International price competition and catch-up in high-tech sectors, 1850-1940[1]

Jonas Ljungberg

To be presented at the Economic History Society Annual Conference, 27-29 March 2015, University of Wolverhampton (Telford)

Work in progress!

ABSTRACT

This paper revisits the question whether Britain, from the late nineteenth century up to the second world war, lagged behind due to a faster structural change or due to a more rapid rise of technology in manufacturing in the up-coming countries. It does so by taking a disaggregate approach and comparing prices for some technologically advanced products in Britain, Germany, and Sweden, from the mid-nineteenth century and through the interwar period: steamships, locomotives, and electrical motors. Price data for technologically advanced products are very scarce and raise methodological difficulties concerning the construction of time series or indexes. The paper argues that matching or splicing, being comparable with hedonic price estimates, can be used. For the mentioned products, the price data indicate that Britain lost in competitiveness against Germany and Sweden, although differently for different products. In a longer perspective technological change and price competition was a necessary condition for catch-up by the latter.

KEY WORDS: international competitiveness; prices; second industrial revolution; technogical change;

CONTACT DETAILS

Jonas Ljungberg, Department of Economic History, Lund University, Sweden

Email: **jonas.ljungberg@ekh.lu.se**

---

[1] In the title "catch-up" has been substituted for "productivity" (cf the conference booklet) since an examination what product prices imply for productivity would require another paper.

International price competition and catch-up in high-tech sectors, 1850-1940

Broadberry (1997, 1998) gave a new twist to the long-standing controversy whether or not the Victorian British economy suffered from a "climacteric." Broadberry questions the traditional view that the US and Germany caught-up with Britain due to successful adoption of the technologies of the second industrial revolution. He argues that not much changed in the relative productivity of manufacturing between US and the UK, or Germany and the UK, respectively. Instead, catch-up is largely seen as a result of structural change in the US and Germany where reallocation of resources from agriculture to sectors with higher productivity levels for many years could draw on the much larger share, in the late nineteenth century, of employment in the agricultural sector. While finding the argument about structural change persuasive, this paper again shifts the focus of the comparison to technology but seen through the angle of prices.

If labour cost and the capital share of value added are known, prices of products can be used to estimate labour productivity. Under competitive conditions marginal product equals average product, that is, productivity. In other words, labour's reward equals productivity and over time the real product wage, that is, the nominal wage deflated by corresponding output prices, will measure productivity change.[2] With focus on prices it would, however, go beyond the space of this paper to extend into productivity measurement. Suffice to say that prices tell about competitiveness. If also the type of products, whether 'old stuff' or innovations and technologically changing products, are considered, prices will tell about lagging behind and catching-up on industry level. Broadberry criticizes the traditional view about technologically based catch-up for being based on aggregate data. By comparing prices in Britain, Germany, and Sweden, for products at the technological frontier of the late nineteenth century, notably steamships, locomotives and electrical motors, the present paper takes a disaggregate approach to catch-up.

Products in international trade are as a rule assumed to adapt to a common price level. If we want to compare prices of products produced in different countries, a problem is to determine if products are identical or somehow a price tag could be fixed to the quality difference. Kravis and Lipsey (1971) performed a price comparison of machinery and other manufactured metal products that were similar but not identical, and they found that even if account was taken of quality differences, price differentials in the international market are persistent. The way Kravis and Lipsey solved the methodological challenges, by hedonic price estimates, has inspired the present examination of prices for electrical motors. For steamships and locomotives the comparison of levels are based on other inferences. The result corroborate the findings by Kravis and Lipsey, yet for a historical period: international markets are not that efficient. And price differences can be used for analytical purposes.

The selection of countries is motivated by Britain being the first industrialized nation whose technological leadership was challenged by up-coming Germany, besides the US for which comparable price data, however, is still missing. Sweden is relevant in the comparison since it was rapidly catching up from being a poor, peripheral country to number four, as regards income level, in Europe by 1950 (Maddison). Moreover, it also signifies a case where structural change, along with productivity growth in agriculture, has been put forward as a rival to growth of manufacturing as an explanation of the success (Ljungberg & Schön 2013).

With some rare exceptions historical price series of technologically advanced products used for, for example, deflation of fixed capital formation over time, have mostly been constructed as composite indexes from input prices and not from output market prices. As a consequence, such estimates have to rely on assumptions as regards important determinants of prices, such as productivity, quality change and profits. The present price estimates for steamships and locomotives are shown to differ significantly from composite indexes by Hoffman (1965) and Feinstein (1988).

Quality change is a crucial problem for the construction of time series of prices and this is also a reason why most historical price statistics are for standardized or rather homogenous products. However, by use of the matching or splicing method, it is possible to use the market's evaluation of quality differences in the construction of consistent series on the basis of price quotations for diversified products. Since "matching" mostly refer to construction of time series for fairly homogenous products (van Mulligen 2003), I also call the method used here "splicing." By splicing it is possible to take account of quality differences and construct a counterfactual time series of the price "if quality had remained the same." This may sound counter-intuitive and as if quality change is ignored. On the contrary though, it is the price increase due to quality change which is adjusted for. A condition is, however, that there are continuous observations and that the diversified products share at least one observation. Say, that we have prices for locomotive A over year 1 to 4, and for locomotive B from year 4 to 8. The common observation in year 4 can then be used to extrapolate A forwards with B to year 8, or the other way, extrapolate B backwards with A to year 1. In principle this method can be used also if observations for one model of a product type is more scattered but there are several models with observations that together cover all years. This is how I have proceeded to construct most of the price series used in the present study. For English and German

[2] See Ljungberg (2004) for a discussion and an empirical application on Swedish industry 1890-1980.

electrical motors, though, there have been enough observations to allow the use of hedonic price regressions where the price is a function of a selection of characteristics. In principle, I would argue that hedonic price measurement and the splicing or matching method provide the same: the point is that it is the valuation on the market which is taken as the measure of quality differences. What may make the hedonic method superior is the use of a larger amount of data why the outcome should be more representative. However, for historical periods large amounts of data allowing for hedonic regressions are seldom found why the “handicraft based” splicing method is the most used in the present paper.

Sources are shortly mentioned in the sections examining price developments of steamships, locomotives and electrical motors below.

II. Prices for steamships

Shipping, and shipbuilding, were the levers of globalization. With the change from wood to iron and, later, steel in the construction of ship hulls, and the change from sail to steam, a shift occurred of the primacy in shipbuilding, from New England to ‘Old’ England and Scotland. This shift went contrary to other domains of the economy, where the US overtook Britain during the second industrial revolution. According to Harley (1972), this loss of American leadership in shipbuilding was an outcome of protectionism in the US which gave shipyards too high prices of iron and steel and not allowed US-flagged ships to be foreign-built. The British leadership was retained until the 1950s, as regards produced tonnage, but as regards technology British shipbuilders were challenged already before. In particular, this happened in the interwar period when Scandinavian shipbuilders took the lead in the change from coal to oil (diesel engines), and, late in the period, from riveting to wielding of the hulls (Ljungberg 1981). In the following this development, from mid-nineteenth century through the interwar period, is examined from the angle of prices on ships that are assumed to be representative for shipbuilders in Britain, Germany, and Sweden respectively. Before the 1890s, markets were somewhat segmented with the Swedish yards mostly producing mainly for coastal traffic or Russian rivers, while the British included ocean going ships, and no data has been found for any German shipbuilder. The latter begins with 1889 and roughly from this time the produced types of ships were broadly similar until a divergence in technology occurred after WWI.

