ASPIRING TO A HIGHER RANK

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Swedish Factor Prices and Productivity in International Perspective 1860–1950

Svante Prado

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ABSTRACT

Aspiring to a Higher Rank: Swedish Factor Prices and Productivity in International Perspective, 1860–1950.

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This dissertation consists of four chapters which expand on the Swedish economic development in an international perspective between 1860 and 1950. The overarching theme is how the Swedish rise, from backwardness to prosperity, is best understood. Chapter 1 identifies two types of recent convergence literature which venture into explorations of the causes of convergence at disaggregated levels of GDP per capita. The first has measured convergence in terms of movements of land prices and real wages for unskilled workers, and stressed the significance of external forces, such as trade, mass migration and capital flows. The other has established comparative levels of labour productivity for different sectors of the economy, and shown that these levels in the manufacturing sector have remained stable in the long-run.

The introductory chapter is followed by two chapters which examine factor prices, while chapters 4 and 5 focus on productivity.

Chapter 2 shows that previous accounts of factor price convergence have overestimated the Swedish catch up because of their reliance on a flawed real wages series for unskilled workers. When a more representative wage series is used and compared to similar real wage series for the UK and the US, much of the alleged catch up slips away. Convergence did take place but at a slower pace than was previously claimed. The third chapter tempers the claim by the recent convergence literature that the Swedish wage-rental ratio increased steeply before World War I. By using a more representative series of land prices it is shown that the Swedish wage-rental ratio moved in a manner similar to other protectionist countries' wage-rental ratios, which fits well with the protectionist turn in Swedish trade policy in 1888. The chapter concludes that domestic growth forces overwhelm the importance of external factors and trade policy in understanding the evolution of the wage-rental ratio.

The fourth chapter establishes comparative levels of Swedish labour productivity in the manufacturing industry vis-à-vis the UK and the US and shows that Swedish convergence was manifest around the turn of the century and in the 1930s and 1940s. Thus, there is no sign of stability in the long-run evolution of relative productivity levels. As a follow up to this finding, the last chapter penetrates deeper into productivity patterns in the Swedish manufacturing industry. It shows that whereas the magnitudes of real cost reductions among industries were quite unevenly distributed until the turn of the century, a more uniform pattern began to assert itself in the decade preceding World War I. That invites efforts to search for common underlying stimuli, what economists and economic historians refer to as a general purpose technology (GPT). One that may have exercised an impact on productivity is electricity.

KEYWORDS: convergence, comparative productivity, TFP, factor prices, real wages, employment, land prices, industrialisation, GPT, GDP, economic growth, Swedish historical national accounts, manufacturing, labour productivity

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Finally, by no means do I wish to implicate any of the aforementioned names in case the reader of this doctoral thesis considers that its conclusions rest on a slender foundation. For what I have made of all the pieces of advice I alone am responsible.

Göteborg, September 2008
Svante Prado

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Chapter 1

Setting the Scene

Two Visions of Convergence

1.1. Introduction

Probing into the causes of the rise and long-term evolution of prosperity is to enter the heartland of economic history. It has been a recurrent theme in the historiography of economic history as well as closely related disciplines, at least since the founding father of economics, Adam Smith, laid the foundation for an inquiry into the nature and causes of the wealth of nations. Though the questions were posed long ago, the answers range widely as all the differentiating aspects of economic growth are being brought to the surface. This thesis reflects on some of the most salient features that figure in discussions of the rise of prosperity from a long-term historical perspective, for instance the measurement of the constituent components and proximate sources of economic growth. It is justified by an interest in forwarding our understanding of the Swedish case; from being a relatively backward country in the mid-nineteenth century – standing in the shadows of the forerunners of industrialisation and economic growth – to embarking on a growth process that would put it on an equal footing with most of the richest countries in the wake of Word War II. Doing so inevitably calls for efforts to improve the foundation on which our conjectures on Swedish economic development in an international perspective rest, implying that a great deal of this thesis is concerned with the establishment of quantitative evidence of relative performance. These efforts make it embody an important aspect of the economic history discipline – that improved understanding of the forces governing economic growth is a corollary of the establishment of reliable facts. The ability to advance our arguments is of little avail if the facts are missing or misleading. In Robert Fogel's opinion: 'the major obstacle to the resolution of [most of the issues in history and economics] … is the absence of data rather than the absence of analytical ingenuity or credible theories' (quoted from McCloskey 2000 p. 86). Furthermore, few would disagree with the view that to set Swedish economic development in relation to other countries is a sine qua non for challenging our long-held perceptions about the attributes of Swedish economic history. Yet it is rarely seen. This thesis takes this prerequisite at face value, by explicitly addressing issues of factor prices and productivity in Sweden vis-à-vis other countries in the latter half of nineteenth century and the first half of the twentieth. Two of the chapters judge Swedish performance against the background of the US and the UK. The UK makes a suitable reference point in being the forerunner of industrialisation and modern economic growth, as well as Sweden's most important trading partner in the nineteenth century, while the US, by superseding the UK as the leader in economic performance, and by receiving the great bulk of Swedish emigrants in the latter half of the nineteenth, serves perfectly as another reference point.

The attempt to counterpoint Swedish economic development against that of other countries' trajectories brings it into close affinity with the literature preoccupied with past experiences of convergence or divergence. This literature spawned in the 1990s after two seminal articles by Baumol (1986) and Abramovitz (1986), which confirmed empirically what Gerschenkron's (1962) historical narrative had hinted at, namely that relatively backward countries enjoyed gains from certain fundamental conditions arising directly from the initial – and continuing – differences in levels of output and productivity. On the other hand, countries which started on much higher levels of output and productivity could not expect to grow as rapidly as those starting behind. Something in what Feinstein (1991) aptly summed up as 'benefits of backwardness and costs of maturity' entailed great scope for catching up. Convergence was manifest among OECD-countries in the golden years, roughly coinciding with the 1950–1973 era (Baumol 1986; Baumol & Blackman 1989), but far less so in an expanded sample of countries and in other historical eras (De Long 1988). Thanks to the growing number of countries for which the Penn World Tables[1] and Angus Maddison (1991, 1995, 2003) provided estimates of long-term GDP, labour input and other macroeconomic indicators, a stream of literature has poured forth to further testify to the negative correlation between initial income levels and subsequent growth rates and identify the fundamental conditions from which the scope for catching up derived. However, most of the articles and books on convergence rarely venture beyond a study of the different growth rates of GDP per worker/man hour that the different countries achieved in a particular time period and in relation to their initial levels. Many salient features of the catching up process remained concealed owing to the high level of aggregation. Partly as a result of a dissatisfaction among some economic historians caused by the shortcomings of the previous convergence literature to come to grips with the fundamental conditions governing the catch up potential of a backward country, two strands of convergence literature emerged in the 1990s, representing different ways to dissolve the underlying components of GDP. They occupy central place in this thesis.

The point of departure of the first approach is the basic premise that the growth of GDP per worker is 'nothing more than a sum of per unit factor returns weighted by specific factor endowments per worker' (Williamson 1995b p. 142).

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[1] http://pwt.econ.upenn.edu/

Sorting out the growth rates for the different factors across countries makes possible a study of convergence or divergence in factor prices. Most of the inspiring work with a commitment to tracing and explaining the movement of factor prices world-wide from a long-term historical perspective is associated with Jeffrey G. Williamson and presented to a wider readership in the book *Globalization and History: the Evolution of a Nineteenth-Century Atlantic Economy*, co-authored with Kevin O'Rourke. Chapter 2 and 3 set the focus on his approach to convergence. The other approach, dealt with in chapter 4, tries to assess the relative productivity performance of different sectors of the economy; a disaggregation of GDP per worker/man hour. Stephen Broadberry is single-handedly responsible for bringing this approach to bear on a long-term convergence context, but the methodology on which his measures rely has a long pedigree (Rostas 1948, Paige & Bombach 1959). In his earlier works most attention was paid to the manufacturing industry, reflecting a long-standing tradition among social scientists to attribute to it a number of outstanding properties in the development process (Kaldor 1966, Cornwall 1977, Bairoch 1982). In later works more sectors have entered the picture (Broadberry 2002, 2006). Chapter 5 is the follow up to chapter 4, and penetrates deeper into productivity patterns in the Swedish manufacturing industry.

1.2. Factor prices

1.2.1. Wages

The story of globalisation and factor price convergence starts with the evidence of dramatic decline in transport cost owing to the application of steam and iron to railroads and ocean shipping and investment in transportation infrastructure in the latter half of the nineteenth century. This created opportunities for labour and goods to move more freely, in particular after the abolishment or at least tempering of many countries' tariff barriers and the removal of laws imposing severe restrictions on the movement of people. The idea behind factor price convergence draws inspiration from the Heckscher-Ohlin theory of international trade, which explains trade patterns across countries by the relative supply of different factors of production. Relative factor endowments govern comparative advantages; countries will specialise in the production of those goods requiring intensive use of the abundant factor, and import goods requiring intensive use of the scarce factor. Relative factor endowments also affect relative incomes. Countries with a short supply of labour and a plentiful supply of land have a large wage-rental ratio, while countries rich in labour and short of land have a small wage-rental ratio. Mass migration changes the relative magnitudes of labour to land ratios, which in turn affect the incomes accruing to labour and land owners. International trade leads to product price convergence, which generates factor price convergence, according to the theorem known as Stolper-Samuelsson.

The focus of chapter 2 is the movement of comparative real wages, one of the factor prices which represent cornerstones in globalisation and factor price convergence literature. Although comparing real wages instead of GDP per capital was nothing new, Williamson in his seminal article from 1995 was, to my knowledge, the first scholar to provide the arguments for substituting the real wages of unskilled workers for GDP per worker/man hour when addressing issues of convergence (Williamson 1995b). He skilfully and single-handedly put together a sample of real wages capturing 15 countries, adjusted for purchasing power parity in three benchmark years, and national series of real wages linked to the benchmarks and spanning the 1830–1990 era in its entirety. On the basis of this sample of real wages for unskilled workers, Williamson told a story of how mass migration, trade and capital flows caused a factor price equalisation in the pre-World War I Atlantic economy. The coefficient of variation for the sample of PPP-adjusted real wages declined, which pointed to an integration of the global labour markets. In addition, whereas previous studies had found little or no significant convergence in GDP per worker/man hour in the pre-World War I period, Williamson claimed that convergence in unskilled real wages had taken place. Mass migration from the Old to the New World caused real wages for unskilled workers in the land-scarce but labour-abundant Old World to catch up with real wages for unskilled workers in the land-abundant but labour-scarce New World. The real wage experience of the Old World was, however, far from uniform. Real wage levels in the large countries in Europe, France, Britain and Germany, did not approach American levels, but the countries on the northern fringe of Europe, Denmark, Sweden and Norway, along with Ireland, accounted for most of the narrowing gap between the Old and the New World.

The Swedish experience exercises an influence, which is larger than mere country size justifies, on the way in which the globalisation story unfolds. The Swedish real wage catch up was manifest according to Williamson's evidence. The US/Sweden ratio dropped from 410 to 157 between 1870 and 1914. If accurately depicted, this pointed to a previous unknown dimension of the growth of Swedish wages in an international perspective, for how could this massive contraction of the US/Sweden wage gap be reconciled with the US/Sweden GDP per capita ratio which remained essentially flat in the same period? Was Swedish mass migration, by draining the supply of labour relative to other factors of production, responsible? The answer is that Williamson's Swedish wage series for unskilled workers is fatally flawed; it does not represent an accurate account of the Swedish pre-World War I wage record for unskilled workers. Williamson's tenacious endeavour to compile comparable units of unskilled workers, based on the tenuous evidence of wages available in the pre-World War I era, forced him to rely on a tiny number of occupations. The lack of wage series for Swedish unskilled construction workers, the most commonly used reference of raw, unskilled labour, made it necessary to add Bagge *et al.*'s

(1933) various wage series for unskilled workers together to form an overall measure. Before 1887 though, unskilled iron workers alone accounted for the movement in Williamson's Swedish series. The steep acceleration of Swedish unskilled iron workers' wages explains the startling contraction of the US/Sweden real wage ratio in the 1870s. There is nothing to indicate the existence of a sharp twist in the movement of the skilled to unskilled wage ratio in the available evidence of Swedish skilled and unskilled wages. Instead, the evidence favours the notion that return to skill was time-invariant. Thus it should be inconsequential whether we use a wage series for unskilled, skilled or the average manufacturing worker to compare with the American and British. When a more encompassing wage series, a modified version of Bagge *et al.*'s (1933) average series for manufacturing, is compared to Williamson's American and British unskilled wage series, the marked reductions of the wage gaps in the 1870s slip away. The narrowing of the Swedish real wage gaps, in relation to the US and the UK, which did take place occurred above all from the mid-1890 on. In the US/Sweden comparison the evidence of convergence becomes even more attenuated if a wage series for manufacturing workers is substituted for Williamson's American unskilled wage series. In sum, the new and more representative wage comparisons in chapter 2 refute Williamson's evidence of a precipitous decline in the UK/Sweden and the US/Sweden real wage ratios. The claim that the wage gap collapsed was based on a misrepresentation of facts.

