and Germany. From the beginning of the industry in Europe, it relied on water power

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and mechanized equipment for preparing the raw materials, in particular stamps for the crushing of rags. Paper-making therefore required substantial amounts of capital.  

Paper-making also demanded skilled labour in key positions. In the strict division of labour in the mills, the forming of the sheet was a critical part of the work process. This task was handled by the paper-maker or vatman. He dipped a mould, a rectangular wooden frame with a large number of fine metal wires, into the liquid vat and lifted it in such a way that the paper mass was evenly distributed and got a suitable thickness. This required great skill and care, and the vatman consequently earned high wages.

As calculated from the Clark database, paper declined strongly in price in England over a long period from the mid-14th century up to the first decades of the 17th century, when prices turned upwards (Figure 5). A strong relative price decline of paper, which roughly parallels the English curve from 1450 to 1650, is also evident in the Netherlands (Figure 5) and in Munich (Figure 6). Paper became cheaper in Spain as well (Figure 7), but the decline, for reasons that remain to be explored, was weaker here than in the other regions explored.

The relative price of paper thus declined substantially in several European regions well before the latter 15th century, when the introduction of the printed book generated a new demand for paper (English prices at that time are for imported paper, since no substantial domestic production was established until the late 16th century). The price decline was remarkably even over time, and was approximately the same in the 15th century as in the 16th.

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15 Coleman, pp. 4-5, 26, 36.
16 Hunter, pp. 241; Coleman, pp. 29-39.
Figure 6: Price of paper in Munich relative to CPI, 1400-1650 (index 1520/24 = 100).

Figure 7: Price of paper relative to a general price index in Aragon and Navarre, 1277-1498 (index 1440/1444 = 100).
The paper industry required a regular supply of raw materials in the form of rags. The periods of rising prices in England during two periods, about 1630-1750 and 1780-1830, are probably related to growing scarcity of rags as the paper industry expanded. England imported rags from a wide European area including Germany, Flanders, and Italy, but imports declined towards the end of the 18th century. After about 1830, output of hand-made paper fell steeply as steam-power and paper-making machines came into general use. This, combined with reductions of the excise and a rising supply of rags due to higher consumption of linen and cotton, drove English paper prices sharply downwards.\(^{17}\)

As pointed out by Coleman, the paper industry could not exist on the basis of unskilled labour, and it could not be organized as a putting-out system. It was essentially a mill industry.\(^{18}\)

The price trends are summarized in Table 2. The price decline before 1500 was very high in the Netherlands and Munich, exceeding 1.5 percent a year. In England and Aragon, prices fell by 0.8-0.9 per cent a year, which is also impressive. Navarre, with an annual decline of about 0.5 per cent fell somewhat below these regions, but the negative price trend is nevertheless statistically significant at a high level. In all regions examined, the price decline before 1500 was larger than during the 16th century, when the annual was in the range 0.5 to 0.7 per cent. During the 17th century, in contrast, the price trend turned upwards in England and the Netherlands. Taken as a whole, these results indicate that the medieval era was capable of efficiently transforming the paper industry.

Table 2. Relative price shifts of paper in England, Munich, the Netherlands, and Spain.

<table>
<thead>
<tr>
<th>Series</th>
<th>Period</th>
<th>Mean annual change, %</th>
<th>t</th>
<th>Sign.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>1353-1499</td>
<td>-0.91</td>
<td>-8.43</td>
<td>0.000</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>1500-1599</td>
<td>-0.55</td>
<td>-11.73</td>
<td>0.000</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1600-1699</td>
<td>0.31</td>
<td>8.06</td>
<td>0.000</td>
<td>78</td>
</tr>
<tr>
<td>Munich</td>
<td>1399-1499</td>
<td>-1.52</td>
<td>-11.40</td>
<td>0.000</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>1500-1569</td>
<td>-0.69</td>
<td>-13.83</td>
<td>0.000</td>
<td>65</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1450-1499</td>
<td>-1.77</td>
<td>-7.70</td>
<td>0.000</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>1500-1599</td>
<td>-0.57</td>
<td>-10.80</td>
<td>0.000</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1600-1699</td>
<td>0.05</td>
<td>1.42</td>
<td>0.157</td>
<td>100</td>
</tr>
<tr>
<td>Aragon</td>
<td>1277-1499</td>
<td>-0.80</td>
<td>-10.313</td>
<td>0.000</td>
<td>84</td>
</tr>
<tr>
<td>Navarre</td>
<td>1351-1444</td>
<td>-0.48</td>
<td>-6.23</td>
<td>0.000</td>
<td>70</td>
</tr>
</tbody>
</table>