A British price index

Efforts to construct a price index for ships, since the rise of modern shipbuilding in Britain, have been pursued along several lines. One line has estimated the average price per gross register ton, (Cairncross 1953, p. 127; Slaven 1980; Craig 1981), without, however, taking account of quality change. Cairncross' index, ranging 1870-1913, was actually a linking of different methods, the first one-third being average values. From the early 1880s Cairncross uses the quotations of the Kellock shipbrokers, which from 1898 onwards are published in the famous Fairplay quotation of a 7500 dwt steamer.

Pollard and Robertson (1979) also use the Kellock/Fairplay quotation, but only for the years 1898-1913. This series is then extrapolated backwards to 1883 by means of a GDP-deflator, but adjusting for "greater fluctuations in the price of ships than in the economy as a whole" (p. 187). Similarly with the Fairplay quotation, Harley (1972) presents a price series of a particular specification for the period 1856-1890. It is a steamer of 2,000 gross tons and capable of 10 knots, based on the records of the shipbuilder Stephen and Sons.

The main line, as it seems, is however to construct a ship price index from the input side, weighing together factor and intermediate costs (Maywald 1956; Feinstein 1988; for the Netherlands, Albers 1996). Feinstein (1988 p.334ff) presents an impressive estimate for the period 1850-1920, on the basis of index series for wages and materials, with an adjustment for the reduced quantity of material with the transition from composite to iron to steel. The quality problem is also comprehended, yet it does, in effect, not influence the price index but only the conversion of tonnage series into value series. As a price index reconstructed from the input side it is assumed that the quality of output is constant, and first when converted to current values adjustment for quality change is undertaken (in order to calculate value of total output from the tonnage figures).

However, the procedure is not unproblematic. Feinstein, hence, assumed that productivity improvements in shipbuilding were absorbed in the industry and not passed over in lower prices. Further, the estimate "effectively assumes a constant profit margin" (p. 342). In fact, this implies that all productivity gains were taken by wages and salaries. The long-term decline in ship prices displayed by Feinstein’s index should then reflect a decline in prices of ship iron and steel.[3] Although my price index differs from the estimate by Feinstein, it lends support to his assumption about the productivity gains which could be related to the particular conditions for British shipbuilding, as will be further discussed below. Another issue with Feinstein’s index is why, despite a meticulous account of the calculations, it differs from the implicit deflator that can be derived from the series on

---

[3] A neglected issue is the representativity, or share in ship materials, of iron and steel. According to Harley (1972), a not insignificant share of material cost pertained to the outfit of ships.

fixed capital formation at current and constant prices. The differential between the steamship price index and the implicit deflator is indicated in table 1.[4]

Table 1. Trend of steamship prices, 1850-1914

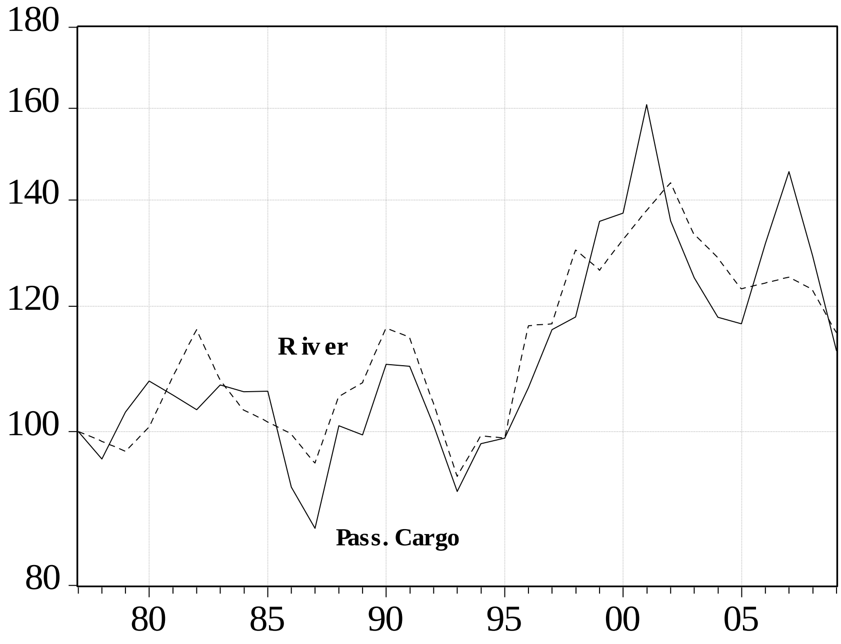
Annual rate of change in percent, various estimates.

Index	**1850-1875**	**1860-1890**	**1890-1914**
British			
Slaven	**-0.09**		
Cairncross (1870-1913)		**-4.48**	**-0.27**
Pollard&Robertson (-1913)			**-0.55**
Feinstein	**0.60**	**-1.60**	**0.43**
-"- implicit deflator (1851-)	**0.74**	**-1.24**	**0.59**
Ljungberg	**-0.41**	**-0.33**	**0.33**
Harley (1856-1890)	**-0.77**	**-2.50**	**- -**
Dutch			
Albers	**0.54**	**-1.00**	**0.72**
German			
Ljungberg	**--**		**1.00**
Swedish			
Ljungberg		**-0.49**	**-0.84**

Note: sources, see text.

Figure 1. Price indexes for Denny passenger cargo steamers, and river steamers, 1877-1909

[4] The series on domestic investments in new ships at current and constant prices are found in Appendix tables III and X, respectively (Feinstein 1988). About their correspondence and relation to the price index, compare page 347.



Source: Estimates on Lyon (1975)

Given the different previous estimates which show (see Table 1) a downward trend between -1.25 and -4.38 per cent per year over the period 1860-1890, the more moderate fall (-0.33) of the present estimate, that should take account of quality change, seems puzzling. Let me first explain how it is constructed and then discuss the puzzle. It is based on the *Denny List* (Lyon, 1975), which supplies technical data and prices, in addition to biographical notes, of the more than 1300 ships built by the Denny Brothers, from 1847 to the 1940s (although price quotations expire with 1932). The prices pertain to the year of delivery which often was at least one year after the contractual agreement. The method used is the matching or splicing method. Several shorter series have been based on different tonnage sizes, and types, as well as the ratio between the space for cargo and the gross tonnage, the speed of the ship, and the number of passengers in different classes (to be shown in appendix!)

Denny built most specialized tonnage, and many river steamers for the overseas Empire were launched at Dumbarton on the Clyde. Since this ship type might bias the present index ranging 1850-1932, two main series were constructed, one mainly of passenger and cargo steamers, and another on river passenger steamers. For the years 1877-1909 these two independent indexes overlap, as shown in figure 1. Their long-term development is identical, and the behaviour through the cycles similar. The difference between them might might be real or artefactual but anyhow of little significance.

Another check on the reliability of the price series is pairwise Granger causality tests. The test indicates if lags of one series add significantly to the explanation of another series, whose lags are also included in the regression. Table 2 reports such tests on Feinstein's index, the present price index for steamships, and price indices for material inputs. While Feinstein's index for materials is weighted according to the estimated distribution between plates and profiles in the hull of a ship, my index is an average of ship plates and ship angles, based on the weekly quotations in the Economist. Though, before 1876 ship iron was only casually quoted, why extrapolation backwards with "sheets" and "bars &c." is undertaken. In 1885 the iron series are chained with corresponding steel series. Since (most) of the series are trend stationary, i e, the deviations from the linear trend are stationary, the tests are run on the deviations from trend instead of first differences which wash out all but short-run information.

The comments will first consider panel A of table 2, and then proceed to panel B. It is reasonable that iron and steel prices with a lag of a couple of years should influence ship prices. The lag is not only depending on the gestation period of building a ship, but also of the endurance from order to delivery. When the contract was signed, the price of the ship was of course influenced of the current conditions, for example iron and steel prices but also wages. In Feinstein’s index, there is only a minor evidence of such a lag, between material prices and ship prices. The lagged relationship is weak by the mere reason that the this ship index is composed of the current year's prices and wages. However, what is striking, in table 2, is not only that my ship price index recurrently was Granger caused with a lag, by the iron and steel prices, of both versions, but also that such a relation is even

Table 2. Granger causality test on prices for steamships, and ship iron and steel.