1.2.2. Land prices

Whereas the evolution of relative real wages was dealt with in Williamson (1995b), the price of land was the focal point in O'Rourke *et al.* (1996). The article documented land prices between 1870 and 1914 in some of the Old and New World countries for which Williamson previously had assessed the development of real wages, making it possible to explore the evolution of wage-rental ratios. The evidence of wage-rental ratios tended to confirm the idea of factor price equalisation as a result of globalisation forces. The wage-rental ratios of the countries in the Old World increased, while they declined, in fact precipitously, in the New World countries. According to the authors this indicated that, apart from factor price convergence, globalisation also brought changing fortunes for labour and landowners. The large inflow of labour to the New World made land a scarcer factor, which benefited land owners. As they already resided in the upper part of the income league, globalisation contributed to increase American inequality. In the Old World the supply of labour diminished, which led to an improved position for labour relative to landowners. Thus, globalisation there was a levelling force. So, the story of globalisation and factor price convergence was told.

The Old World sample was sub-divided into one group labelled protectionist and another group labelled free trade. The justification for the two labels was that some European countries tried to mitigate the negative impact that imports of cheap grain would have on the incomes of large land owners. This protectionist stance would lead to a slower increase of the wage-rental ratios than in the free trade countries where forces of globalisation were allowed to exert an unrestricted influence on relative factor prices. The Swedish wage-rental ratio increased as steeply as the wage-rental ratios in the other Old World countries with free trade labels. Sweden was therefore labelled free trade despite the compelling evidence showing that large farm owners rallied successfully for increased tariffs in 1888 to stem the flow of cheap grains from the New World (O'Rourke & Williamson 1999 p. 54). Chapter 3 documents an alternative and more representative series of Swedish land prices, which makes the wage-rental ratio move more in line with the other Old World, protectionist countries, thereby reconciling the contradictory evidence of the Swedish protectionist trade policy and O'Rourke *et al.*'s (1996) evidence of the evolution the Swedish wage-rental ratio. The Swedish terms of trade (agricultural prices/industrial prices) developed very favourably for farmers in the twenty years preceding World War I. This favourable development was due to the rapid price increase of animal products. Swedish farmers changed their output composition in favour of animal products at the expense of crop products, which boosted land prices. That explains the sluggish manner in which the wage-rental ratio increased.

Furthermore, the article subtly makes the point that the external forces, repeatedly stressed by Williamson and his co-authors, were overwhelmed by domestic growth forces,[2] for, a priori, we should expect the wage-rental ratio to increase in response to forces associated with sustainable economic growth. Both theory and history bear witness to the close link between economic growth and structural transformations on the one hand and the evolution of relative factor prices on the other. To appreciate fully the force with which industrialisation and accumulation of capital exercise an impact on the evolution of the wage-rental ratio, let us turn briefly to some stylized facts about the economic growth process.[3] What is known as income elasticity signals how the proportions in which consumers allocate their growing incomes to different categories of expenditure change as time goes by. Income elasticity for food is lower than for manufactured goods and services, and for farm products income elasticity is even lower than for food as processing and marketing add to the final value of food. As income elasticity for food is below unity, the growth of the farm sector lags behind the growth of GDP. This is called Engel's law and is

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2 Harley (2007) also argues that the lens through which Williamson's globalisation story is seen, the Heckscher-Ohlin trade theory and Stolper-Samuelsson theorem, is too narrow. Yet his argument is centred on the role of the frontiers in peripheral areas of the Atlantic economy. Globalisation is about the incorporation of these areas with respect to the creation of infrastructure, institutions and a number of additional historical and theoretical issues.

3 A more formal treatment of this subject is presented in Bohlin & Larsson (2006).

one of the most attested regularities in economics. Thus, the farm sector is bound to decrease, which distinguishes it from industry and service sectors. Apart from this distinguishing feature, the farm sector shares the following two characteristics with other economic activities: First, the expected rate of return on capital in agriculture, whether in the form of farm land, buildings or tractors, does not display any long-run trend (Kaldor 1961). Second, the growth of wages for agricultural workers, the most important cost item for farmers, tracks the growth of wages elsewhere. In addition, wages grow in parallel to GDP per man-hour, ignoring for a moment the intermittent changes in the income distribution between wages and profits, and the growth of GDP per man-hour does not fall short of the growth of GDP; at the very least it outstrips the growth of output in agriculture. With those fundamental conditions in mind we turn to the reality of the farmer. The yield of the rented land determines to a great extent the rental a tenant is prepared to pay a landowner. The larger the difference between the yield per land unit and the required rate of return, the more he is willing to pay in rent. The growth of yield per land unit is dependent on the growth of sales revenues minus the growth of costs. The growth of sales revenues per land unit is the sum of growth in prices and volume. Engel's law imposes a constraint on the growth of volume so what remains to make the growth of land rentals track the growth of wages is increased productivity and improved terms of trade. The long-term evidence suggests that neither of these two counteracting forces has been at work: the terms of trade (agriculture/industry) have moved up and down but have not shown any long-run tendency to increase, and productivity in agriculture has at least not outgrown productivity in industry. The upshot of it all is that the increase in the wage-rental ratio is a corollary of economic growth.

How come, then, Williamson and his co-authors have documented evidence of declining wage-rental ratios in the latter half of the nineteenth century, an era in which economic growth must have exerted a strong force on the way relative factor prices evolved? What prevented the wage-rental ratio from obeying the logic of economic growth? The answer rests with the historical, indeed unique, context. Before the middle of the nineteenth century, land was practically free or could be purchased at very low prices in areas like the US and Australia. In relation to the Old World the land to labour ratio was very high. A soaring number of immigrants in newly settled areas transformed into private holdings the land that previously had belonged to the indigenous population. Land was given a price. The land to labour ratio declined as the frontier drew to a close; and the final closing of it coincided with the transport revolution which made the world wide open to exports of agrarian products from the newly settled territories. The price of land rose rapidly from very low levels, and it is no wonder the wage-rental ratio declined. The persistent neglect of the fundamental importance of the vast disparities in levels of land prices between the Old and the New World, which were present in 1850, makes the late nineteenth century Atlantic economy look like the perfect illustration of how globalisation brought forth a factor price convergence; just like the Heckscher-Ohlin theory predicted.

In fact, the occurrence of this factor price equalisation merely illustrates the influence of historical contingencies. Domestic growth forces, which form the subject of the two remaining chapters, matter more.

1.3. Productivity

1.3.1. Comparative perspective

In a long list of influential articles Stephen Broadberry, either single-handedly or in joint efforts, has tried to study convergence at disaggregated levels of GDP. Although the methods on which his assessments rely can be traced back to Rostas (1948), he has applied them skilfully to an in-depth study of long-term convergence of comparative labour productivity at sector levels. He has demonstrated that GDP falls short as a measurement unit when probing into the causes of convergence or divergence in history. The point of departure is to attempt to estimate comparative levels of labour productivity for different industries and then to combine these into an overall benchmark for the manufacturing industry. This is called the industry of origin approach and aims to compare output levels by industry. The method has mostly been used to estimate relative productivity in manufacturing industries, but may well serve to estimate relative levels in other sectors. One way to establish comparable levels of labour productivity is to measure physical output per worker, for instance tons of cement per worker. This method has mostly been used in pre-World War II benchmarks because it requires homogenous and easily comparable goods and official statistics which report physical quantities to a greater extent. In post-World War II benchmarks the net value per worker method has been used instead. It transforms net output in each country's currency into a single unit of pay by so-called unit value ratios. Unit values are product values divided by physical quantities. The weighted unit value ratio represents a quasi exchange rate, comprising semi-finished products but omitting transport costs, distributive margins and imported products. To look at a longer sweep of history requires time series of labour productivity for each country, adjusted to the benchmark for one year. Any additional benchmarks control for consistency between benchmarks and time series projection.

An outstanding feature of Broadberry's and others' efforts to trace the movements of US/UK and Germany/UK comparative labour productivity ratios back to the mid-nineteenth century is the long-term stability of relative productivity in the manufacturing industry. For instance, in the US/UK comparison, the two-to-one gap in labour productivity had already been established in the mid-nineteenth century. Swings around this relative level occurred, especially during wars, but without a long-run tendency to alter the two-to-one American lead. In the aggregate, the US overtook the UK as the leading country at the end of the nineteenth century and raced ahead during the twentieth century. The evidence of stability in the comparative productivity ratio in manufacturing on the one hand, and catching up and falling behind in the aggregate on the other, calls into question the idea that the manufacturing industry holds the key to understanding convergence. Convergence in the aggregate comes about mainly through structural transformation whereby relatively backward countries raise average productivity by transferring labour from agriculture to industry and other modern sectors of the economy. An older literature, some of which was focussed on convergence, stressed the role played by the transfer of knowledge; late starters can borrow technological innovations in physical plant and machinery as well as best-practice procedures from advanced nations.[4] Although the transfer of knowledge embraces a wide array of economic and social practices and modes of operation applicable in sectors other than manufacturing, Broadberry's evidence nevertheless challenges the enduring importance the older literature attached to technological progress, capital accumulation and growth in dynamic manufacturing industries to explain convergence. In Broadberry (1997) he also provided some tentative indications of comparative evidence in other countries. Sweden along with Norway, Denmark the Netherlands and Germany form a sample labelled 'Northern Europe'. These countries' productivity levels relative to the UK show, first, that the level of labour productivity was quite close to the British at the beginning of the twentieth century and, second, that the ratios remained fairly unchanged during the twentieth century. The Swedish series stretched from 1913 to 1989 with a benchmark in 1935.

So how does Broadberry explain the stability of the productivity ratios in manufacturing? His framework to explain the unchanged US/UK productivity ratios in manufacturing throughout the nineteenth and twentieth century is centred on the role of initial technological choices, and the capital accumulation which follows once the use of a particular technology has been established. After a specific adaptation of a new technology has taken root that initial choice will have an enduring influence on the future path productivity follows. Thus, he appeals to the idea of path dependence to explain the persistence in comparative productivity levels over time. Countries adapt new technologies to fit country-specific circumstances, which implies that convergence will not take place unless countries imitate the most efficient technologies in the leading country without transforming them according to local circumstances. The initial choice of technological adaptation depends on factor endowments. The whole idea is firmly rooted in the long-standing debate about American versus British technology choices in response to different factor endowments. That makes the framework ambiguous in a wider country perspective. In addition, it is difficult

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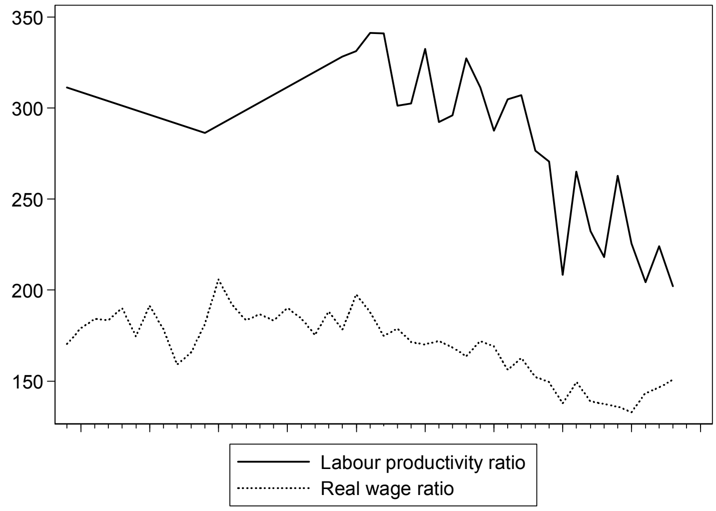
4 Gomulka 1971, Cornwall 1977, Nelson and Wright 1992 all emphasize the role of technology transfer in explaining catching up while Abramovitz (1986) and Feinstein (1991) include other factors as well.

GRAPH 1.1. The movement of UK/Sweden productivity and real wage ratios, 1869–1913 (Sweden=100)

Note: The series of labour productivity is interpolated during the First and Second World Wars.
Sources: Real wage ratios, see chapter 2, graph 2.9 (series titled *modified*); productivity ratios, see chapter 4, graph 4.1

to translate the idea of initial technology choice into palpable historical evidence. Therefore, chapter 4 keeps that part of Broadberry's convergence conjecture out of the account.

From a Swedish perspective there are at least two reasons as to why we should pay Broadberry's long-term productivity evidence due attention. First, his conjecture of stable productivity ratios in manufacturing is a challenge thrown down to the numerous minds of Swedish economic history that have accorded great importance to the many new and dynamic manufacturing industries that sprang up in the last decades of the nineteenth century and gathered further pace after the turn of the century. Did the perception of Swedish economic historians, that the manufacturing industry propelled the economy forward and laid the foundation for Swedish catching up with the core, lead us astray as to the true importance of manufacturing? Second, it does not take long to figure out that Broadberry's conjecture put into a Swedish late nineteenth century context is well-nigh impossible to reconcile with Williamson's real-wage picture, which showed that the UK/Sweden and the US/Sweden real wage ratios literally plummeted between 1870 and 1914. The great virtue of economics, and especially national accounts, is the firm restrictions imposed on our different measures; they all must add up in a consistent manner. If the Williamson and Broadberry pictures are true, a manifest reallocation of Swedish incomes, from



GRAPH 1.2. The movement of US/Sweden productivity and real wage ratios, 1869–1913 (Sweden=100)

Note: The series of labour productivity is interpolated in 1869–1879, 1879–1889 and during the First and Second World Wars.
Sources: Real wage ratios, see chapter 2, graph 2.8 (series titled *modified* adjusted to a benchmark in table 2.4 for all manufacturing industries based on wage data from Albert Rees); productivity ratios, see chapter 4, graph 4.2.

capital to labour, must have occurred because there is an intrinsic link between productivity growth in the manufacturing sector and the benefits accruing to workers and capitalists. Clearly, there is no evidence of a massive income reallocation in favour of labour. So, either one or both of the two pictures are in error. The second chapter documented that Williamson's Swedish real wage series for unskilled workers rested on a faulty foundation. The Swedish wage level did catch up with the British and American but at a much slower pace than Williamson's comparison made us inclined to believe. So what about comparative labour productivity ratios?