To sum up, paper-making appears as an industry where prices were pushed down in a dramatic way during the late medieval period, due to economies of scale, technological advancement and organizational change. The striking price decline of printed books in Western Europe during the late Middle Ages, which has been discussed in recent research\(^{19}\), was partly the result of falling paper prices. Paper-making, like metal production, defends its place as one of the key industries in the emergence of an infrastructure of practical knowledge in the European economy.

\(^{17}\) Coleman, pp. 65, 107, 170, 195-199, 203.
\(^{18}\) Coleman, pp. 38-39.
Seven centuries of prices in Sweden

The new CPI for Sweden is a useful tool for providing a broad overview of relative price shifts in the very long term.

Figure 8a: Relative prices of iron, grains, and butter in Sweden, 1291-2007 (index 1580/89 = 100)
Source: Edvinsson–Söderberg database.

Iron/CPI and wheat/CPI, England 1209-1869
Greg Clark, Global Price and Income History Group
Figure 8a displays the relative prices of iron, grains, and butter in Sweden from 1291 up to 2007. The gradual evolution of the characteristic price structure of the West described in the introductory section of this paper, with low prices of industrial goods relative to the price of food, is clearly seen. In contrast to iron, grains and butter prices were rising during most of the pre-industrial era. As is clear from the prices of iron and wheat in England (Figure 8b), which is based on Clark’s database, a similar emergence of a new price structure is seen after the Black Death. This shock appears to have triggered the long-term downward pressure on iron prices, lending support to the hypothesis presented above.

Relative grain prices in Sweden, which form a fairly complete series from about 1410 onwards, tended to decline in the century following the Black Death. This is expected, given reasonable assumptions about population decline leading to a per capita income rise and a downward pressure on prices of basic commodities such as grains.

The 17th century is characterized by stagnating or falling grain prices, which is a general European phenomenon of the time. With population rising during most of the 18th century, grain prices surged upwards again, culminating in the years of the Napoleonic Wars.

After about 1820, grain prices declined again, despite strong population growth. This is of course the early stage of the Agrarian Revolution, which led to a substantial drop in prices during the second half of the 19th century. Technological transformation of agriculture was dramatic during the second half of the 20th century. Together with rapidly rising real incomes and a low elasticity of demand for grain, this resulted in an unprecedented price fall. The recent upward surge in grain prices (2007) is clearly visible, but we also see that this was a price rise from an extremely low level.

Finally, we may note that grains became more expensive relative to butter during the late 15th century and the whole of the 16th. The start of the grain price rise around 1460 may indicate that population began to recover at about this time. The changing relative price between grains and butter during the 16th century are compatible with a Malthusian view according to which population increase and reclamation of marginal lands drove grain prices upwards.