Prices are deviations from trend as described in the text. For three lags only probabilities < 0.20 are reported. "F", as first letter, denotes Feinstein's index, "S" Slaven, and "L" Ljungberg.

Figures denote probability for the Null-hypothesis

Panel A:	**1860-1890**		**1890-1914**		**1860-1914**	
	2 lags	**3 lags**	**2 lags**	**3lags**	**2lags**	**3lags**
LI&S causes FSHIP	**0.094**	**0.172**	**0.686**		**0.066**	**0.115**
FSHIP causes LI&S	**0.033**		**0.998**		**0.105**	
FI&S causes FSHIP	**0.066**	**0.141**	**0.412**		**0.280**	
FSHIP causes FI&S	**0.042**		**0.477**		**0.257**	
LSHIP causes FSHIP	**0.124**	**0.159**	**0.829**	**0.146**		
FSHIP causes LSHIP	**0.002**	**0.004**	**0.083**	**0.050**	**0.249**	**0.006**
FI&S causes LI&S	**0.072**		**0.835**		**0.310**	
LI&S causes FI&S	**0.015**	**0.021**	**0.628**		**0.027**	**0.030**
LSHIP causes LI&S	**0.919**		**0.707**		**0.758**	
LI&S causes LSHIP	**0.036**	**0.070**	**0.119**	**0.043**	**0.128**	**0.023**

LSHIP causes FI&S	**0.090**		**0.829**		**0.126**	
FI&S causes LSHIP	**0.000**	**0.001**	**0.080**	**0.026**	**0.189**	**0.003**
Panel B:		**1850-1875**				
		2 lags	**3 lags**			
FI&S causes FSHIP		**0.227**	**0.138**			
FSHIP causes FI&S		**0.207**	**0.121**			
FI&S causes SSHIP		**0.059**				
SSHIP causes FI&S		**0.381**				
FI&S causes LSHIP		**0.004**	**0.006**			
LSHIP causes FI&S		**0.384**				
FSHIP causes SSHIP		**0.053**				
SSHIP causes FSHIP		**0.344**				
FSHIP causes LSHIP		**0.005**	**0.007**			
LSHIP causes FSHIP		**0.469**				
SSHIP causes LSHIP		**0.715**				
LSHIP causes SSHIP		**0.392**				

stronger from Feinstein's to the present index. This is reflecting the fact that both material prices and wages influenced the ship prices with a lag, due to the delay of delivery.

Panel B, for the period 1850-1875, gives further support to the above considerations. Both Slaven's and my index seem to be "caused" by material prices and wages, although a visual inspection would show a largely disparate behaviour. Yet, it is not quite accurate to call it "Slaven's index", since he reports the average prices per gross register ton of steamers built by Denny's, and regards these only as a conditional reflection of the price level as quality is not considered (Slaven 1980). The statistical significance for the causality from material prices, as well as from the compound index of material prices and wages (i.e., Feinstein's ship prices), to ship prices, was stronger for the present index, at the 1 per cent level; against the 6 per cent level for Slaven's. With three lags my index still retains a significance less than 1 percent, which support the cyclical behaviour in the present index.

A weakness of the matching method is that some mis-matches may result in a drift of the index. Hower, such a mis-match ought to reduce the Granger causality, which, actually, is most significant for the present index, in particular for the critical period 1860-1890. Internal consistency between the two Denny series as well as the Granger cause analysis thus corroborate the validity of the present ship price index.

However, as hinted to above, it is puzzling that this index, which should take account of quality change, displays less decline in steamship prices than the previous estimates. When taking account of quality change, both productivity gains and erosion of profits as a consequence of new entrants into the business should have reduced prices (Ljungberg 1990, 1991; Ljungberg and Lobell 2012). For the period 1850-1875, this expectation is fulfilled by Harley's and the present index, but not by the others (see table 1). In the period 1860-1890 Harley's and the other estimates decline far more than the present index. The general decline in this period is a reflection of the fall in prices of iron and steel. This is transparent in Feinstein's index where decline and fluctuations of ship and iron/steel prices are close to identical, with the concomitant reduction of used quantity of iron/steel compensating for increasing wages. When the trend of steel prices bent up in the 1890s, differences between the different estimates diminish. compensating for increasing wages.

The puzzle remains, why the present index displays a significantly smaller decline than in other estimates, and stable prices for the whole period 1850-1914. Market conditions may explain why British steamship prices did not fall with productivity growth or quality change. British shipbuilders were superior and produced a major share of the world output. Even if this share declined from almost 80 per cent in the 1890s to 60 per cent in the years before World War I, both total output and exports grew in absolute terms and they did not need to bother about competition (Pollard 1957). Yet, even if international competition did not force them to cut prices, competition among British shipbuilders should have extered a pressure. A conjecture, in line with Feinstein's assumption that productivity gains were absorbed by the industry, is that shipbuilding firms had developed overhead costs that became the standard. The very rapid growth of British shipbuilding during this period, the mushrooming of new firms dominating whole municipalities and districts should then have created a sort of patriarchalistic welfare communities. *"Jarrow [close to Newcastle on the Tyne] for example, was the town whose occupation, livelihood, housing, and other amenities depended entirely on Palmer's Shipbuilding Company. 'So completely, in fact, is the town identified with the works, that it might more appropriately be called 'Palmer's town,'' wrote one admirer in 1904."* (Pollard and Robertson, 1979, p. 54).

In the second half of the nineteenth century, British shipbuilding was relocalised from South by lower wages in North and Northeast, according to Pollard and Robertson (1979). Localised outside the metropolitan centers there were little of opportunities to alternative employment and to retain the labour force regardless of fluctuations in demand, a kind of social contract was probably worth its price. Hence, the gains in productivity did not result in lower prices but were consumed in the industry. The realism of this interpretation could be examined in the light of an international comparison.

The international price level

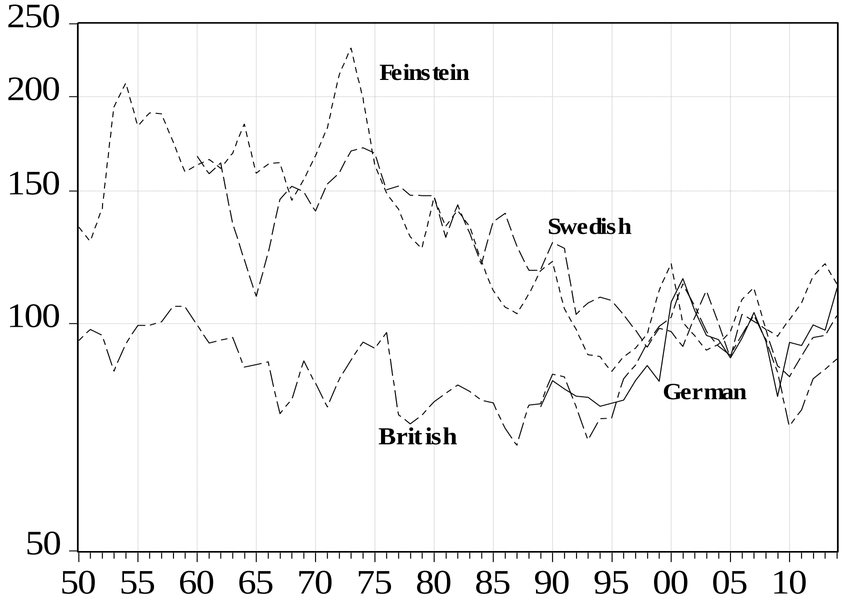
Swedish shipbuilding is often seen as rather insignificant before World War I (Olsson 1983). However, it is not undisputable that shipbuilding was trailing in the Swedish industrialization. The production of wooden sail ships was well established, in an international perspective, in the mid-19th century. The transition to steam and iron gave rise, before 1850 or in the third quarter of the century, to a handful of shipyards, some of which became big companies for a hundred years. However, in the 19th century, they normally did not build ocean going steamers, but smaller ships for the Baltic or coastal traffic. Nevertheless, they had the capability to design and build tankships for the Russian petroleum trade already in the early 1880s. These were river steamers, dividable for being able to pass the locks.