In chapter 4 an attempt is made to use the industry of origin approach, either the physical quantity per worker method or net value per worker method, to establish three successive benchmarks of US/Sweden and UK/Sweden comparative labour productivity, for 1909, 1924 and 1935. Time series of comparative labour productivity spanning the period between 1869 and 1950 are furthermore linked to the benchmark of 1924. The long-term evidence suggests that the growth of Swedish labour productivity relative to British and American was impressive. Before the Swedish catch up began in earnest around the turn of the century there was a two-to-one British lead. The first Swedish acceleration in 1900 reduced 80 per cent of the distance and the second in the 1930s wiped out the remaining gap, convergence was a fait accompli, and Sweden surged ahead of Britain. The US/Sweden comparison bears a striking resemblance to the timing and magnitude of the two episodes of Swedish catch up on Britain, but the remaining distance in 1950 stood at 150, reflecting American superiority. The investigation thereby puts flesh on the bare bones of the perception of Swedish economic historians that the manufacturing industry was the engine of growth, propelling convergence forward. In addition, it brings the evidence of pre-World War I movements of relative real wages and relative labour productivity together in a consistent manner, as graphs 1.1 and 1.2 make immediately apparent.[5]

Chapter 4 also underscores the importance of structural transformations to understand the course economy-wide convergence follows. The ratios of the GPD per capita series show that Sweden was catching up interruptedly on Britain but failed to narrow the American lead at the whole economy level. The answer rests with the initial level and evolution of sectoral shares of employment. Sweden and the US gained from an initial and sizable share of the labour force engaged in agriculture, a sector with low value added per worker, which testified to their delayed acceleration of economic growth in relation to the UK. The onset of sustainable growth reallocated labour from agriculture to industry and services, sectors with higher value added per worker, which raised the average level of value added per worker. The movement of these sectoral shares of employment completes the convergence picture chapter 4 intended to establish.

1.3.2. Yeast or mushrooms?

The results in chapters 2 and 3 thus downplay the significance of the external factors that Williamson with co-authors equates with the rising force of globalisation in the latter half of the nineteenth and beginning of the twentieth century. Instead, chapter 4 redirects our attention to the advances across a broad frontier within the Swedish manufacturing industry, which put Sweden on a path towards convergence in labour productivity and real wages in relation to the US and the UK. There is no need to appeal to the theorem of factor price equalisation and exhaust the short list of evidence of factor prices and factor proportions to uncover the factors responsible for catching up. We may, instead, come closer to laying bare the underlying factors if we attempt to gather consistent evidence of industry-specific data for output and input in the manufacturing sector. And that is what chapter 5 sets out to accomplish. The

5 There are uncertainties surrounding the American relative wage level, as well as the growth of wages after 1890, which makes it difficult to establish a robust comparison of wages in the US vs. wages elsewhere. If an alternative American wage series is used the Swedish wage convergence slips away altogether.

prerequisite for this enterprise, it hardly needs saying, is access to official statistics. Sweden represents a fortunate case in the sense that the Swedish Industrial Statistics appeared in the mid-nineteenth century and were published annually thereafter.[6] To put the appearance of the Swedish Industrial Statistics into context it suffices to mention that the Bristish Cenus of Production was published in 1907 for the first time and appeared every second year thereafter, and the US Census of Manufactures was first published in 1810 and appeared decennially until 1909. However, the Swedish Industrial Statistics suffer from a number of flaws that circumscribe their usefulness in exploring growth rates of output, labour input and productivity in the nineteenth century. Important areas of what we today consider manufacturing industries proper, such as sawmills, dairy and flour mills, were excluded. The guiding principle behind this exclusion was that economic activities closely related to the agriculture and forestry sectors did not belong to manufacturing. These activities accounted for a considerable share of the manufacturing industry and their omission leaves a deep impression in the Swedish Industrial Statistics until at least 1896. Yet, Jörberg's (1961) enquiry into the growth and fluctuations in the Swedish manufacturing industry rested on the notion that the coverage in the Swedish Industrial Statistics was, if faulty, at least representative. His authoritative affirmation of the usefulness of the Swedish Industrial Statistics justifies the recycling of it to address those issues that he, for lack of complementary information, left out of his account. The great supply of prices for final products that, thanks to Ljungberg (1990), is readily available, paves the way for exploration of productivity issues by industry.

Successive efforts to fill in the output gaps in the Swedish Industrial Statistics were made within the first and the fifth generations of the Swedish Historical National Account, where Lindahl *et al.* (1937) represent the first and Schön (1988) the second. They have managed to bridge many of the insufficiencies by drawing on alternative sources and using a series of ingenious assumptions. Their accomplished records have improved our knowledge about output growth for the industries that were ignored or insufficiently covered by the Swedish Industrial Statistics. However, we have scarcer evidence of the number of workers in these industries, which obstructs a straightforward enquiry into productivity growth rates for manufacturing as a whole. Jungenfelt (1966) was the first scholar who tried to match Lindahl *et al.*'s estimated output levels for excluded industries with employment, but Schön has since raised the output levels for excluded industries further. Chapter 5 therefore contains an endeavour to remedy the inconsistency between Schön's higher output levels for excluded industries and Jungenfelt's previous employment estimates, which related to Lindahl *et al.*'s lower level of output. The methodology used in chapter 5 to match employment and output draws inspiration from Verdoon's law, which

6 Bidrag till Sveriges officiella statistik. D. Fabriker och manufakturer.

establishes a positive relationship between growth of output and growth of productivity. Industry-specific elasticities are used to extrapolate backwards from the year in which a previously excluded industry entered into the Swedish Industrial Statistics. Both the trend and level of the new series of employment for the manufacturing industry are very similar to Jungenfelt's series, vindicating previous studies relying on either the trend or the level of Jungenfelt's employment series in conjunction with Schön's output series.

The classification of the numerous industries starts from the modern, post-1913 Swedish Industrial Statistics' allocation into 9 groups of industries based on the kinds of raw materials being processed, with the exclusion of the ninth group, public utilities, and handicraft production. Each group is then furthermore sub-divided so as to include 28 industries in 1868, a number which increases gradually to 41 industries after 1898. The large number of industries included in the sample calls for an analytical tool to bring order to a vast variety of growth experiences across industries and over time. Harberger (1998) proposed two distinct characteristics of the overall pattern of growth experiences formed by industries or by firms within an industry: Either the pattern is uneven and resembles mushrooms or it is even and resembles yeast. The mushroom metaphor is justified by the unpredictability with which mushrooms crop up in a field whereas the yeast metaphor draws on the evenness with which yeast cause bread to rise. Harberger showed some late (1970–1994) twentieth century evidence of total factor productivity (TFP) growth rates in American industries and Mexican firms. He concluded that the growth process resembled mushrooms rather than yeast. High rates of TFP growth were largely localised to a few industries, while the majority of industries and firms achieved modest growth rates and some even suffered from negative growth rates. Furthermore, there was no persistence in the rank of industries. Shortly after ascending to the peak of the growth rank table, industries descended to the bottom. Harberger also introduced the expression 'real cost reduction', which is defined as the extent to which output would have increased within a time period had the industry operated with the same quantity of material, capital and labour inputs as in the initial year. It distils the essence of what economic agents seek to accomplish, namely to reduce costs, be they labour, capital or intermediate consumption. These real cost reductions are additive over all industries, which brings the possibility of attributing to each industry its contribution to the total sum of real cost reductions undertaken in a specific timeframe. Ranking industries by TFP growth rates in descending order, along with each industry's value added in initial year's prices, the cumulative sums of real cost reductions show, somewhat surprisingly, perhaps, that sometimes less than 50 per cent of the industries (share of initial value added) accounted for the 100 per cent of real cost reductions. The contributions from the remaining industries enjoying real cost reductions were offset by those who were burdened with real cost increases. The share of industries adding to the 100 per cent cumulative sum of real cost reduction provides a measure of how unified the pattern of real cost reductions was between two points in time.

The endless squabble over the use and implication of TFP warrants a minor note on how a measure of TFP was attained. TFP indicates the efficiency with which capital and labour are used to produce final output and amounts to no more than the weighted sum of the growth of labour productivity and the growth of capital productivity, weighted by each factor's share of income. Its property is best understood through an accounting identity which shows how gross output in current prices can be dissolved into quantities of labour, capital and material inputs on the one hand and their respective remuneration, wages, return on capital and prices of input materials on the other. This duality has proved to be useful in historical studies because if there is a shortage of quantity data prices, which are usually in better supply, can be used instead. The result is what is frequently referred to as the dual approach to TFP and has served as an analytical tool for assessing productivity in both agriculture and manufacturing in several historical studies. However, whereas there is often sufficient information at hand on wages, prices of materials and prices of final goods, the returns to capital tend to escape our attempts to measure it, either because of scarce supply of historical observations or because our proxies suffer from logical inconsistency. The latter concerns most of all the use of the interest rate as a proxy for the returns to capital. It is quite time invariant and it is a foreign element introduced into an accounting identity. In chapter 5 I argue that the dual approach to TFP is inapplicable in the absence of information on the returns to capital. The only solution available is to return to the primal definition of TFP, that it equals the weighted sum of the growth of labour productivity and the growth of capital productivity, and furthermore assume away the impact of capital productivity on TFP, meaning that output and the capital stock grow in parallel. That turns the grand story of TFP into nothing but the growth of labour productivity times labour's share of income; a neat solution. Evidence in the manufacturing industry buttresses the assumed constancy of the output to capital ratio, but as we enter the realm of industry-specific trajectories we can no longer overlook the fact that the capital to output ratio was subjected to episodes of sharp increases or decreases, widening the possible margin of error for the estimated TFP growth rates by industry.

The investigated era is divided into five overlapping time periods which coincides with Jörberg's (1961) special investigations into the primary material underlying the Swedish Industrial Statistics in 1872, 1880, 1889, 1897, 1903, 1912.[7] It shows that prior to the last sub-period in 1903–1912, the growth patterns in each of the four preceding sub-periods were quite uneven. Less than

[7] The reason these years were chosen as start and end points in the sub-periods is that Jörberg (1961) compiled additional information from the primary material which can be used to further explore the determinants behind the productivity patterns in future works.

60 per cent of the industries (measured as share of initial value added) accounted for the 100 per cent of real cost reductions. The average TFP growth rates were rather moderate in these four sub-periods and most of the overachieving industries were quite small. In addition, there was a lack of persistence in the rank of industries according to their achieved TFP growth rates. The formal test, the Spearman rank correlation coefficient, failed to single out any sustained rank across time periods. The overall message conveyed by the empirical investigation into the pattern of real cost reductions before 1903 points squarely to a growth process which resembles mushrooms a lot more than yeast.

Still, in the last sub-period a tendency towards a more even growth pattern is discernible. The period coincides with the turning point in the manufacturing industry around the turn of the century, which shifted the growth rate of labour productivity upwards until 1912. Chapter 4 documented the fact that this period marked the beginning of the Swedish catching up in labour productivity in manufacturing with the US and the UK. A remarkably large share of the industries (94 per cent of initial value added, or 32 out of 39 industries) contributed to the 100 per cent of real cost reductions. The coefficient of variation, whether for TFP or real cost reductions, was roughly halved in relation to the previous sub-periods. A commonality of TFP growth rates prevailed.

The hunt for the determinants of our observations justifies the attempt to assign to the pattern of real cost reductions a label which aptly summarises the experience of a vast number of industries. If we gravitate towards the yeast label it is appropriate to think of a factor, let us imagine a technology with a great deal of spillover, which impinges significantly on a wide variety of manufacturing processes. One such example is the concept of general purpose technology (GPT). It is said to have great scope for improvement, broad externalities, many technological complementarities and eventually become widely used (Lipsey *et al*. 1998). The steam engine, electricity and information and communication technology have figured prominently in the economic history literature as examples of GPTs. Yet it is important to keep in mind the compelling evidence showing that the eventual realisation of a GPT's potential is a long-delayed and far from automatic process. Thus, we cannot expect to find a clear cut connection between growth patterns and a GPT in operation. What we perhaps can expect to find is an even growth pattern and a matured GPT. If, on the other hand, our observed productivity growth rates refuse to form a yeast-like pattern, it may be more apt to imagine cost reductions, as Harberger (p. 5) put it: 'stemming from 1001 different causes'. That vision is a challenge to the whole idea of modelling. It renders elusive the relentless quest for generic explanations to account for our historical evidence.

The pro-mushroom evidence in the manufacturing industry prior to the turn of the century questions whether a GPT was at work. The difficulty of coming up with generic explanations for the pattern of real cost reductions translates into a prerequisite to place each industry-specific trajectory firmly in the historical context, and to detail the state of knowledge under which each industry operated in order to account for all their idiosyncratic upturns and downturns over time. Simply put, evidence of mushroom-like patterns of real cost reductions cries out for more history.