The next two centuries also fall nicely into this interpretation. Stagnating population during the 17th century resulted in higher prices of butter relative to grains, whereas the opposite is seen during the 18th century demographic expansion. During the latter half of the 19th century, rising incomes made butter prices diverge from grain prices. The long term relative price decline of butter came late, not until about 1930, but it was then quite strong.
The prices of two other interesting goods, salt and firewood, are depicted in Figure 9. Salt became very much cheaper in the long run. By the mid-14th century, the price of salt was about 60 times higher than in 1914. The price of salt certainly was volatile, as access to the Swedish market was dependent upon sea transports. Piracy in the Baltic Sea sometimes disturbed the salt trade during the Middle Ages and the 16th century. Greater risk in shipping of course pushed prices upwards. Nevertheless, the price decline over the medieval period as a whole is impressive. This was accomplished partly by turning to cheaper, though more distant, supplies of salt, from the Bay of Biscay rather than from the salt mines of northern Germany. The threats from piracy were met with bigger and better armed ships sailing in convoys. During the medieval era, the salt trade was the most advanced sea transport organization of its time in this region. From the Swedish horizon, then, salt may be regarded as a good with a relatively high content of knowledge and capital.20

The firewood price curve is quite different. During the pre-industrial era, the technology for making firewood probably did not change much. This was a labour-intensive activity which was resistant to the application of practical knowledge that transformed the dynamic metal-producing and shipping sectors. In this respect, firewood production probably much resembled the production of grains and butter before the Agrarian Revolution. The price rise of firewood during the 20th century, when technological change did take place, probably is due to do the expansion of alternative uses of timber as well as to the price rise of other fuels.

Summing up, then, the price trends of the five goods discussed here support the view that a new price structure started to evolve already during the medieval era, as goods with large inputs of knowledge and capital (iron, sea freights) declined relative to the price of goods with low such inputs (grains, butter, firewood). The emergence of the price structure

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20 The reasons for the salt price increase during the 20th century are not known to us.
that was characteristic of the West, with low prices of industrial goods and high prices of food, can be seen in Sweden even though this was a peripheral economy during the medieval era. Also, the speed of relative price reductions of iron and salt is striking.

Sea transports

Before the 20th century, sea transports assumed a key strategic role in the overall development of the knowledge economy. It was the main means of communication over long distances. Improved sea transports increased international market integration and accelerated the spread of innovation systems.

Knick Harley demonstrates that British freight rates declined only modestly during the century prior to 1850, and then rapidly when metal steamships came in use. Although Douglass North shows that antebellum cotton freight rates declined, this was according to Harley specific to the young American market, due to better packing of cotton, and did not reflect a general decline in freight costs.

For Sweden, transport costs across the Baltic Sea could are especially important, since much of the foreign trade was conducted on this route. Although there are no continuous, annual series before the 19th century, there are some notations for various years, which give important information concerning long-term trends.

Freight rates are complicated to analyse since these could be quite different between various ports. Although freight costs increased with increased distance, there was not necessarily a linear relation, since other factors could also be important. Freight costs were also somewhat different for various goods, and were higher per unit of weight for higher-valued goods. For example, freight rates for copper were much higher than for iron, since copper was more valuable per kilogram. It is, therefore, important to analyse homogenous data through time, of the same commodity on the same route from one port to another. Such data is difficult to find for Sweden, but is available for other international routes, for example, across the Baltic Sea. There were also significant annual fluctuations for the same route. For example, during times of war freight rates tended to increase substantially.

For Sweden, there are some interesting sources on freight rates for the Middle Ages and the Early Modern Period. In 1705 and 1740-1764 a large number of freight rates from Stockholm to other ports are available in *Stockholms stads priscourant*. The earliest source is probably from 1327 from Falsterbo in Scania. Some other sources also exist for the 16th and 17th centuries. Table 3 presents some of these rates. These have been estimated first in grams of silver, then transformed into real costs in Sweden and UK based on the purchasing power of silver in those two countries. The real cost on the route Stockholm-Gdańsk has been set equal to 100.

An interesting observation that can be made from Table 3 is the huge variations in freight rates on routes of different lengths. In the 16th century, freight rates from Stockholm to Reval were quite low, not significantly above the freight rate from Stockholm to Gävle in the north of Sweden. In the 18th century, freight rates from Stockholm to England, France and Holland were 3-6 times the freight rate on the route from Stockholm to Gdańsk.