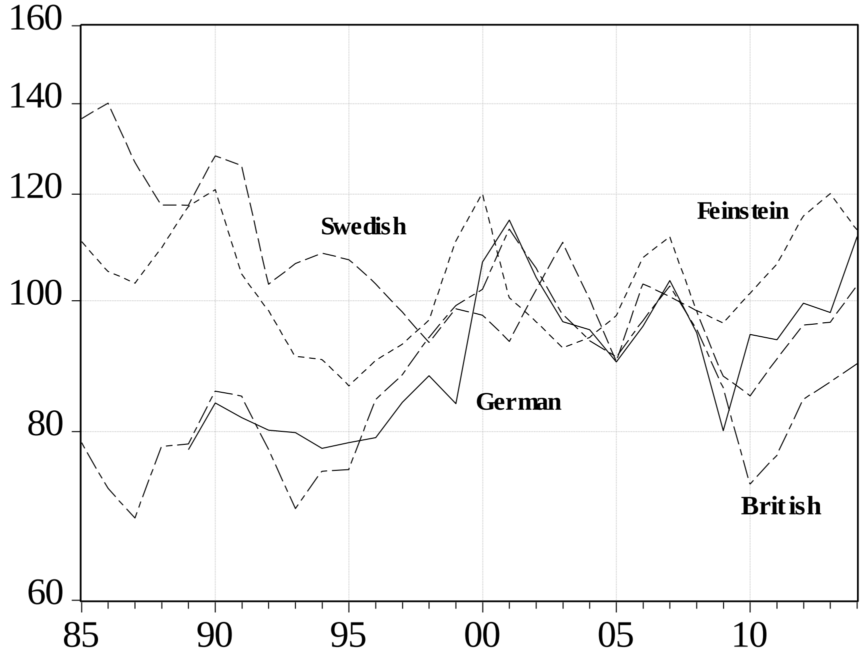
The price index for Swedish steamships is based on the records of three firms and is construed in a similar way as the British one. The index probably reflects the conditions on a market that first around the turn of the century became more integrated in the international market. This also explains the enduring decrease of Swedish ship prices, also in the decades before 1914 (see table 1).

However, another interpretation is also possible. As is seen in figure 2, the Swedish ship prices rather well matched British ship prices, as measured by Feinstein's index, from the 1860s or 1870s to the early 1900s. Seemingly, Sweden had already adapted to the international market. Probably, though, that interpretation is precipitous. Firstly, one could have doubts about the validity of Feinstein's index, as argued above. Secondly, Swedish yards were not competing with the British until about 1900, but largely produced for a segmented market. Thirdly, Swedish shipbuilders were in a process of both catch-up and market integration and the prices converged towards an international level. It is, thus, not surprising that Swedish ship prices fairly well followed production costs, as estimated by Feinstein, even if wages increased faster in Sweden than elsewhere.

In Germany, modern shipbuilding took off in the last quarter of the 19th century. Already at the turn of the century, it was stated that German yards could build fast liners cheaper than anyone, even if the British still were the most competitive on cargo steamers (Schwarz and von Halle, 1902, II:276ff). The present German index is construed, along the matching method, from the records of Blohm + Voss, a leading shipbuilder in Hamburg. Unfortunately, it has not been possible to start earlier than 1889, although already some years before large, ocean going ships were built at this yard. Even if contempory observers held the belief that all shipbuilding outside Britain was heavily subsidized before World War I, a survey at the turn of the century presented another picture. In Germany, the Netherlands, and Scandinavia, the principal subsidy was for post liners, but not for shipbuilding in general. And this was the case to no less extent in the United Kingdom. In France and Italy, however, subsidies for shipbuilding were substantial (Schwarz and von Halle, 1902, I:112 ff).

Figure 2a-b. Price indexes for steamships, top, 1850-1914, below, 1885-1914.





International level, 1901-07=100

Sources, see appendix; computation, see text.

Thus, the German steamship price index demonstrates that the leading German builders could match the British even if the industry had not the capacity to capture more than a marginal share of the market. From 1889 onwards, the British and German indexes follow suit for a couple of decades as can be seen in figure 2. All indexes have been put at the base of 1901-1907, and arguably this also reflects the common level.

It is a tricky task to assess the levels, because one must always doubt that it is identical ships which are compared. Table 3 reports, however, a conjectural effort. Fairplay's quotation of a single-deck steamer of about 7500 tons deadweight, "of a bare specification", is taken as the standard, in the column to the right. The other pre-war ships were built by Denny on the Clyde, Blohm + Voss in Hamburg, and one at Lindholmen in Gothenburg. Only for the Denny ships are measurements of both gross register, and deadweight tonnage, given.

An estimate is arrived to by comparing prices per ton for ships of similar type and size, and then estimating what that would translate to for a 7500 deadweight-tonner. It is assumed that the 7500 deadweight-tonner is of 4500 gross register tons. For the Swedish one of 1913, gross tonnage must be estimated, therefore the range of the price. All the estimated prices, including that from Denny, are in the range 13 to 55 per cent above Fairplay's quotation, but rather close to each other. It could be assumed that all the three countries hovered around a common level early in the century. The uncertainty, as well as the unstable nature of the ship prices, motivate a rather long base period. From 1910, German armaments with production of *Panzerschiffe* had gained momentum, which probably boosted the German level. 1901-1907, thus, seem a reasonable common base period while the British undercut the competitors the final years before World War I (figure 2b).

The Fairplay 7500-tonner

However, does not the discrepancy between the Fairplay 7500-tonner, and the other quotations indicate that something is fundamentally wrong in this comparison? Not necessarily. The error might be with the Fairplay quotation. This conjecture affords a digression into the interwar period.

In the bottom of table 3, prices of 1925 and 1926 are reported. Here the discrepancy with the Fairplay quotation has further widened. A German steamship has a price twice as high and a motorship two-and-a-half as high. Swedish motorships in 1925 and 1926 were priced about two thirds above the Fairplay quotation. Arguably, the Fairplay quotation was under-estimating the market for a seaworthy ship. A few years later this was also admitted by the journal. In a letter to Fairplay 1933, Mr A L Ayre, a British shipbuilder, criticised the journal's quotation, and emphasized: *"It can never be a sound method of comparing **values** of ships, however much it may be used by the lesser experienced to compare prices."* It was conceded, by the editor, that while the January quotation of 1933 was about £32,000, actually at the same time, the price offered for such a ship ranged between £62,350, for "very plain job", and £74,850, for "good specification." (ibid. p. 532)

If £62,350, 95 per cent higher than the Fairplay quotation, was the price for a "very plain job" in the depression year 1933, it is plausible that the quotation £60,000 in 1926 also was too low. Adjusting the Fairplay quotation in 1925 and 1926 with the 95 per cent differential, derived from 1933, it seems that the Swedish shipbuilder undercut the market while the German Blohm + Voss was on the level with its tender in 1925, for a cargo steamer of 7500 DWT, *nota bene*, of "einfacher Bauart." The same German ship, but fitted with diesel engines and electrical deck machinery, should add almost half a million (SEK) to the price - this difference between steam and combustion engines diminished in the decade to come. However, also in 1925 the Swedish shipyard Kockums delivered two 7500-tons, cargo motorships, one of which to Norway. And another three were ordered, in the same year, by Norwegian shippers, who certainly did not want to pay any affluence of the crew, and delivered in 1926. It could be added that Kockums, at the frontier of the expanding Scandinavian shipbuilding, made a loss of 400,000 crowns on each in 1925, and more than 200,000 each in 1926. Thus, it seems not unreasonable to assume that the international price for the "7500-tonner" in 1925-26 actually was two million SEK, and not one million, as quoted by Fairplay. Arguably, also for the years before World War I, my calculations on the basis of the shipbuilders' records come closer to an international price level than the Fairplay quotation.