On the other hand, the uniform pattern of real cost reductions, which began to manifest itself after the turn of the century, invites efforts to search for a specific underlying factor whose dynamic properties spill over into a wide array of manufacturing processes and continue to reverberate long after its infusion. The most likely GPT candidate in the years preceding World War I is electricity. Electrification of Swedish industry accelerated in the 1900s owing to the scarcity of domestic supply of fossil fuel, abundance of hydropower and energy-intensive industries; around the turn of the century roughly 10 per cent of all motive power was electrified and by the outbreak of World War I that share had increased to 50 per cent. Schön (2000a) believes that electricity was the new technology on which a new development block was created in the 1890s. Electricity was an infusion of new motive power into various manufacturing industries. In contrast to the steam engine, which mainly benefited large production units, a package of electricity-based industrial process innovations made possible the mechanisation of smaller production units as well. The foremost advocates of electricity as a GPT in the US in the interwar years, David and Wright (2005 p. 141), maintain that 'electrification saved fixed capital by eliminating heavy shafts and belting, a change that also allowed factory buildings themselves to be more lightly constructed'. In an earlier article David (1990) argued though that the transformation of industrial processes by electric power technology did not gain momentum until the period 1914 to 1917. Swedish evidence of a broad productivity surge after the turn of the century and rapid electrification is a possible nexus which deserves more attention in future works.

1.4. Conclusions

The identification of two recent and potentially fruitful ways to decompose the components of the movement of GPD per worker/man hours has inspired this investigation of Swedish economic development in an international context. The first is proposed by Jeffrey G. Williamson and his collaborators. With their globalisation tale they try to convince us that factors external to each country in the late nineteenth century Atlantic economy sufficed to dictate convergence by altering those relative factor proportions that have an immediate bearing on the rewards accruing to capitalists, labour and land owners. Still, any convincing story should be bolstered by compelling evidence. After all, it is the various country experiences in the Atlantic economy that form the plot in the globalisation story, and each of these affects, uniformly – the countries included in the sample are not weighted by size – the manner in which the story unfolds. My sceptical inquiry of the Swedish wage evidence of unskilled workers, which

Williamson uses, shows that the evidence is based on a biased sample of workers. It is a fallacy to claim, as he does, that the Swedish wage gaps vis-à-vis the US and the UK contrasted spectacularly between 1870 and 1913. For sure, wages in Sweden grew faster than in the UK, but only from around the turn of the century. Whether they also performed better than US wages depends on the choice of US wage series.

Chapter 3 on land prices and the Swedish wage-rental ratio likewise modifies the previous literature's claim that factor prices simply obeyed external factors. Instead, the chapter directs our attention to domestic growth forces. The evolution of land prices is governed by productivity in agriculture and the composition of animal and crop products. The new wage-rental ratio, which chapter 3 documents, increases more slowly than it was thought previously. Hence, the first part of the thesis casts doubt on the usefulness of studying convergence without bringing domestic growth forces into the picture.

The second way to decompose the components of the movement of GDP per capita/man hours, proposed by Stephen Broadberry, is to examine productivity by sectors. Chapter 4 takes into serious account his suggestion that relative productivity ratios in manufacturing may remain stable over time while economy-wide convergence is caused by structural transformation. The chapter compares the growth of Swedish labour productivity with that of the UK and the US between 1869 and 1950. Swedish convergence was manifest from around the turn of the century and in the 1930s. Hence, the Swedish manufacturing industry is the place to search for the convergence forces that caused real wages for Swedish workers, whether labelled skilled, unskilled or manufacturing, to outgrow the wages of British and American workers. The Swedish experience contrasts with Broadberry's previous evidence of long-term stability in the evolution of comparative US/UK productivity ratios in manufacturing. As in the globalisation story, Sweden, however peripheral and insignificant in terms of sheer size, was on a trajectory which makes our assessment and understanding of convergence more complete.

The final chapter takes a closer look at the Swedish manufacturing industry for the period 1868 to 1912. It assigns to the overall pattern of productivity growth rates in five sub-periods either the yeast or the mushroom label, depending on whether real cost reductions were uniformly distributed or scattered widely across industries and over time. The mushroom label summarises the nature of the growth process before the turn of the century, whereas the evenness with which industries underwent real cost reductions in the pre-World War I decade justifies the yeast label. The exploratory search for common stimuli, which may have caused the growth pattern to resemble yeast rather than mushrooms, concludes that electricity is a possible yet unproven candidate. The issue that remains is whether electrification was sufficiently established to impinge on the array of different manufacturing processes before World War I.

Chapter 2

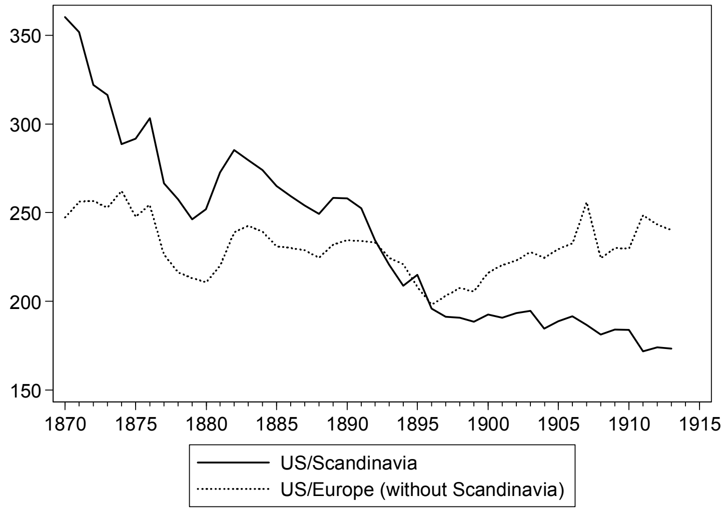
Fallacious Convergence?

Williamson's Real Wage Comparisons under Scrutiny

2.1. Introduction

A great deal of the economic history literature of the past twenty years has appealed to words like convergence and globalisation. Perhaps the unabated interest in our current era of globalisation has made history-oriented scholars more apt to turn to previous globalisation eras to throw light on contested issues. From the vantage point of the present it seems the appearance of Jeffrey G. Williamson's (1995b) article *The Evolution of Global Labour Markets since 1850: Background Evidence and Hypotheses* marked a turning point by providing input for new ways of thinking about converging and diverging forces in the Atlantic economy.[8] His was the first work to present real wage levels adjusted for purchasing power parities for a large sample of countries, making it possible to answer old questions and ask new ones about integration of international labour markets. Important evidence was provided by a decreasing coefficient of variation in the real wage sample as a whole, thus pointing to a general income convergence in the Atlantic economy. Thus convergence was not only a feature during the Golden years between 1950 and 1973 as previously was claimed. Another piece of evidence well worth our attention was the diminishing income gap between the Old and the New World; the labour-abundant Old World caught up with the labour-scarce New World with mass emigration serving as the prime mover of contraction. The US is the telling example of a New World country, with an unexploited frontier, a low labour to land ratio and high relative real wages. Declining transport costs, the advent of laisser-faire, and unexploited real wage gaps in the mid-nineteenth century created opportunities for European labour to seek out employment in the US and elsewhere in the New World. The mass migration that followed brought about a real wage convergence, as labour became a scarcer factor in Europe and a more

8 Williamson and his collaborators have elaborated the idea of factor price convergence in more than fifty articles (McInnis 2000). As late as in 2007, Williamson (2005) was the second most cited article in the economic history journals (Vaio and Weisdorf 2008).



GRAPH 2.1. American/European real wage ratios, 1870–1913

Sources: An augmented and revised data set, based on Williamson (1995b table A2.1) with some revisions made in O'Rourke and Williamson (1997).

abundant one in the US.[9] This story was aptly summarised in the book *Globalization and History* (O'Rourke and Williamson 1999).

Although most of the articles and books that retold and refined this story approached the Atlantic economy as a whole, it is in fact the Scandinavian countries which account for most of the real wage convergence found in the sample (graph 2.1). The grand globalisation tale of the late nineteenth century progresses without the core – France, Germany and Britain.[10] It is therefore a matter of some weight to take a look at Sweden, the largest country in Scandinavia, the region which propelled the Old World's wage levels towards the New.[11] In addition to the evidence of the extraordinary Swedish wage catch up with the US and the UK which has an impact on the manner in which the globalisation tale unfolds, the idea of factor price convergence, as caused by

9 Williamson (1995b) changed the focus of concern from domestic factors along the lines of Gerschenkron (1962), Abramovitz (1986), and Baumol (1986) that had imbued writings up to then to external ones, such as trade and migration. He also substituted real wages and other factor prices for GDP records, capital accumulation, and structural transformation as a performance measure.

10 Scandinavia's outstanding achievement was therefore subject to further elaboration in O'Rourke and Williamson (1995a, 1995b) and the rest of the periphery was dealt with in O'Rourke and Williamson (1997).

11 Ljungberg (1996) contains the only critical discussion of O'Rourke and Williamson's two articles (1995a, 1995b) which addressed explicitly Scandinavia's role in the globalisation tale.

external globalisation forces, has also crept into the language of Swedish economic history. In fact, it holds a prominent position in the most influential book on the economic history of Sweden, Schön (2000b p. 225), who used Williamson (1995b) real wage series in illustration of the thesis that Swedish mass emigration to the US drove a wedge into the development of wages and GDP per capita in 1870-1910. The growth of wages outstripped the growth of GDP per capita.[12]

The chapter discusses the way levels and movements of Swedish wages have been compared to the US and the UK. This is done by considering all the steps in the construction of wage comparisons over time: first, estimating relative price levels of consumables, so-called purchasing power parities (PPP); second, establishing comparable levels of real wages for a benchmark year; and third, linking time series of real wages to the benchmark to cover a longer sweep of history. This chapter shows that the second and third steps are crucial. Our perception of wage gaps depends on the choice of workers underlying the benchmarks. The use of construction workers, especially skilled ones, gives the impression of wide pay distances between American and European workers. Wage benchmarks based on manufacturing workers tend to narrow these distances. Furthermore, the chapter documents the fact that the unskilled wage series used for Sweden is unrepresentative and does not constitute an accurate account of Swedish real wage experience for unskilled workers. Swedish real wage growth has been significantly overestimated, which in turn has caused an upward bias as to the magnitude of convergence taking place between the Old and the New World. The deceptive picture of wage convergence painted by Williamson stems from his reliance on a flawed Swedish wage series for so-called urban unskilled workers. The use of wage series for unskilled workers turns on the searchlight on the movement of skilled to unskilled pay ratios. The issue at stake is whether it is justifiable to use a wage series for unskilled workers behaving differently from more inclusive wage series. The chapter modifies the Swedish wage series which implies that much of the alleged narrowing of the wage gaps between the US and the UK and Sweden slips away. It also brings forth a complete new comparison, based on wage series for manufacturing workers.

2.2. Real wage benchmarks

Williamson (1995b) deals with the years 1830 to 1988 divided into three sub-periods: before World War I (1830–1913); the interwar-years (1914–45); and the

[12] The idea is further detailed and elaborated in Schön (2006). See also Herlitz (2002) for a discussion of the impact of O’Rourke and Williamson’s globalisation story on Schön’s interpretation of Sweden.

post World War II-era (1946–88).[13] Each sub-period contains a benchmark year that establishes the real wage levels in relation to the UK for all the countries in the sample. The sub-periods are covered by national real wage series linked to respective benchmarks. The appendix contains the data sources and methods. The first part of it consists of national series for real wages for all countries; the second establishes real wage benchmarks for each sub-period; and the third links the national wage series with the respective benchmarks. The exception is the UK series that are left unaltered, set equal to 100 in each benchmark year. Thus all series are expressed in relation to the UK allowing for cross-country comparisons. The method partly avoids the problems inherent in historical comparisons of GDP provided by Bairoch (1976), first, and Maddison (1982, 2003), later, whose series only in practice – not in theory – admit comparisons far off the reference point (Prados de la Escosura 2000; Ward and Devereux 2003). A quick glance at a country's relative standing in 1835 in Williamson's data set is thus a real wage ratio 70 years off the reference point (the benchmark year of the first sub-period is 1905), which is to be compared with what Maddison offers in terms of a GDP ratio 165 years away from its benchmark.