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In the 17th and 18th centuries, the change in the real costs of freight rates was probably insignificant, but a decline sometimes during the Middle Ages and/or the 16th century is likely to have occurred. The real freight costs on the route Stockholm-Amsterdam was about the same in 1640 as a century later. The real costs of transporting iron from Stockholm to Reval in 1527 was 88 percent of the real costs of transporting iron from Stockholm to Gdańsk in 1745 and 51 percent above the real costs of transportation between Stockholm and Copenhagen in 1761. Since the route Stockholm-Gdańsk was almost twice the length of the route Stockholm-Reval, while the route Stockholm-Copenhagen was of somewhat lengthier than the route Stockholm-Reval, this suggests some decline in the real freights between the early 16th and 18th centuries. Real freight rates from Sweden to Britain in the 14th century seem to be around twice the level in the 18th century (the high freight costs on the route Stockholm-London 1705 and 1745 were probably due to war, and the lower freight costs in 1752 probably more truly reflect costs during peacetime).

Figure 10 presents an index of freight rates deflated by the Swedish Consumer Price Index for the period 1513-2000. For the period 1513-1754 the freight series is based on van Zanden’s series of freight rates on the route Amsterdam-Preussia/Gdańsk.24 For the period 1757-1832 it is based on freight rates from United Kingdom to the Baltic Sea.25 For the period 1832-2000 it is based on the price deflator of sea transports in Swedish historical national accounts.26 These three series have been spliced.27 While Figure 10 follows the real costs (in terms of equivalence in goods and services), Figure 11 follows the labour costs (in terms of equivalence in payment of labour input), of freight rates.

Figures 10 and 11 show no signs of improved productivity in sea transports from the late 16th to the early 19th centuries. Freight rates deflated by the CPI were, on, average 2.7 times higher, and freights deflated by the wage rate 2.1 times higher, during the first half of the 16th century than in the 18th century, which may suggests a productivity increase in sea transports during the course of the 16th century, as discussed above.

From the 1830s or 1840s, real freight rates declined continuously. By the 1860s real freight rates had been halved compared to the 1830s, which was accompanied by a significant rise in foreign trade, enabling the subsequent industrial transformation in Sweden. Real freight rates continued to decline during the 20th century, although they increased significantly during the two world wars (reaching high points in 1917 and 1945, respectively). In the 1990s, real freights were only around 6 percent of the average level in the 18th century.

Since the productivity of the overall economy also increased, the decline in the freight rates deflated by the wage rate was even steeper than the real freights, as shown by Figure 11. The labour input in the 1990s was only 0.3-0.4 percent the level in the 18th century, which indicates that the labour productivity of sea transports could have increased as much as 300-fold during this period.

Table 3: Freight rates 1327-1761 of one last (assumed to be equal to 18 ship pounds or 12 barrels) for various routes.