Table 3. Prices of comparable ships in Britain, Germany, and Sweden

Estimated price, and the Fairplay quotation converted to Swedish crowns (thousands), according to exchange rates. "SS" means steamship, and "MS" motorship.

Year **Description**	**Price/GRT in nat'l currency**	**Estimated price in SEK for a "7500-tonner" (A)**	**(A)/(B)**	**Fairplay "7500-tonner" (B)**
1899 Fairplay				***949***
Britain, SS, 7965 DWT/5197 GRT	**£14.40**	**1,182**	**1.25**	
Germany, SS, -- /4801 GRT	**M267.65**	**1,072**	**1.13**	

1900				***995***
Britain, SS, 7965 DWT/5197 GRT	**£14.67**	**1,204**	**1.21**	
1901 Fairplay				***920***
Britain, SS, 7967 DWT/5150 GRT	**£17.40**	**1,423**	**1.55**	
Germany, SS, -- /4756 GRT	**M333.26**	**1,335**	**1.45**	
Germany, SS, -- /5873 GRT	**M275.84**	**1,105**	**1.20**	
1911 Fairplay				***797***
Germany, SS, -- /4897 GRT	**M250.15**	**1,002**	**1.26**	
1913				***946***
Sweden, SS, 6000 DWT/ --	**SEK252-265**	**1,163**	**1.23**	
1914 Fairplay				***922***
Germany, SS, -- /4499 GRT	**M315.40**	**1,263**	**1.37**	
1925 Fairplay				***1,003***
Fairplay, corrected		**1,954**	**1.95**	
Sweden, MS, 7500 DWT/ --		**1,631**	**1.63**	
Germany, SS, 7500 DWT/ --		**2,032**	**2.03**	
Germany, MS, 7500 DWT/ --		**2,469**	**2.46**	
1926 Fairplay				***1,040***
Fairplay, adjusted		**2,022**	**1.95**	
Sweden, MS, 7500 DWT/ --		**1,722**	**1.66**	

Sources: Fairplay, various editions; Lyon (1975); Blohm + Voss records; Kockums records.

British shipbuilders retained the major share of world output and were surpassed by the Japanese first in 1956. However, their leadership both as regards prices and technology was captured by Scandinavian builders, here represented by the Swedish yard Kockums, in the 1920s. While the British stuck to steam, Scandinavians were pioneers in diesel fuelled motorships and oiltankers which after World War II came to dominate shipping.

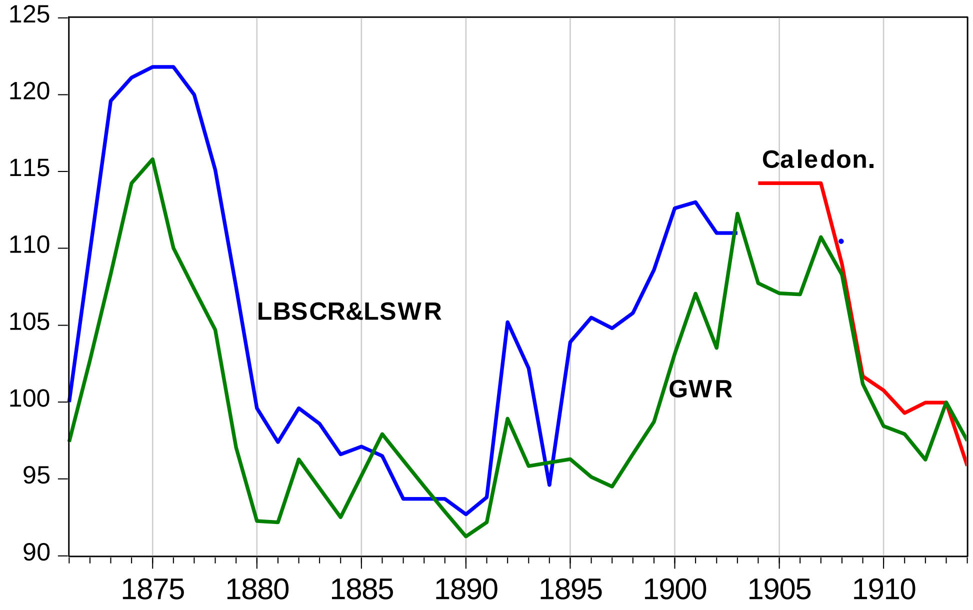
III. Prices of Locomotives

Railways were crucial for shaping of the modern society. This is unmistakable, either seen in their complementary context, for example with the backward linkages to iron and steel industry (Fremdling, 1977), or the forward linkages to transport and personal travel, or when taking account of their share of capital formation (Hoffmann, 1965, p. 143; Feinstein, 1988, appendix). Furthermore, they were an important lever for technological development, one case in point being steel, and another engineering. The evolution of locomotives bear witness on the latter. Locomotive prices should therefore be of interest, due both to their economic weight and to their technological content.

The price indexes for locomotives, presented here, are based on renewals records of railway companies, that is, transaction prices. Two basic problems encounter the construction of these series. First, how to ascertain that the series represent homogeneity over time; and, second, across countries?

Each index is built up by linking shorter series, usually with gaps for single years, and each of these shorter series should quote prices for the same, or almost the same, locomotive. The links ought to be over a sequel of years, since one crude observation will otherwise result in drift of the whole series. The German and Swedish sources supply basic technical specifications and each single locomotive can be identified with a high degree of certainty. The British sources are usually more sparse on this point, but disparate records end up with much the same result. This can be seen in figure 3, where the fluctuations match fairly well. However, there is a difference in the volatility between, on the one hand, the somewhat calmer behavior of Great Western Railway (GWR), and on the other hand, the larger swings of the two London-south railways (LBSCR and LSWR) and the Caledonian Railway. This might reflect differences market relations.

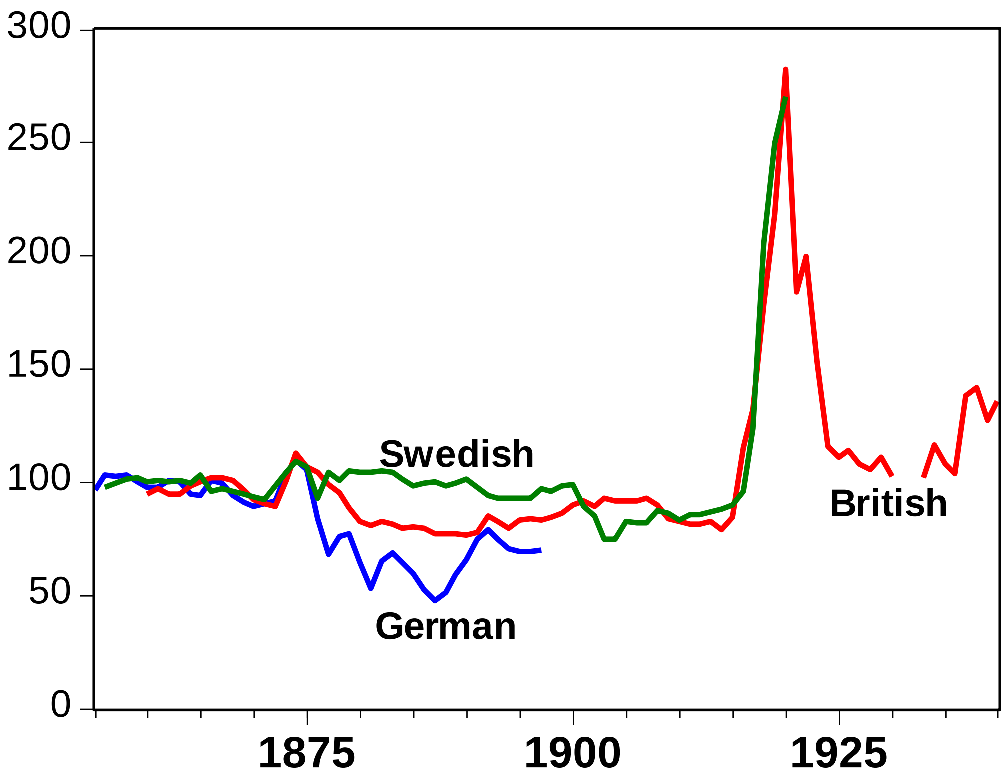
Figure 3. Estimates of British locomotive prices and costs, 1880-1914