2.2.1. New Purchasing Power Parities

Williamson uses PPPs to transform different currencies into pounds. The basket of goods consists of food items and housing (rent). His large sample of countries allows an upper limit of 13 in terms of the number of items included in the household budget. The food items and rent are weighed by their relative importance in a typical household budget, and the weights are average budget shares for the USA, the UK, Sweden, Germany, France, Belgium, and Italy. The average budget weights represent a pattern of consumption for a typical urban consumer living in a quite affluent society at the beginning of the twentieth century. They are probably not representative of less affluent countries such as Brazil, Spain and Portugal. What we have learned from the extensive literature on international comparisons is that using exchange rates for converting different currencies into a single unit of pay inevitably overestimates income gaps between rich and poor countries (Heston and Summers 1980; Hansson 1988, 1991). American levels of output per worker in the manufacturing sector appear to have been twice as high as British wages, indicating a potential for high relative wages in the US (Broadberry 1994). Most of the manufacturing sector in the US was exposed to the world market in providing tradable goods. Rapid growth rates of wages followed in traded-goods industries but workers' mobility between sectors also led to rising wages in non-traded-goods industries

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13 Since the publication of Williamson (1995b) the data set has been revised twice. The correct British series is set out in Williamson (1995a). In O'Rourke and Williamson (1997) further revisions include Portugal, Spain, Norway and the Netherlands.

and service sectors, which entailed higher prices there. The known and certain fact of high wage levels in the US should lead us to suspect that the higher prices in sectors other than those oriented towards the world market raised the cost-of-living in the US relative to other countries. Thus US/Sweden wage ratios calculated by PPP should come out more favourably for Swedish workers than ratios calculated by official exchange rate. The mismatching of sample years in Williamson (1995b) obstructs, however, a straightforward interpretation of estimated price relations. Data used for establishing the Swedish and Argentinean PPPs refer to 1914, for the US 1909 and for all the other countries 1905. To establish new PPPs we simply change the sample year from 1914 to 1909 and 1905 to render the prices of consumables directly comparable with the US and UK respectively. Ljungberg (1990), complemented by Myrdal (1933) provides prices for the same products as in the Board of Trade[14] in the UK (1908) and in the US (1911), the same sources as used by Williamson. The Swedish prices refer to country averages, as the prices in Board of Trade. I have used Fisher ideal indices to establish PPPs for each binary country comparison, as in formula (2.1), where p_i^* represents prices of good i in Sweden and p_i prices of good i in the US or the UK, and θ_i^* is Swedish expenditure weights and θ_i British or American.

$$\text{Purchasing Power Parity} = \left[\left(\sum_{i=1}^{n} \theta_i^* \left(p_i^* / p_i \right) \right) \left(\sum_{i=1}^{n} \theta_i \left(p_i^* / p_i \right) \right) \right]^{1/2} \qquad (2.1)$$

The estimated PPP:s and the official exchange rates in table 2.1 confirm what has just been outlined on expected incongruities between PPP and exchange rate. The official exchange rate is 38 per cent higher than the average Swedish/US price relation of typical consumer goods, and the corresponding disparity for Sweden/UK ratios is 10. Thus, it sets in relief high relative cost-of-living in the US, an important factor to reckon with when establishing international wage relatives.

[14] Report of an inquiry by the Board of Trade into Working Class Rents, Housing and Retail Prices together with the rates of wages in certain occupations in the principal industrial towns of the United Kingdom and United States of America.

TABLE 2.1. Estimated PPP:s for Sweden/UK 1905 and Sweden/US 1909

	Budget weights			Price ratios	
	Sweden	UK	US	kr per pound	kr per dollar
Tea and coffee	0.04	0.07	0.07	6.28	1.48
Sugar	0.08	0.06	0.05	33.91	4.87
Bacon and sausage	0.04	0.06	0.05	14.23	2.72
Beef and veal	0.06	0.18	0.20	11.37	2.98
Pork	0.04	0.02	0.06	12.94	3.45
Lamb and mutton	0.00	0.06	0.04	12.55	3.34
Cheese	0.03	0.03	0.02	21.17	3.12
Butter and margarine	0.19	0.13	0.11	12.53	2.13
Potatoes	0.04	0.06	0.07	14.32	1.27
Flour and meal	0.09	0.06	0.08	16.33	2.78
Bread	0.13	0.14	0.08	22.95	2.39
Milk	0.20	0.08	0.09	9.19	1.67
Egg	0.06	0.06	0.09	13.80	2.72
Total food	0.75	0.80	0.73		
Rent per three room	0.26	0.20	0.27	20.35	3.13
PPP				16.47	2.71
Official exchange rate				18.18	3.74
Ratio of exchange rate to PPP				110	138

Note: The budget weights do not sum to unity because of round figures.
Sources: Budget weights from Williamson (1995b, table A3.2). British and American prices of consumables from Williamson (1995b, table A3.1) and Swedish from Ljungberg (1990) and Myrdal (1933). Rent from Williamson (1995b, table A3.1).

2.2.2. Workers underlying Williamson's real wage benchmarks

The workers underlying the wage benchmarks in Williamson (1995b) are so-called unskilled and skilled urban workers, classified in accordance with a standard outlined by the Board of Trade (1908, 1911). They belong to building and engineering. This approach follows a long tradition of comparing wages of artisans or construction workers (Phelps Brown and Hopkins 1956; Allen 2001). A paucity of data for workers belonging to sectors other than construction may justify this choice; otherwise, a more inclusive measure is preferable. Referring to construction workers only will imply a strong US wage level bias as the construction workers there appear to have had the advantage of being very well-paid in relation to their European peers. The selection of this narrow definition of workers has overestimated the wage distance between Europe and the US (Shergold 1982). Extremely high wages were paid to a skilled minority of American workers but more modest wages to the unskilled majority (Allen 1994). In fact unskilled US workers did not do any better than the British until

TABLE 2.2. Correspondence between Board of Trade's sample of skilled construction workers in the US and the UK and the sample of municipal workers in Sweden

American and British sample	Swedish sample
Bricklayers	
Masons	
Carpenters	X
Stonemasons	
Joiners	
Cabinet makers	
Plumbers	X
Plasterers	
Iron workers	
Stucco workers	
Painters	
Blacksmith	X
Pipe layers	X
Pavers	X
Blasters	

Sources: For the US: Board of Trade (1911); for the UK: Board of Trade (1908); and for Sweden: Kommunalarbetarnas löner i Sverige 1865–1930.

the years ensuing 1906 (Phelps Brown 1977).[15] A further argument against the use of construction workers is that they produced mostly for local markets in which unionisation prevailed and competition was restricted. Firms operating within the manufacturing industry were more likely to meet stiff competition from abroad, which set apart their workers' wage conditions from the rest of the economy.

For Sweden Williamson matches the Board of Trade's (1908, 1911) sample of wages for American and British skilled and unskilled construction workers with that of Bagge *et al.*'s (1935) for Swedish skilled and unskilled municipal workers.[16] Swedish municipal workers belonged mostly to the construction sector at this time, yet table 2.2, which compares the Swedish and British/American sample of workers labelled skilled, indicates a worrisome lack of correspondence; in sum, like has not been compared with like.[17] The discrepancy between the samples of skilled workers will not matter a great deal if wages for different occupations in the building trade were uniformly

15 In the US, skills of the kind represented by engineering and building workers were probably in short supply, while in Scandinavia a great many (landless) people had gained knowledge of handicraft production because of the short season for traditional agricultural works (Gadd 2005).

16 Bagge's *et al.* (1935) summary statistics of wages for municipal workers comes from a special investigation published two years earlier (Kommunalarbetarnas löner i Sverige 1865–1930).

17 Lack of details in the Swedish investigation prevents a similar comparison of unskilled workers.

TABLE 2.3. UK/Sweden real wage ratios, 1905

		Feinstein	Board of Trade
Textile	hourly	149	
Mining	hourly	142	
Engineering	hourly	94	
Weighted average	hourly	118	
Manufacturing, annual	annual	92	
Agriculture	weekly	104	
Building	hourly	109	
Building, skilled	hourly		116
Building, unskilled	hourly		101
Williamson	weekly		114

Sources: the UK: Feinstein (1990, 1995), Board of Trade (1908); Sweden: Bagge *et al*. (1933, 1935).

distributed. If that is the case it would make Swedish municipal workers a reasonable proxy for construction workers to be compared to the Board of Trade's sample. Be that as it may, a more serious problem with Williamson's comparison is his use of weekly average earnings instead of hourly. Average working hours per week for municipal workers were around 59 in Sweden in 1909 (Bagge *et al*. 1935 p. 15), while weekly working hours were 47 in the US (Board of Trade 1911 p. xix). The US construction workers happened to belong to the lucky ones who enjoyed a less strenuous workday around the first decade of the twentieth century (Shergold 1982), while in Sweden municipal workers toiled as many hours as the average Swedish worker (Arbetsstatistik 1911). Adjusting Williamson's estimated US/Sweden wage gap (building workers) for working hours expands it from 179 to 245.[18]

2.2.3. New real wage benchmarks for manufacturing workers

Wage ratios for workers in sectors other than agriculture will probably show a somewhat different picture of wage distances between workers in the three countries. Wage ratios differ widely by industries, however, which poses a potential problem for establishing wage benchmarks. Tables 2.3 and 2.4 show the wide ranges among the wage ratios. The UK/Sweden ratios range from 94 for engineering to 149 for textile, and the US/Sweden ratios from 128 for saw mills to 304 for skilled workers in building. What does the true picture look like? Let us instead try to establish a benchmark based on manufacturing workers.

[18] The average of skilled and unskilled building workers from Board of Trade's (1911) sample is 245.

TABLE 2.4. US/Sweden wage ratios, 1909

		Douglas	Rees	Board of Trade
Textile	hourly	149	135	
Mining	hourly	175		
Metal	yearly	203	182	
Saw mills	hourly	128		
Food	yearly	153		
Wood pulp	yearly	147	121	
All manufacturing industries	hourly	184	136	
Agriculture	weekly	156		
Building	hourly	278		
Building, skilled	hourly			276
Building, unskilled	hourly			214
Williamson	weekly			179

Sources: the US: Douglas (1930), Rees (1961) and Board of Trade (1911); Sweden: Bagge *et al.* (1933, 1935).

Within the context of his historical national accounts, Feinstein has refined existing evidence of British nominal and real wages in a number of important works. In Feinstein (1995) he reported British average weekly earnings for workers in engineering, mining and textile. If we weight these industries by their shares of employment in 1911, based on information from Feinstein (1990), we can establish a reasonable measure of weekly average earnings in manufacturing. These weekly earnings need to be converted to average hourly earnings to make them comparable to Swedish measures. Bienefeld (1972) provides the denominator by reporting weekly working hours for the different industries. British working hours were on average 53.3 in the manufacturing sector.

Turning to Swedish wage data, we still rely on the Bagge *et al.* (1933) documentation of average hourly earnings for manufacturing workers as a whole and a number of separate industries. However, the way these wages were constructed requires a minor digression in order to justify a slight modification of their wage levels. As no official wage statistics existed before 1913, information on wages was attained from archival sources. The authors tracked the movement of wages for a sample of representative workers. That method is sometimes called kinetic since it records the movement of wages better than it establishes the average wage level of all workers in a particular industry. The authors used cross-sections to compare wage levels of the selected workers with the average level of all workers in a particular concern. These cross-sections were made for 1865, 1885 and 1905 and it was found that in most cases the wage level of the selected workers was on average five per cent higher than the average of all workers. Accordingly, we have lowered the hourly earnings as reported by Bagge *et al.* (1933) by five per cent. The UK/Sweden wage benchmark for manufacturing based on hourly earnings then becomes 119. That is very close to the benchmark of 114 which Williamson drew on, although it seems a mere coincidence that his benchmark tallies so well with ours since his was based on weekly earnings for construction workers and ours on hourly earnings in manufacturing.

For the US/Swedish comparison, matters are a bit trickier. Douglas (1930) and Rees (1961) present two completely different pictures of average wage levels for the US manufacturing sector. By using different samples they arrive at very different results.[19] Using Douglas data for the manufacturing sector as a whole gives a US/Sweden benchmark of 184, but after exchanging Rees for Douglas the gap narrows to no more than 136! Rees claims that Douglas' wage levels are too high because of his reliance on union rates. It is worth reiterating Rees' argument against union rates as a measure of labours' actual rewards. Firstly, union rates tend to be more stable through time than earnings actually received by union members, and secondly, and for the present context most importantly, as the lion's share of workers were not unionized, levels of union rates were too high.[20] Rees persuasively demonstrates how Douglas' reliance on union rates raised the estimated wage levels above factual levels. Other indirect evidence further reinforces the impression that the lower US/Sweden wage ratio for manufacturing workers holds. The thorough investigations undertaken by Shergold (1982) and Phelps Brown and Browne (1968) show that at the beginning of the twentieth century the majority of US workers enjoyed a real income lead by no more than around twenty per cent in relation to the British. If we further assume a safe ground for the UK/Sweden comparison, which showed a less than twenty per cent British advantage, Douglas' wage levels seem implausibly high. In Rees' estimate the pieces of wage evidence are brought together in a consistent manner.

However, comparative levels of labour productivity in the manufacturing sector may provide additional evidence used to discriminate between the two possible US/Sweden wage relatives. Chapter 4 provides estimates of comparative levels of labour productivity for Sweden, the UK and the US. The US/Sweden productivity benchmark for 1905 was 252, which indicates that if anything the relative wage level of 136, implied by Rees' American wage data, is remarkably low. The labour productivity benchmark is closer to the relative wage level of 184 implied by Douglas' American wage data. The UK/Sweden

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[19] This controversy should not be confused with the one on the growth of American real wages in 1890-1914. Rees constructed a different cost-of-living index increasing less than Douglas' which made his real wage series grow faster. Their series for nominal wages recorded similar rates though.