<table>
<thead>
<tr>
<th>Year</th>
<th>Transport</th>
<th>Currency unit</th>
<th>Price per last</th>
<th>Gram silver per last</th>
<th>Purchasing power of silver in Sweden, 1745 = 100</th>
<th>Real cost in Sweden, Stockholm-Gdansk 1745 = 100</th>
<th>Purchasing power of silver in UK, 1745 = 100</th>
<th>Real cost in UK, Stockholm-Gdansk 1745 = 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>1327</td>
<td>Toruń-Bergen</td>
<td>Gros tournois</td>
<td>60</td>
<td>216</td>
<td>123</td>
<td>486</td>
<td>104</td>
<td>410</td>
</tr>
<tr>
<td>1327</td>
<td>Falsterbo (Scania)-England</td>
<td>Gros tournois</td>
<td>60</td>
<td>216</td>
<td>123</td>
<td>486</td>
<td>104</td>
<td>410</td>
</tr>
<tr>
<td>1327</td>
<td>Falsterbo (Scania)-England</td>
<td>Gros tournois</td>
<td>120</td>
<td>432</td>
<td>123</td>
<td>971</td>
<td>104</td>
<td>821</td>
</tr>
<tr>
<td>1327</td>
<td>Falsterbo (Scania)-Flanders</td>
<td>Gros tournois</td>
<td>64</td>
<td>230</td>
<td>123</td>
<td>518</td>
<td>104</td>
<td>438</td>
</tr>
<tr>
<td>1327</td>
<td>Falsterbo (Scania)-Scotland</td>
<td>Gros tournois</td>
<td>66</td>
<td>238</td>
<td>123</td>
<td>534</td>
<td>104</td>
<td>451</td>
</tr>
<tr>
<td>1508</td>
<td>Gävle-Stockholm, iron</td>
<td>Mark örtug</td>
<td>1</td>
<td>14</td>
<td>244</td>
<td>62</td>
<td>226</td>
<td>57</td>
</tr>
<tr>
<td>1518</td>
<td>Reval-Stockholm archipelago (12 barrels bread or beer)</td>
<td>Mark örtug</td>
<td>1.2</td>
<td>14</td>
<td>281</td>
<td>70</td>
<td>197</td>
<td>49</td>
</tr>
<tr>
<td>1527</td>
<td>Stockholm-Reval, iron</td>
<td>Mark rigisk</td>
<td>2</td>
<td>20</td>
<td>242</td>
<td>88</td>
<td>196</td>
<td>71</td>
</tr>
<tr>
<td>1640</td>
<td>Stockholm-Amsterdam</td>
<td>Daler (silvermynt?)</td>
<td>10.5</td>
<td>173</td>
<td>99</td>
<td>312</td>
<td>96</td>
<td>305</td>
</tr>
<tr>
<td>1705</td>
<td>Stockholm-Amsterdam, iron</td>
<td>Guilder</td>
<td>23</td>
<td>221</td>
<td>99</td>
<td>401</td>
<td>108</td>
<td>436</td>
</tr>
<tr>
<td>1705</td>
<td>Stockholm-London, iron</td>
<td>British schilling</td>
<td>54.5</td>
<td>360</td>
<td>99</td>
<td>653</td>
<td>108</td>
<td>711</td>
</tr>
<tr>
<td>1745</td>
<td>Stockholm-Gdańsk, iron (18 ship pound)</td>
<td>Polish florin/gulden</td>
<td>9</td>
<td>55</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>1745</td>
<td>Stockholm-Amsterdam, iron</td>
<td>Guilder</td>
<td>18.5</td>
<td>178</td>
<td>100</td>
<td>324</td>
<td>100</td>
<td>324</td>
</tr>
<tr>
<td>1745</td>
<td>Stockholm-France, iron</td>
<td>Guilder</td>
<td>28</td>
<td>269</td>
<td>100</td>
<td>491</td>
<td>100</td>
<td>491</td>
</tr>
<tr>
<td>1745</td>
<td>Stockholm-London, iron</td>
<td>British schilling</td>
<td>50</td>
<td>330</td>
<td>100</td>
<td>603</td>
<td>100</td>
<td>603</td>
</tr>
<tr>
<td>1752</td>
<td>Stockholm-London, iron</td>
<td>British schilling</td>
<td>26</td>
<td>172</td>
<td>91</td>
<td>285</td>
<td>89</td>
<td>278</td>
</tr>
<tr>
<td>1761</td>
<td>Stockholm-Copenhagen</td>
<td>Lübeck Schilling</td>
<td>24</td>
<td>30</td>
<td>105</td>
<td>58</td>
<td>97</td>
<td>54</td>
</tr>
</tbody>
</table>

Figure 10: Freight index of Swedish/Baltic Sea transports deflated by Swedish CPI (1700-1799 = 1000).

Figure 11: Freight index of Swedish/Baltic Sea transports deflated by Swedish wage rate (1700-1799 = 1000).
Food and cloth industries

Food and textile industries transform raw materials produced by the agriculture into finished products. The productivity of these industries could be studied through the price of the finished product relative the raw material and wages. While before the industrial revolution, the marginal productivity of land was a key to the development of the price of unfinished agricultural products, such as grain, the relative price of food and textile industries were more closely linked to the development of the knowledge economy.