Sources: See text. (1913=100)

Great Western acquired their locomotives from the company works at Swindon, the largest British locomotive manufacturer in the last quarter of the century and it is reasonable that the vertical integration moderated price fluctuations. The LBSCR&LSWR renewals are mixed between acquisitions from commercial producers and the company workshops while all Caledonian renewals were acquired on the market. One could notice that in the setback after 1907, the Caledonian Railway's open market prices were synchronised with those of the GWR. The existing differences might reflect market conditions as well as being artefactual since probably there is no such thing as the "right price". The British price index for locomotives (see below, figure 4), for the years 1880-1914, has been aggregated from the LBSCR&LSWR, the GWR, and the Caledonian series. For preceding years data are also derived from the North Eastern Railway, and after World War I sales from the North British Locomotive manufacturer (NBL) is the sole source (overlapping with Caledonian during the war).

Figure 4. Comparative price indices for locomotive (British level 1864-66=100)



Sources: See text. [to be specified]

In figure 4 price indexes for locomotives in Britain, Germany, and Sweden are presented. As striking as the similarity up to 1875, are the divergences thereafter. Are the differences due to fundamental bias, or did prices diverge? And how could the levels be assessed?

Table 4 gives some of the evidence of the levels, comparing prices for similar locomotives in the three countries. However, only in one case can it be assured that exactly the same locomotive has been compared, and that is the uncoupled passenger engine, acquired from Beyer and Peacock in Manchester to Sweden and Germany in the 1860s. Two countries bought from a third country, and an integrated market with equal prices was established but, as already mentioned, prices came soon to diverge, at least for some decades. The other pairwise comparisons in table 4 consider very similar and substitutable locomotives even if there might be some minor differences in the outfit.

The indexes are built on significantly more data than those shown for comparison in table 4. After 1875, Swedish locomotive prices stayed at a high level, the British fell by about a fifth and the German were temporaily down to a half in the late 1880s. Excluding yard engines from the German index would only slightly raise its figure in 1897 from 70 to 74, against the British of 83. It is likely

Table 4. Relative prices of locomotives in Britain, Germany, and Sweden

Description Year	S/G	S/GB	G/GB
Uncoupled passenger			
1863	101		
1864	105		
1866	96		
Three coupled goods			
1866	85	93	110
1867	94	94	101
1868			97
1870	108	103	95
1871	105	104	97
1872	114	112	98
1873	112	110	98
1874	102	92	90
1875	102	102	100
Three coupled goods			
1882, 1st semester			79
1883, ditto			80
1885, 2nd, and 1886, 1st semester			64
1893			96
1894, 2nd semester			87
Two coupled express			
1891			93
1894, 2nd semester			88
1896, (G: 2nd / GB: 1st semester)			98

Note: Relations based on prices for similar locomotives and exchange rates [sources to be specified]

that German locomotive prices fell relative British, and it seems reasonable to let both indexes average 100 for 1871-75. The choice of base year is defended by the abundance of observations for these years, and by the fact that several old models expired and new were introduced in the 1870s. A tentative explanation for the larger fall of the German prices is the difference in market structure, with more independent producers having a larger share of the market whereas in Britain many of the railway companies were at least partly supplied by their own works.[5]

Then, how could the extremely high level of Swedish locomotive prices during the last quarter of the century be explained, against the background of being at the "international level" in the third quarter? Just like for Germany, import of British locomotives were vital in the start. A special relationship was established between the Swedish State Railway (SJ) and Beyer and Peacock, and

[5] Unfortunately the German official statistics on railways stopped quoting the acquisition prices of locomotives after 1897. A continuation of the index based on archival records is planned.

already in the 1850s models developed by this firm were also manufactured by Swedish works (Klemming 1906). Perhaps independently, but just like the pattern of the great British companies, SJ established its own construction department, contracting production at Swedish works. From 1877 until the turn of the century, all renewals of the State railways were Swedish built and higher prices were accepted. Then a series of locomotives were bought from the USA and these were cheaper and also had a depressing impact on Swedish made locomotives. The decrease in Swedish locomotive prices matched a general fall in prices of several innovative Swedish engineering products in these years (Ljungberg, 1990). Figure 4 does not reject the presumtion that Swedish locomotive prices fell to the German level that presumably was below prices in Britain in the first decade of the new century. However, from 1908 to 1920 (when the Swedish index expires) Swedish prices fairly well matched the British but (so far) we do not know about the German.

Which are the implications of the indexes? A brief comparison with other price estimates is shown in table 5. Hoffmann's "Index der abgeleiteten Dampfmaschinenpreise" is partly based on price quotations for various machinery, such as steam engines in the beginning and later on electrical motors, partly computed as a function of iron and steel prices, and a trend. Starting the comparison in the 1850s would somewhat reduce the difference, as Hoffmann's index is booming higher in 1856 than in the mid70s. However, the main difference is due to the deeper fall in my index in the 1880s. Down to 1890, Hoffmann's index is close to the decline in iron prices, but in the following decades iron and steel prices increased while the machinery index decreased, yet at a slower rate.

Table 5. Trend of locomotive prices and of related machinery

Annual rate of change in percent.

Index	**1860-1890**	**1890-1914**
Machinery (Germany) (Hoffman 1965, p. 572f)	**-1.42**	**-0.48**
Present for German locomotives	**-2.37**	**-0.42 (1890-1897)**
Rolling stock and vehicles (Britain) (Feinstein 1988)	**-0.30**	**1.24**
Present for British locomotives	**-0.93**	**0.29**

The largest share of British investments in *rolling stock and vehicles* up to World War I was locomotives (see Feinstein, 1988, ch. 15). It is therefore relevant to compare the present index with the implicit deflator for these assets (computed from Feinstein 1988, appendix, Tables III and X; originally, its main component is, similar as for ships, constructed from input prices, wages, iron and wood, ibid. p. 313). The differences over the two periods are clearly significant, and they are mostly due to the 1860s and the ten years before 1914, while the years in between are rather similar.

In the present index, the more pronounced decrease over the period 1860-1890 is due to a higher level before the boom in the 1870s, than after. This seems also conceivable, given the technological progress manifest in frequent model changes in the 1870s, and given the stiff competition, both on the international market and between the older commercial locomotive builders and the new company works. Market conditions thus seems to have been different for locomotive manufacturers than in shipbuilding and productivity gains were, when taking account of quality change, passed on in lower prices.