[20] According to one estimate around 11.6 per cent of the work force in manufacturing were unionized in 1910 (Rees 1961 p. 21). In Douglas sample, however, union rates were given a weight of 31.5 per cent, and the rest came from payroll industries.

comparison brings the same incongruity if to a smaller extent; the benchmark of labour productivity is 160 and the relative wage level is 118. A relative level of labour productivity far off the relative wage level may indicate that distributional considerations play an important part. In this case it suggests that the share of value added accruing to labour was higher in Sweden than the UK and the US. Yet it is important to remember that productivity differences do not translate directly into real wage differences – recalling the discussion on PPP in relation to official exchange rates – because prices of the consumables underlying the estimated PPP increase relatively more in the productivity leading country. The estimates of comparative labour productivity levels do not reflect these implications. Furthermore, Broadberry (1994) has shown that the American productivity level was around twice the British in the first decade of the twentieth century when at the same time Shergold (1982) showed that the American wage lead was no more than around twenty per cent. As we cannot expect parity between relative real wage and labour productivity levels we should attach more importance to Shergold (1982) and Phelps Brown and Browne's direct evidence of comparative wage levels.[21] Since the relative wage level implied by the use of Douglas' American wage data is difficult to reconcile with what this literature unfolds concerning the American wage level in relation to the British it is my conjecture that Rees' American wage data is closer to the truth.

2.3. Real wage series and movement of pay ratios

The choice of series for nominal wages and cost-of-living index influences any comparison of real wage levels far off the reference point, as do interpretations of relative movements. While the wage benchmarks in Williamson (1995b) were based on a mixture of skilled and unskilled construction workers, his real wage series represent unskilled workers in manufacturing. Williamson's justification for basing comparisons on male urban unskilled workers only, instead of a more encompassing wage measure, is that less skilled workers in different industries were subject to similar demand and supply forces which did not derive from industry-specific developments of new technologies. Another argument he has put forward is that the great bulk of

21 There is a recent literature (van Zanden 1999, Allen 2001, 2005, Broadberry and Gupta 2006) which attempts to compare wage levels between India and Britain, and between the developed parts of north-western Europe and the less-developed parts of southern, central and eastern Europe. While comparisons based on the silver content of the currencies indicate a large gap between the developed country or region and the less developed country or region, the gap diminishes significantly in comparisons of the amount of food wages could purchase. This indicates higher productivity in the developed country or region which brought higher prices and nominal wages.

emigrants from the Old World were unskilled. The argument that the choice of workers matters turns on the assumption of pay ratio movement in one direction or another. For instance, if mass migration over the Atlantic made unskilled workers in the New World worse off while benefiting the unskilled workers remaining in Europe, changing pay ratios must have followed suit (unless levelling forces set in with strength enough to revert the trend). The label unskilled is, however, very elusive, and it will become clear below that scant wage information for most countries in the nineteenth century makes it a highly questionable exercise to construct wage series for unskilled workers instead of resorting to series comprising more workers. On the other hand, wage comparisons of aggregate measures bring into consideration the potential effects of labour heterogeneity on earnings. What, in fact, are we comparing? Growth patterns and fluctuations in the constituent series underlying the final index vary widely. More rapid and more volatile changes in some industries compensate for slower growth and more stable patterns in other industries. What we hope to achieve with the use of an aggregate measure is the general direction of change. An aggregate measure is the best option at hand as long as there is a paucity of wage data for comparable, well defined groups of workers. And, furthermore, no agreement has been reached on any turn of the series displaying pay ratios between skilled and unskilled workers in the nineteenth century. The unsettled debate surrounding inequality in the late nineteenth century cautions against the use of real wage series for unskilled workers exhibiting a markedly different behaviour from series for wages for workers as a whole.

2.3.1. Swedish evidence

The Swedish real wage series in Williamson (1995b) refers to a real unskilled industrial wage index from Bagge *et al*. (1933) who present series for hourly earnings for various skilled and unskilled workers but no separate skilled and unskilled series for manufacturing as a whole. Williamson pieced together four of the separate unskilled series: iron, wood pulp, sugar and engineering.[22] However, before 1888 his final unskilled series includes only the series for unskilled iron workers. Below, we will contrast Williamson's series for wages for unskilled workers with a series for wages for manufacturing as a whole (skilled and unskilled). This latter series is based on the separate wage series in Bagge *et al*. (1933), but differs somewhat from their series for average manufacturing which until now has represented the natural reference point of wage movement for Swedish industrial workers in the nineteenth century. The difference stems above all from a different weighting of the constituent wage series as the digression in Appendix 2..2 informs. Graph 2.2 which puts the two

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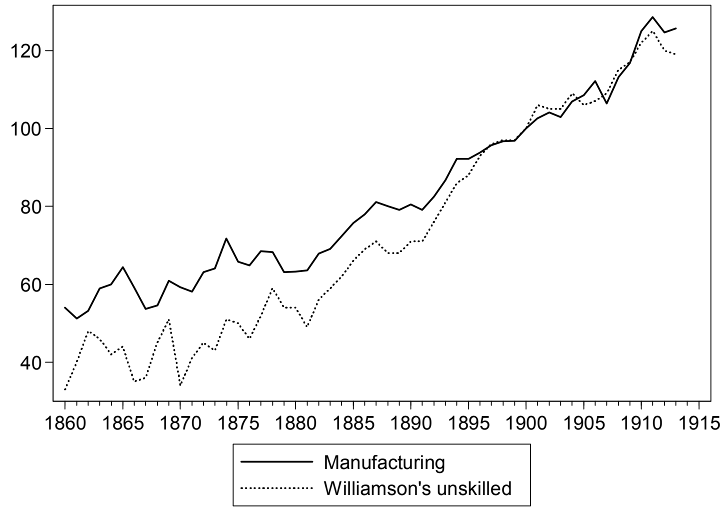
22 This information cannot be found in the appendix in Williamson (1995b) but I have on request received the missing link from the author.



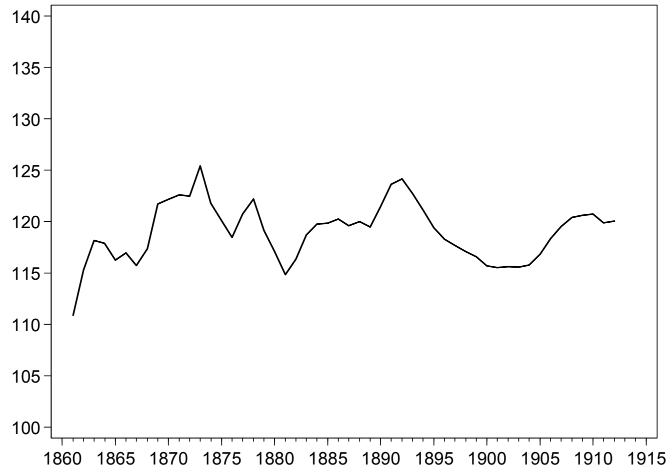
GRAPH 2.2. Real wage series for manufacturing and unskilled workers in Sweden, 1860–1913 (1900=100)

Sources: Wages: unskilled workers from Williamson (1995b table A1.1). The series for manufacturing workers represents a modified series based on the industry specific wage series in Bagge et al. (1933), set out in Appendix 2.1. Cost of living: Myrdal (1933 table A column 17, budget b).

series, Williamson's unskilled and manufacturing as a whole, together indicates a significant discrepancy before the 1890s. The series for iron workers causes this deviant pattern; disagreement disappears after 1888 when the series consists of more occupations. Williamson's unskilled series starts from a lower level, attains the modified Bagge *et al.*'s series in 1892 and they accompany each other in the following years. The computed growth rate for Williamson's unskilled series is more rapid, especially if the starting point is 1870 when the series for unskilled workers dips, suggesting that rewards to unskilled workers progressed more rapidly than rewards to manufacturing workers between 1870 and 1913. This point deserves further emphasis: 1870 is the first year from which real wage data are available for all the countries in Williamson's sample. Results from computable general equilibrium (CGE) models refer therefore – for the sake of comparability – to the years between 1870 and 1913.[23]

One way of checking the implied divergence of the skilled-unskilled pay ratio suggested by graph 2.2 is to construct an index of all skilled-unskilled wage

[23] See O'Rourke and Williamson (1995a, 1995b, 1997).



GRAPH 2.3. Skilled/unskilled wage ratios in Sweden, 1861–1912

Note: A combined index of the different skilled/unskilled wage ratios for workers in the following industries: iron 1860-1913, engineering 1903-1913, wood 1890-1913, paper pulp 1895-1913, municipal workers in Stockholm 1860-1893, and municipal workers in all towns in 1894-1913. The combined series is a three-year moving average.
Sources: The series of iron workers from Larsson (1986) and all the other series from Bagge *et al*. (1933).

ratios presented in Bagge *et al*. (1933, 1935).[24] Only the series for iron workers and municipal workers in Stockholm cover the years before 1887, making it provisional in the extreme to say anything about the movement of pay relatives before that year.[25] I have constructed a combined series by splicing the different indices and adjusting the level to the average wage level in 1903 in order to fill up as long a time span as possible. Graph 2.3 contains the three-year moving

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24 Lundh *et al*. (2004) compiled daily and annual wage series for skilled and unskilled workers for nine regions in 1861–1913, based on Bagge *et al*. (1933, 1935), monographic firm or branch studies and data from the archive of the Tariff Commission of 1876 (Tullkommiten). The overwhelming impression from these wage series, if admittedly based on a graphic inspection of mine, is that the gap between skilled and unskilled workers' wages in the nine regions remained unchanged.

25 In a local study of Bredsjö ironworks (Larsson 1986) confirms the tendency of a narrowing gap between skilled and unskilled iron workers in the 1870s and 1880s. This tendency coincides with a turning point with respect to the way workers were paid. A rigid wage policy gave gradually way to more market based principles in which productivity and market conditions came to be more important. Less skilled workers benefited more from this transition than their masters did, perhaps as a result of a larger weight given to piece work and higher productivity. As for the fortune of unskilled workers in branches other than iron, we simply know next to nothing.

GRAPH 2.4. Real wage series for agricultural and manufacturing workers in Sweden, 1860–1913 (1900=100)

Sources: The wage series for manufacturing workers represents a modified series based on the industry-specific wage series in Bagge *et al*. (1933), set out in Appendix 2.1. The wage series for agriculture from Jörberg (1972a pp. 713–4). Both series deflated by a cost-of-living index from Myrdal (1933 table A column 17, budget b).

average of the combined series. It fails to capture any long-term movement in either direction.[26]

Day rates for a male agricultural worker represent another indicator of the relative price of unskilled workers. The comparison between agricultural and manufacturing workers in graph 2.4 defies claims of steady movements of pay ratios in either direction. In contrast to Williamson's unskilled series, the series for agricultural wages starts at the same level as the series for manufacturing workers, and instead of falling further behind at the beginning of the 1870s, it shot up as a result of the agricultural boom in the mid 1870s (Jörberg 1972b). It furthermore lags behind in the agrarian crises in the latter half of the 1880s. Apart from these deviations, however, the series for agricultural wages sticks quite closely to the series for manufacturing. Thus, for assessing the long-term movement of the Swedish real wages from the second half of the nineteenth century until the First World War, it should be unimportant whether the wage series consists of skilled or unskilled workers, but this conclusion rests on scanty evidence.

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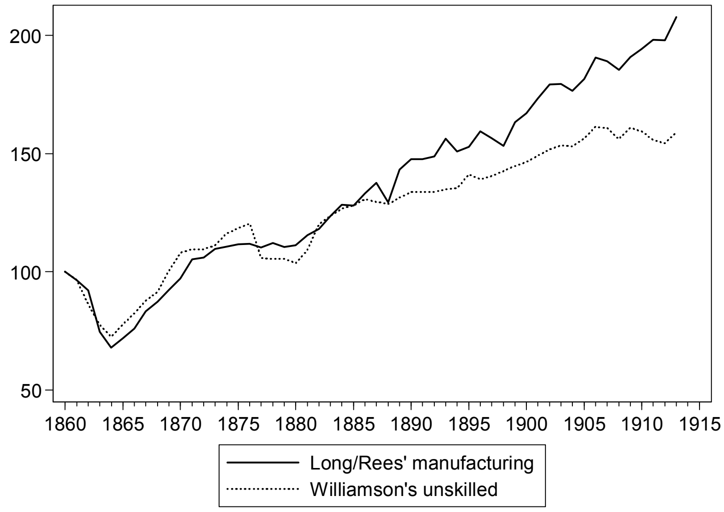
[26] Swedish pay ratio=57.34+0.115*TIME (t-ratio: 0.832).



GRAPH 2.5. Real wage series for unskilled and manufacturing workers in the US, 1860–1913 (1860=100)

Sources: The series for real wages for unskilled workers from Williamson (1995b table A1.1). Nominal wages for manufacturing workers for 1860–1890 from Long (1960 table A-11) and for 1890–1913 from Rees (1961 table 1). Both series deflated by a cost-of-living index from David and Solar (1977 table 1).

Admittedly, Swedish mass migration, by diminishing the supply of unskilled workers, may have served to contract skilled to unskilled pay ratios. Widening pay ratios are however an equally persuasive hypothesis as the migration era coincides with the end of around 150 years of very rapid land reclamation in the country side, which abruptly diminished working opportunities for landless rural workers, thus augmenting the labour supply. The issue of pay ratio movements in one direction or another is after all empirical, and certain answers must therefore await future research. Until then the safest option at hand is to stick to the series for manufacturing wages as a whole. Most of the workers underlying the series were unskilled manual workers living in urban areas anyway. Two-thirds of the male blue-collar workers in the US manufacturing industry were either operatives or labourers, whereas only one-third was craftsmen, foremen, or other more skilled workers (Rosenbloom 1996).