The price of bread can be related to the price of wheat, rye and barley.

In Gothenburg in December 1714, 28 100 kg of wheat cost 5.1 daler kopparmynt, rye 4.3 daler kopparmynt, barley of better quality 4.4 daler kopparmynt and barley of inferior quality 3.7 daler kopparmynt. 100 kg of bread of better quality ("Cajute-bröd") cost 14.7 daler kopparmynt and of inferior quality ("skiepsbröd") 8.8 daler kopparmynt. This implies that the value ratio of better quality bread to wheat (per kg) was around 2.9 and of inferior quality bread to rye or better quality barley was around 3.4. Similar ratios can be found in the 16th and 17th centuries. For example, in 1473 65 loafs of bread cost 3 mark penningar. 29 Assuming that these loafs weighted 50 kg, it would imply that 100 kg bread cost 6 mark penningar. The price of barley was around 2 mark penningar per 100 kg. Thus a ratio of 3 to 1, the same as in Gothenburg 1714. This would suggest that the productivity of bread production did not increase between the 15th and the 18th century, i.e. it was one of the stagnant sectors (in terms of productivity change).

In contrast, there seems to be some productivity improvements in the beer industry between the Middle Ages and the 16th century. If the beer price is deflated by the grain price, the real costs of beer (in terms of grains) in Sweden was less than half in the period 1500-1599 than in 1365-1499. The sharpest fall occurred up to around 1550. The relative price of beer seems to increase towards the late 16th century, which could be an effect of changes in the measures used, making this result somewhat uncertain.

For international comparisons, Figure 12 presents the real cost of beer in UK, by deflating the price of beer by the price of barley for the period 1400-1869. It also presents a series of the beer price deflated by the wage rate of building workers. The data are from Gregory Clark’s price series. 30 The real cost in terms of barley decreased dramatically during the course of the 16th century, which confirms the picture from Sweden. However, in terms of labour input the decrease was much less dramatic. One explanation of this divergence was that the barley price was quite low in the 15th century, while it increased in the 16th century. Since the beer industry increased its productivity a small fall in the price of beer in terms of labour input was possible. Thus the decrease in the marginal productivity of grain production, which accompanied the 16th century due to the population growth, was partly offset by an increased productivity of such final consumption goods as beer.

28 Göteborgs rådhusrätts och magistrats arkiv, Signum L I (Kollegiernas protokoll), vol. 4-6, Göteborgs landsarkiv.
29 Stockholms stads skottebok 1460-1468, p. 564.
Figure 12: The price of beer deflated by the price of barley and the wage rate, respectively, in UK 1400-1869, smoothed average.

Table 4 presents the development of the real price of coarse cloth, calculated as the price of coarse cloth deflated by the grain price. Table 4 clearly shows a dramatic fall in the real price of cloth during the course of the 16th century, which suggests a substantial increase of maybe 200 percent in the productivity of textile industries during the course of 16th century. There is, however, some uncertainty whether the quality of the coarse cloth price are the same before and after the mid-16th century.

Table 4: The real price of coarse cloth (the price of course cloth deflated by the grain price), 1830-1839 = 100.

<table>
<thead>
<tr>
<th>Period</th>
<th>The price of coarse cloth deflated by the grain price, average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1450-1499</td>
<td>195</td>
</tr>
<tr>
<td>1500-1549</td>
<td>183</td>
</tr>
<tr>
<td>1550-1599</td>
<td>85</td>
</tr>
<tr>
<td>1600-1649</td>
<td>73</td>
</tr>
<tr>
<td>1650-1699</td>
<td>48</td>
</tr>
<tr>
<td>1700-1749</td>
<td>67</td>
</tr>
<tr>
<td>1750-1799</td>
<td>64</td>
</tr>
<tr>
<td>1800-1849</td>
<td>88</td>
</tr>
<tr>
<td>1850-1899</td>
<td>99</td>
</tr>
</tbody>
</table>