IV. Prices for electrical motors

A third industry of great importance from the 1890s, is electrical engineering. Especially for Germany and Sweden this was the case, while in Britain this industry became somewhat outcrowded by the old industrial structure (Kennedy 1987). I this section earlier Swedish series (Ljungberg 1990) are compared to estimates for Britain and Germany. While the Swedish series were construed with the matching method by comparisons of certain models in price lists as well as acquisitions by the Kockums shipyard, the British and German series are hedonic price indexes. For Britain, these are based on the sales records of the Leeds firm Greenwood and Batley, specialized on machine tools (about this firm, see Floud 1976). Electrical motors and dynamos were manufactured already in the early 1880s, by Greenwood and Batley, but more frequent production began in 1894. The specifications in the sales records were important both for producers and customers, and are relevant for the calculation of a hedonic price. This is assumed to have been constant during the whole year, and a function between the technical variables and the price could be estimated for each year. The technical variables hence were assigned specific coefficients by a regression, and then a price for specified models could be simulated for all the years. The regression for each year had the form:

PRICE = CONSTANT + HP + SIZE + LOG(RPM)

HP is the effect in horsepowers; SIZE was an internal classification of Greenwood and Batley (though "Size" later became standardized as the height to the axle); and RPM, revolutions per minute, which are converted to logarithms. In a first regression a fitted price was estimated, and the difference between fitted and actual price (the residual) served the omitting of outliers. A probable origin to the occurrence of outliers are motors fitted with extras which have not been specified by the book keeper; or extreme voltage, that, unfortunately, only casually is reported in the sales book. Still there were, on average 53 observations left for each year, 1900-1921, considering the main type of direct current motors. The minimum number of observations was 18 in 1904 and in 1921. In the second regression the independent variables were designed a coefficient for each year. Finally, the specifications of a handful of motors were combined with the coefficients in equations, and the price series were computed. For continuous current motors the proceeding was similar, resulting in estimated prices 1904-1920, though with a gap in 1905. Observations were fewer than for direct current, on average 39 when the year 1905 is excluded, but only for three years less than 22.

While the British series could be based on transactions, actual market prices exclusive of discounts, the German series had to be based on list prices which tend to be more sticky. These price lists are from the Siemens central archive, ranging 1894-1907, with gaps but also with annotations about price changes up to December 1908. The AEG central archive has also provided price lists from the period 1912-1938.

Regressions of a similar type, though all variables logged, were applied on the German data. On the positive side, with price list data, is that outliers can be eliminated through the selection of the sample to certain categories. Hence coefficients could be determined in the first regression. Successive alterations in the specifications from year to year make, nevertheless, the hedonic method very useful. Furthermore, the hedonic method for British and German motors made also possible a comparison of price levels with Swedish motors, whose specifications in the years 1906-1907 were inserted into the respective simulation equations why these models served as the basis for the price comparison across countries and time.

The results are reported in table 6, and figure 5 illustrates the development, so far charted from the 1890s into the interwar period. A constraint on the comparison is that the British motors are not specified whether with "Schleifringsanker" or with "Kurzschlussanker." Both Swedish and German motors are of the former type, but as these were 10-20 percent more expensive than the latter, one may presume that the costly motors made by Greenwood and Batley also were of the "slip ringed" type. Swedish and German prices further consider open motors, and closed motors prevailed in the sales of Greenwood and Batley. An analysis of the AEG 1912 price list, show that open motors were

Table 6. Price levels of comparable electrical motors in Britain, Germany, and Sweden, 1906-1907.

Continuous current, open motors, *Schlefringsanker (slip ringed)*, including pulley.
Prices in Swedish crowns accordning to exchange rates.

	3 HP 1500 rpm	**7 HP 1200 rpm**	**10 HP 1000 rpm**	**20 HP 750 rpm**
1906				
Britain	638	679	790	1454
Germany	291	497	654	1073
Sweden	420	683	900	1325
1907				
Britain	669	726	815	1297
Germany	305	520	685	1124
Sweden	420	634	825	1300
Prices relative to Britain, 1906-1907				
Germany	46	72	83	80
Sweden	64	94	107	95

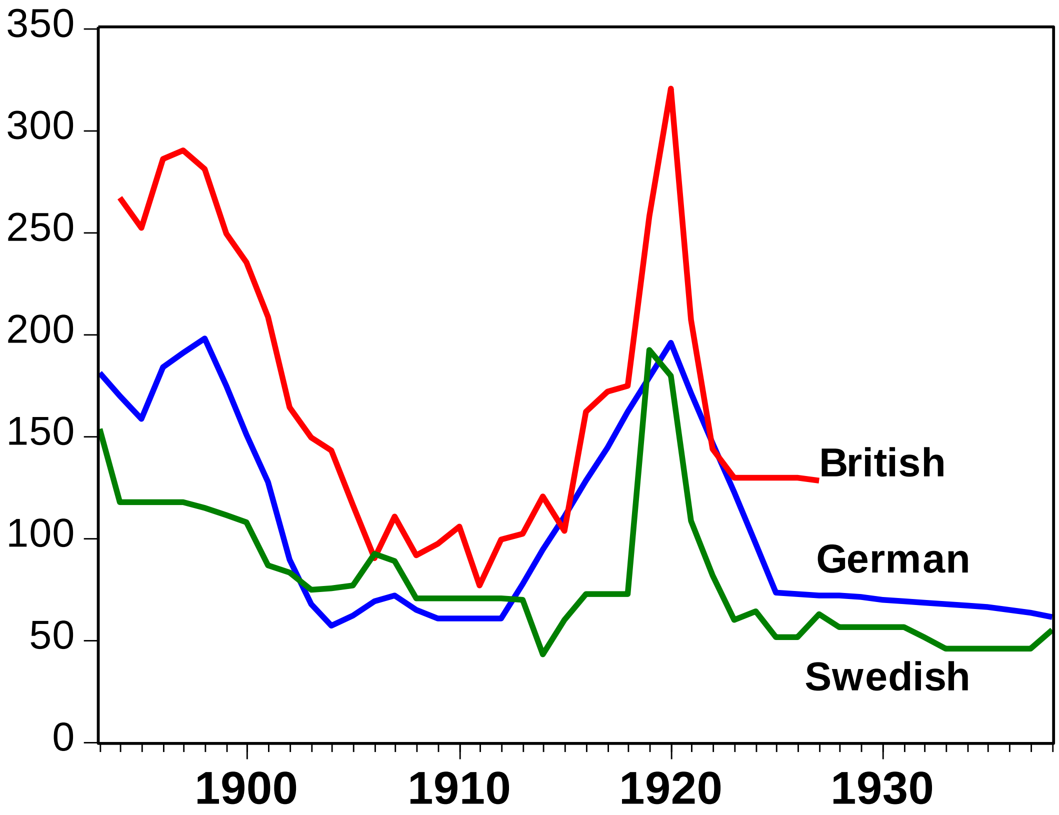
Note: Estimations, see text. Sources [to be specified]

on average 36 percent cheaper than corresponding closed types. As a correction for closed motors, the Greenwood and Batley prices therefore have been multiplied with 0.64 in the comparison.

On average for the four motors in 1906-1907, the relative price levels, with 100 for Britain, are 70 for Germany and 90 for Sweden. These price levels are used for the reference year in the indexes shown in figure 5. It should be observed, that there are frequent interpolations in the German series, the most critical being 1908-1912. Thereafter only bench-mark years are given for Germany, 1920, 1925, 1930, 1935, and 1938, why the years in between are interpolated.