2.3.2. American evidence

The slow-growing real wage series for unskilled American workers is the cornerstone of the belief that wages in the Old World converged rapidly towards the New World in the latter half of the nineteenth and the beginning of the twentieth century. Otherwise, the grand story of factor price convergence would not work. Graph 2.5 plots Williamson's unskilled series alongside a series which represents manufacturing as a whole. This latter series is a spliced index of Clarence D Long's wage series for 1860–1890 and Albert Rees' wage series for 1890–1914, deflated by a cost-of-living index from David and Solar (1977).[27] The comparison of these two wage series reveals that a large gap between the two appears gradually after the end of the 1880s. Between 1890/94 and 1910/14 Williamson's series for unskilled grew 0.79 per cent annually while Rees' series grew 1.45 per cent annually. It is therefore worth looking a bit closer at the origin of Williamson's unskilled series. The references are twofold: Williamson (1975) himself furnishes wage data for the years between 1860 and 1889 and David and Solar (1977) for the ensuing years until 1914.[28] Let us focus on the latter sub-period. David and Solar based their series on compilations by Whitney Coombs (1926), who in his turn used the Nineteenth Annual Report of the Commissioner of Labor for the years up to 1907, and the Bureau of Labor Statistics from 1907 onwards. Coombs series is based on full-time weekly earnings of the lowest paid occupations reported for each industry, thus excluding most common labourers. Carter and Sutch (1998) label his series 'lower-skilled labour'. That may explain why the series makes appreciably less progress after 1907. The slow growth of wages for American unskilled workers goes a long way to explaining how it all of a sudden became possible to tell a story of factor price convergence while previously GDP/capita measures had failed to capture any narrowing income gaps between the Old and New World.

If true, the wage series in graph 2.5 conveys a measure of rising American inequality. Can other evidence buttress the slow growing American wage series for unskilled workers? And have pay ratios between skilled and unskilled workers been at stake in the literature on American late nineteenth century inequality movements? Habakkuk, in his seminal study in 1962, believed that the mass of unskilled immigrants from Southern and Eastern Europe entering the US at the end of the nineteenth century was large enough to leave a deep impression in the pay ratio record, expanding the wage gap between skilled and unskilled workers. He did however not present any evidence for it. Williamson and Lindert (1980), in tracing the long term Kuznets U-curve, focused more on

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27 Different ways of estimating average hourly earnings make the two American indices less suitable for studying cyclical behaviour. Long's series is based on average hourly earnings derived from daily wages, whereas Rees derived his average hourly earnings from annual earnings. See Margo (2007) for a brief introduction to the US wage sources referred to by Long, Douglas and Rees.

28 The sources underlying Williamson's series for wages for American unskilled workers are as follows: 1861-1869: Abbot (1905), table X, p. 363, which in turn was based on data from the Aldrich report (1870-1890): Long (1960), table A-4, pp. 139-40, laborers in eastern cities, based on Bulletin 18, 1890-1913: Coombs (1926), table 5, col I, which in turn was based on the Nineteenth Annual Report of the Commissioner of Labour published in 1905 and for 1890-1907 wage quotations compiled by the Bureau of Labour Statistics.

domestic explanations, in particular technological imbalances and different sectoral growth rates of total factor productivity.[29] They saw an upturn in skilled-unskilled pay ratios in the decades preceding the Civil War and another starting in the mid-1890s. Their claim that antebellum America experienced a surge in inequality sparked some debate (Grosse 1982; Margo and Villaflor 1987), but to my knowledge not much ink has been spilled on their evidence of the next surge in inequality which took place in the mid-1890s.[30] Graph 2.6 shows their skilled-unskilled pay ratios in the US between 1860 and 1913. Unskilled workers lost ground steadily from the mid-1890s until World War I, which provides some support for Williamson's use of a wage series for unskilled workers which after the end of the 1890s lags behind wages for workers in general.[31] It is not independent evidence though; the pay ratios are in fact computed by the same unskilled wage series as the one appearing in graph 2.5.

Rising American inequality fits squarely with the historical narrative. A recurrent theme in the economic history literature is the gradual turn-around in immigration policy, from unrestrictive towards more restrictive and eventually prohibitive laws in the late nineteenth and early twentieth century. One of the explanations behind the evolution of immigration policy is the threat a soaring number of immigrants from the less developed parts of Southern and Eastern Europe posed against American born unskilled workers. When the supply of unskilled increased their relative bargaining position may have worsen, retarding the growth of their wages. There is thus no reason to expect *a priori* that Williamson's unskilled American wage series is based on a faulty foundation. The reliability of the series depends on how representative Coombs' sample of lower unskilled workers is. Carter and Sutch (1998 p. 336) 'have serious reservations about Coombs' data, which are a pastiche of observations drawn from a variety of sources'. They hint, but actually do not prove, that the series misrepresents the movement of unskilled real wages. In contrast to Williamson's British and Swedish unskilled wage series, the American includes at least a variety of occupations which makes it more trustworthy evidence.

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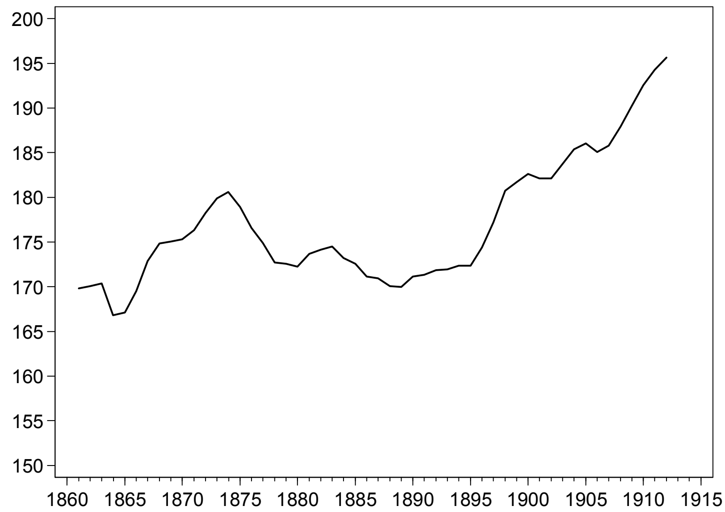
29 One of the explanations behind the inverted U-curve, inspired by Kuznets (1955), is that rapid industrialisation brings about increased demand for skills, which in turn affects the skill premium. Skilled labour is a complement to capital, and falling prices of capital lead therefore to increased demand for skill. The inelastic supply of skill leads to changes in the structure of pay; the skilled-unskilled wage gap expands and inequality follows in its wake. The skilled-unskilled pay ratio declines in due course of time when the supply of skills is more in harmony with demand and so inequality reverts to its initial position (Kaelbe 1991).

30 Lindert (2000) in his search for the turning points in increasing American inequality did not lay any emphasis on the evidence of expanding skilled-unskilled pay ratio in the 1890s. One local study which belies Williamson and Lindert's pay ratio evidence is Shergold (1977). He showed that the skilled-unskilled ratio actually decreased.

31 US pay ratio=-512.61+0.738*TIME (t-ratio: 7.884)

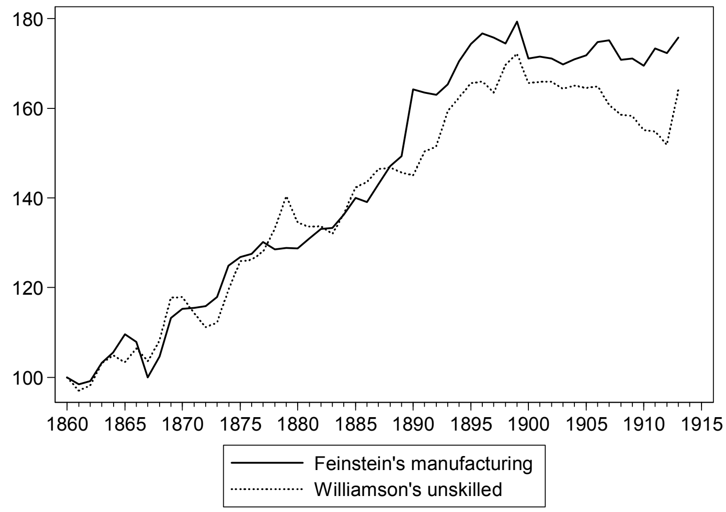


GRAPH 2.6. Skilled/unskilled wage ratios in the US, 1861–1912

Note: Three years moving average.
Sources: Williamson and Lindert (1980 p. 307).

2.3.3. British evidence

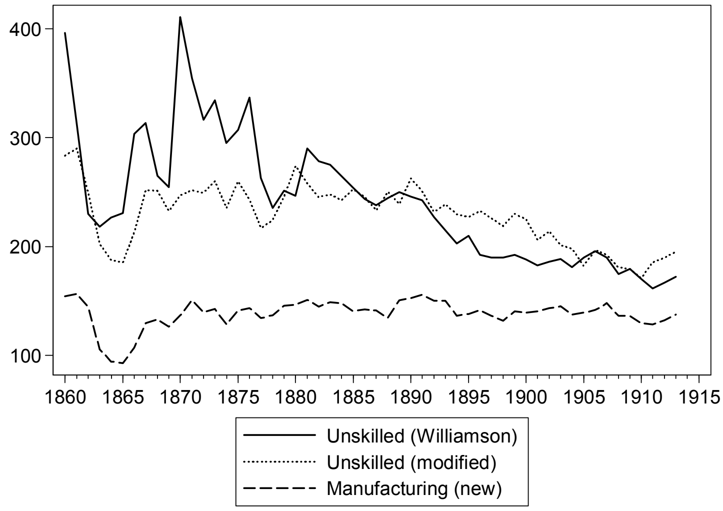
Williamson's unskilled series for the UK consists of a sample of bricklayer's labourers' daily wages. In contrast to the American series of unskilled wages, it is a very narrow definition of a measure intended to measure the rewards to raw, unskilled labour in general. The sample was originally collected by the Board of Trade (1908) and remained unpublished until it was rediscovered by Boyer *et al.* (1993). To construct a manufacturing series for comparison with Williamson's unskilled series we can turn to Feinstein's painstaking investigation into the movement of average daily earnings in the UK. Still, his most encompassing index of manufacturing covers only the years between 1880 and 1913 (Feinstein 1990), while elsewhere he has presented a more long-term series based on manual workers from five broad sectors: agriculture, building, coal mining, cotton textiles, and engineering (including shipbuilding and vehicles) (Feinstein 1995). To render that series a better representation of manufacturing, agriculture and building were excluded and the remaining components were weighted by their shares of employment in 1881 (Feinstein 1990). The two British series have then been spliced in order to cover the whole period. Graph 2.7 indicates that the choice of wage series will influence our view of movement of the UK/Sweden wage ratio, but to a lesser extent than in the US/Sweden comparison. The two series move in tandem until at least the turn of the century after which the wage series for unskilled workers started lagging behind. In the British case inequality



GRAPH 2.7. Real wage series for unskilled and manufacturing workers in the UK, 1860–1913 (1860=100)

Sources: The real wages series for unskilled workers from Williamson (1995b table A1.1). Nominal wages for manufacturing (coal mining, cotton textiles and engineering) for 1860–1880 from Feinstein (1995 table A.23) and for 1880–1913 from Feinstein (1990 table 4). Both series deflated by a cost-of-living index from Feinstein (1995 table A.24).

does not seem to play an equally important part in the story, surprising though it seems in light of the fierce debate about pay-ratios and other inequality measures in the wider historiography of British economic growth and living standards in the nineteenth century. Williamson's study from 1985, in which the contour of an inverted U-curve as measured in the movement of pay ratios appeared, provoked critical reactions. It challenged long-held views on the restrained movement of skill differentials (Phelps Brown 1977; Soltow 1968). Responses came from Jackson (1987) and Feinstein (1988) who pointed to the lack of robustness as incomes for lawyers and doctors account for nearly all the inequality, let alone the fact that those incomes were mismeasured. Crafts (1989) summarised the British debate by concluding that the data set has to be augmented to make it possible for any future claim of pay ratio movements to rest on a firmer evidential basis.



GRAPH 2.8. Different series for US/Sweden real-wage ratios, 1860–1913

Note: The series titled *Williamson* is based on Williamson's comparable real wage series, the American series divided by the Swedish. The series called modified has a different Swedish series but adjusted to the same benchmark in 1909 as the series called Williamson. The series called new has, apart from a new Swedish series, a new American series. In 1909, the new series is furthermore linked to a new real wage benchmark of 136 set out in table 2.4.
Sources: Wages: The series titled *Williamson* from Williamson (1995b table A2.1); the Swedish series in modified and new is a modified series for manufacturing workers based on the industry-specific wage series from Bagge *et al*. (1933) and set out in Appendix 2.1; and the American series in modified from Long (1960 table A-11) and Rees (1961 table 1). Cost of living: the US, (David and Solar 1977); Sweden, Myrdal (1933 table A column 17, budget b).