It is obvious from figure 5, that price levels were not fixed to each other. Even if the comparison is based on simulated prices for identical motors, the hedonic functions reflect a specialization for each country or producer. The Greenwood and Batley motors were generally somewhat bigger than the German and Swedish, which probably contributed to but not satisfactorily explains the divergence. More important is probably that Greenwood and Batley still used a customized way of production while Sweden and, even more, Germany already had a standardized production. It should, however, be observed that the British series after 1920 is based on a different source than the sales records of the Leeds firm. It is an extrapolation with a contemporary price index provided

Figure 5. Comparative price indices of electrical motors, 1893-1938 (British 1906-07=100)



by the British Electrical and Allied Manufacturers' Association (BEAMA) for the years 1920-1927. The alternative interpretation is of course that the British level is exaggerated for all years and the curve should be shifted downward to the “international” German-Swedish level. Yet, the empirical data do not support such an interpretation and it seems more reasonable that the Greenwood and Batley prices were representative for a domestic market than local outliers in an integrated international market.

Furthermore, seemingly a striking difference develops from the 1910s between Swedish and German motors. Maybe, this is explained by a difference between prices for continuous current motors, in the Swedish sample, and for direct current, in the German. In Sweden, during the twenty years up to World War I, continuous current motors decreased 40 percent, while direct current motors decreased less than 15 percent (Ljungberg, 1990, p.320, footnote). Also in the German data motors for continuous current display a steeper fall than those for direct current but the former series only covers 1896-1909 so it is tricky to make any inferences. This uncertainty is underlined by the Greenwood and Batley series which do not show any diverging trends for the two kinds of electrical motors. What the present price data for electrical motors suggest is that the British lagged behind in competitiveness and that Germany was leading before WWI but might have been challenged by Sweden in the 1910s and 1920s.

VI. Concluding remarks

The price comparisons in this paper add som flesh to the story of British decline and European catch-up. While the early British industrialization that pulled workers out of agriculture long before the similar process developed in other countries created an advantage for catch-up by the latter, the mere existence of this advantage of backwardness does not tell how the catch-up came along. How could workers have been pulled from agriculture had there not been growing industries?

In shipbuilding Britain actually advanced and took leadership from the US after 1850, thus demonstrating the opposite to what happened in other branches of manufacturing. Continuous technological change took place and the British met growing competition even if its share of the world tonnage launched stayed above a half until after World War II, and with a growth in absolute terms British shipbuilders seemingly did not worry. Both German and Swedish shipbuilders could, however, compete in prices after the turn of the century 1900. Diesel engines replacing steam and the emergence of tank oil shipping moved the technological leadership in the interwar period to Scandinavian yards, and Swedish prices undercut both British and German. British yards continued to build steamships when motorships were advancing and the late nineteenth century technological advantage was lost. It is somewhat puzzling how the leadership slided out of hands of the British and that ship prices in the nineteenth century only declined moderately, far less than prices of iron and steel or productivity would predict. An explanation could be that the patriarchalistic welfare communities built up around British shipyards consumed a growing share of the value added and few if any yards could escape this situation.

In locomotive manufacturing Britain had leadership but lost this to Germany already in the 1870s. The leveling of prices between Britan, Germany and Sweden already in the 1860s was due to British deliveries and also direct transfer of know-how in the early development of the industry. However, in Sweden manufacturing of locomotives was in effect protected during the last quarter of the nineteenth century, which explains a high price level. In the early years of the new century Swedish locomotive prices again converged with British but it remains to research if this was also the case with the German. In lack of German price data after 1897 it cannot be settled if Britain regained its competitive leadership or if this was irrevocably lost in the 1870s. Anyway, the technology of steam had reached maturity and was to be replaced by electricity and combustion engines. In the latter case we saw it was lost in shipbuilding with emergence of diesel motorships. In the former case, competition in the field of electrical motors may give an indication.

In electrical engineering Britain, despite an early start, was left behind by both Germany and Sweden before World War I. Standardized mass production was the key to the forging ahead by German and Swedish industries. In Britain customized manufacturing of electrical motors survived and implied a higher price level. In both electrical engineering and shipbuilding competition was not only a question about offering the lowest prices but also about development of a more advanced technology and the creation of a corresponding market. In a longer perspective this was a necessary condition for catch-up.

References

R Albers, 1996, Manuscript

S N Broadberry 1997, *The Productivity Race. British Manufacturing in International Perspective, 1850-1990,* Cambridge: Cambridge University Press

S.N. Broadberry 1998, "'How Did the United States and Germany Overtake Britain? A Sectoral Analysis of Comparative Productivity Levels, 1870-1990', *Journal of Economic History,* 58: 375-407.

A Cairncross, 1953, *Home and Foreign Investment, 1870-1913. Studies in Capital Accumulation*, Cambridge.

R Craig, 1981, 'Willaim Gray & Company: A West Hartlepool Shipbuilder Enterprise, 1864-1913', in P L Cottrell and D H Aldcroft (eds.), *Shipping, Trade and Commerce*, Leicester.

Fairplay, 1933, "Shipping Values", *Annual Summary of British Shipping Finance*.

Fairplay, various issues.

C H Feinstein, 1988,'Sources and Methods of Estimation for Domestic Reproducible Fixed Assets, Stocks and Works in Progress, Overseas Assets, and Land,' in C H Feinstein and S Pollard (eds.), *Studies in Capital Formation in the United Kingdom, 1750-1920*, Oxford.

C H Feinstein, 1976, *Statistical Tables of National Income, Expenditure and Output of the U.K. 1855-1965*, Cambridge.

R Floud, 1976, *The Britisch Machine-Tool Industry, 1850-1914*, Cambridge.

R Fremdling, 1977, 'Railroads and German Economic Growth: A Leading Sector Analysis with a Comparison to the United States and Great Britain', *Journal of Economic History*, vol. XXXVII No 3.

W G Hoffmann, 1965, *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts*, Berlin.

W P Kennedy, 1987, *Industrial Structure, Capital Markets, and the Origins of British Economic Decline*, Cambridge: Cambridge University Press.

V Klemming, 1906, 'Lokomotivens utvecklingshistoria,' in, *Statens järnvägar 1856-1906*, part III, Stockholm.

I B Kravis and R E Lipsey, 1971, *Price Competitiveness in World Trade*, New York: NBER.

J Ljungberg, 1990, *Priser och marknadskrafter i Sverige 1885-1969. En prishistorisk studie*, Lund.

J Ljungberg 1991, 'Prices and Industrial Transformation', *Scandinavian Economic History Review*, vol. XXXIX No 2.

J Ljungberg, 1996, 'European Market Integration and the Behaviour of Prices, 1850-1914', *Lund Papers in Economic History*, No 54.

J Ljungberg, 2004, ”Earnings Differentials and Productivity in Sweden, 1890-1980.” in S. Heikkinen and J.L. van Zanden (eds), *Explorations in Economic Growth. Festschrift to Riitta Hjerppe*, Amsterdam: Aksant.

J Ljungberg and H Lobell 2012, ‘Prices as an indicator of innovation. A European comparison’, paper at the XVIth World Economic History Congress, 9-13 July 2012, Stellenbosch University, South Africa

J Ljungberg and L Schön 2013, ‘Domestic markets and international integration. Paths to industrialization in the Nordic countries’, *Scandinavian Economic History Review,* 61: 101-21.

J Lyon, 1975, *The Denny List,* vols. 1-4, Greenwich: National Maritime Museum.

K Maywald, 1956, 'The Construction Costs and the Value of the British Merchant Fleet, 1850-1938', *Scottish Journal of Political Economy*.

S Pollard and P Robertson, 1979, *The British Shipbuilding Industry, 1870-1914*, Cambridge, Mass.

K Rogoff, 1996, 'The Purchasing Power parity Puzzle', *Journal of Economic Literature* vol. XXXIV, June.

T Schwarz and E von Halle, 1902, *Die Sciffbauindustrie in Deutschland und im Auslande*, 2 parts, Berlin.

A Slaven, 1980, 'The Shipbuilding Industry', in R Church (ed.), *The Dynamics of of Victorian Business. Problems and Perspectives to the 1870s*, London.