2.4. New real wage comparisons

2.4.1. US/Sweden

Time series for real wages between 1860 and 1913, adjusted to the benchmarks, give opportunity to assess relative real wage movements over time. The selection of workers underlying the real wage series matters when assessing the movement of the US/Sweden real wage ratio. Graph 2.8 compares Williamson's US/Sweden ratio (Williamson) with a modified ratio in which the Swedish series instead represents manufacturing as a whole (modified). It may at first glance seem a modest difference between the two – overall, they move *pari passu* offering no reason to alter or modify Williamson's contention – but one feature merits special treatment. In the modified series the startling contraction in the US/Swedish real wage ratio in the 1870s has slipped away. If we take the first reference point in 1870 and the last year of the series, 1914, as the second, Williamson's index drops 253 percentage points, from 410 to 157, while the modified series declines more moderately, from 236 to 202, or 34 percentage points.[32] Almost all of the alleged magnitude of the US/Sweden wage contraction is now erased. Furthermore, I link the Long-Rees series for manufacturing to the new US/Sweden benchmark of 136, the series labelled *new*.[33] Graph 2.8 depicts what turns out to be a series for wage ratios without trend altogether; in the course of fifty-four years the Swedish catch-up with the US wage level is non-existent. Looking at the global labour market from this new angle, furnished with more encompassing wage series, the claims made by Williamson and his collaborators of a 'collapse' of the New-Old World real wage ratio seem a bit doubtful.

2.4.2. UK/Sweden

The UK/Sweden comparison whose constituent components are highlighted in graph 2.9 shows some similarities with the US/Sweden comparison but overall downplays the role of different wage measures. Williamson's series (Williamson) of UK/Sweden ratios indicates that at the beginning of the 1870s the UK wage level was around twice the Swedish. The series has a volatile nature until the mid-1880s, which is a pattern we remember well from the US/Sweden comparison. While Williamson's British series represents bricklayer's labourers, the Swedish series represents iron workers (pre-1888). When modifying the Swedish series by substituting manufacturing for unskilled wages the surging pre-1885 wage gaps disappear; instead, the modified comparison sticks more closely to a British lead of around 50 per cent until the last decade of the century. In the modified comparison Williamson's British series of daily earnings of bricklayers has furthermore been adjusted to take account of changing working hours to make it a better counterpart to the Swedish series of hourly earnings in manufacturing.[34] The start of the 1890s marks the beginning of a trend towards unity, which brought about convergence, and finally reversed roles, on the eve of World War I. The final step implies a comparison of manufacturing wages on both sides. To make Feinstein's more encompassing measure of weekly earnings strictly comparable to the Swedish hourly it incorporates changing working hours. No markedly different picture

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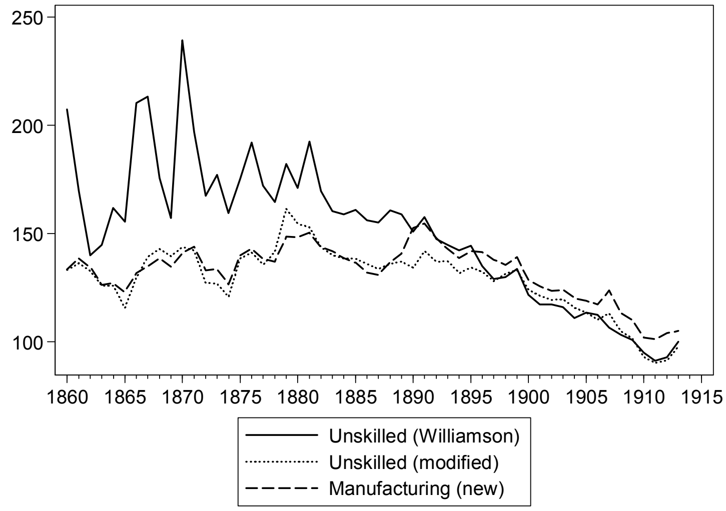
32 O'Rourke and Williamson sometimes use a three-year centred moving average but it only partly irons out the disparity between the two indices, see for instance O'Rourke and Williamson (1997).

33 The series is linked to the US-Sweden benchmark based on Rees' estimated US wage level. The wage gap would have been a great deal larger if it was linked to the benchmark based on Douglas' estimated American wage level. However, it would not have altered the trend of the series.

34 The source of working hours is Huberman (2004). His earliest benchmark is however from 1870. Extrapolation backwards, using the estimated trend coefficient between 1870 and 1880, extends his series of working hours back to 1860.



GRAPH 2.9. Different series for the UK/Sweden real-wage ratios, 1860–1913

Note: The series titled *Williamson* is based on Williamson's comparable real wage series, the British series divided by the Swedish. The series titled *modified* has a different Swedish series but adjusted to the same benchmark in 1905 as the series titled *Williamson*. The series titled *new* has, apart from a new Swedish series, a new British series. The new series is furthermore linked to a new real wage benchmark of 118 from table 2.3.
Sources: Wages: The series titled *Williamson* from Williamson (1995b table A2.1); the Swedish series in new and modified is a modified series for manufacturing workers based on the industry-specific wage series from Bagge *et al*. (1933) and set out in Appendix 2.1; and the British series in new for 1860–1880 from Feinstein (1995 table A.23) and for 1880–1913 from Feinstein (1990 table 4). Cost of living: the UK, Feinstein (1995 table A.24); Sweden, Myrdal (1933 table A column 17, budget b).

emerges when comparing the movements of manufacturing wages adjusted to the new UK/Sweden benchmark of 118.

2.5. Conclusions

Sweden represents the largest country in Scandinavia, a peripheral region that appears to have been an overachiever in the late nineteenth century catch up with the core. Much of what has been written about 'spectacular' factor-price equalisation in the first era of globalisation relies on real wage comparisons first presented by Jeffrey G. Williamson in his influential article *The Evolution of Global Labour Markets since 1850: Background Evidence and Hypotheses* (1995b). This chapter takes a closer look at the way Sweden has been compared to the US and the UK, modifies existing evidence and brings forth a new comparison.

Williamson greatly exaggerated the Swedish wage gap in relation to the US by using wages for both skilled and unskilled building workers in a benchmark for 1909. American building workers, especially the skilled, received much higher pay than their European counterparts at the turn of the century. The pay distance narrows, therefore, if we consider instead what most manufacturing workers received. The new US/Sweden wage benchmark based on Albert Rees' wage data for manufacturing workers then becomes 136, in contrast to 276, which is based on skilled construction workers. The estimated US/Sweden wage gap becomes enlarged if instead Paul Douglas' American wage data are used.

The Swedish catch up with the US and the UK has been overestimated because of reliance on merely a single pre-1887 Swedish wage series for unskilled iron workers, which behaved differently from what we know – at least with some certainty – about Swedish wage behaviour in general in that it progressed at a remarkably swift pace in relation to average manufacturing wages. The scanty evidence of any pay ratio movements in Sweden points, however, to stability, which indicates that it is unjustifiable to regard unskilled wages as outpacing wages for manufacturing wages as a whole. The choice of Swedish wage series, whether representing skilled, unskilled or manufacturing workers, should be unimportant, provided it includes a representative sample of occupations. After substituting a modified Swedish series, based on Bagge *et al.*'s (1933) various wage series for manufacturing workers, for Williamson's Swedish unskilled wage series, the remarkable drops in the 1870's in the US-Sweden and UK-Sweden wage ratios disappear. Instead the narrowing of the gaps occurred after the turn of the century. In addition to this modification of the Swedish wage series, a comparison is also made between the modified Swedish series and an American series, based on Clarence D. Long and Albert Rees' wage data, and a British series, based on Charles Feinstein's wage data, capturing the wage experience of a sample of manufacturing workers. That further modification makes the series of US/Sweden ratios remain essentially flat, whereas it does not affect the UK/Sweden comparison.

Finally, Swedish workers' wages caught up with British workers' around the turn of the century, whether we use Williamson's unskilled or Feinstein's more encompassing wage series. This finding also accords with the evidence of comparative labour productivity ratios in manufacturing presented in chapter 4. Thus the UK/Sweden comparison is unambiguous. On the other hand, the US/Sweden comparison is ambiguous. There are difficulties as far as the estimated wage gap in 1909 concerns and Williamson's American unskilled wage series diverge markedly from the series capturing manufacturing at large. This brings to the fore large wage dispersions and subsequent measurement problem as distinguished American features, making it difficult to establish an authoritative picture of wages in the US vs. wages elsewhere. Using again the evidence of comparative labour productivity ratios in manufacturing from chapter 4, which shows that Sweden reduced the American distance after the turn of the century, make us in fact gravitate towards Williamson's unskilled series as expressing most adequately the wage experiences of manual workers in the manufacturing sector. Yet a final affirmation as to the representativeness of the different American wage series has to await future research efforts.

Appendix 2.1. Real wage series

TABLE A.2.1 Real wage series for the US, the UK and Sweden, 1860–1913 (1900=100)

	US		UK		Sweden	
	Unskilled	Manufact.	Unskilled	Manufact.	Unskilled	Manufact.
1860	68	60	58	56	33	54
1861	66	58	56	55	40	51
1862	59	55	57	56	48	53
1863	53	45	60	58	46	59
1864	50	41	61	59	42	60
1865	53	43	60	62	44	64
1866	56	45	62	61	35	59
1867	60	50	60	56	36	54
1868	62	52	63	59	45	55
1869	69	55	69	64	51	61
1870	74	58	69	65	34	59
1871	75	63	67	65	41	58
1872	75	63	65	65	45	63
1873	76	66	65	67	43	64
1874	79	66	70	71	51	72
1875	81	67	73	72	50	66
1876	82	67	74	72	46	65
1877	72	66	75	74	52	68
1878	72	67	78	73	59	68
1879	72	66	82	73	54	63
1880	71	67	79	73	54	63
1881	75	69	78	74	49	64
1882	82	71	79	76	56	68
1883	84	74	78	76	59	69
1884	87	77	81	78	62	72
1885	87	77	84	80	66	76
1886	89	80	85	80	69	78
1887	88	82	87	83	71	81
1888	88	77	88	85	68	80
1889	90	86	87	87	68	79
1890	91	88	87	96	71	81
1891	91	88	90	95	71	79
1892	91	89	91	95	76	83
1893	92	94	96	96	81	87
1894	92	90	98	99	86	92
1895	96	91	100	102	88	92
1896	95	95	100	103	93	94
1897	96	94	99	103	96	96
1898	97	92	102	102	97	97
1899	99	98	104	105	97	97
1900	100	100	100	100	100	100
1901	102	104	100	100	106	103
1902	104	107	100	100	105	104
1903	105	107	99	99	105	103
1904	105	106	100	100	109	107
1905	107	109	99	100	106	109
1906	110	114	100	102	107	112
1907	110	113	97	102	109	106
1908	107	111	96	100	115	113
1909	110	114	96	100	117	117
1910	109	116	94	99	122	125
1911	106	119	93	101	125	129
1912	105	118	92	101	120	125
1913	109	124	99	103	119	126

Note: The American and Swedish unskilled real wage series come from Williamson (1995 table A1.1) while the British unskilled real wage series from the same source is adjusted for working hours and deflated with a different price series from Feinstein (1995 table A.24). The Swedish real wage series for manufacturing in 1860–1868 and 1912–1913 is based on Bagge *et al.*'s (1933 table 26) original series for manufacturing workers as a whole and in 1868–1912 the modified version (Laspeyres, base year 1868) of their series (see Appendix 2.2). For sources of the other series, see graphs 2.8 and 2.9.

Appendix 2.2. New wage series for Swedish manufacturing

Since official wage statistics for manufacturing workers did not appear before World War I, our wage evidence comes from Bagge *et al.*'s (1933) detailed investigation based on archival sources. The usual reference point to the movement of pre-World War I Swedish wages is their index of average wages in manufacturing based on averages for iron and steel, mining, metal manufacturing and engineering, sawmills, wood-pulp mills, paper mills, food products, textile industry and leather, rubber goods and chemical industries (Bagge *et al.* 1933 pp. 43–4). The authors do not give any precise information on the assigned weights but list the factors they consider most important in assigning to each industry an appropriate weight. Those factors are, for instance, the quality of the wage material, the size of the firm from which the pay record was taken and the number of workers in that industry. Quality seems to have mattered most (pp. 38–9): 'The greatest attention, then, has been paid to the quality of the series, though, to some extent the relative size of the occupations and concerns have also been considered'. The lack of detailed insights into the process of aggregation frustrates any attempt to replicate their average series of manufacturing. This is unfortunate inasmuch as Schön's (1988) revisions of output, within the context of Swedish historical national accounts, and the corresponding adjustments of the number of workers by me for the period 1868–1912 (chapter 5), justify a closer look at what a different weighting scheme, based on the wage bill, may bring about. In the following attempt to assign to each series a new weight, based on the new information on output and employment for 1868–1912, the quality factor attributable to each series is left out of consideration. Instead, the recorded growth rates of wages implied by each of the series are taken at face value.

The starting point is the wage material for different industries, or groups of industries, which underlie the computation of Bagge *et al.*'s series of average wages. At times, these series have been complemented with the wage material presented in the monographs section to create as many industry-specific wage series as their investigation permits. Furthermore, to avoid the potential influence of reductions in working hours on the movement of wages, hourly earnings are the preferred wage measure. When hourly wages are not available daily wages are the second best option, and annual wages a last resort. When an industry-specific series of wages is not at hand I use the wage series of the most closely related industry, or the series representing the group of industries to which that industry belongs.

Two factors put the construction of wage relatives in favour of the compilation of actual wage levels: First, instead of establishing the average wage level in a particular firm or industry, Bagge *et al*. track the wage record for a sample of representative workers. They may, therefore, have been more successful in their attempt to picture the *movement* of wages than establishing actual *levels*. Second, there is an unfortunate mixture of hourly, daily and annual wages which makes it difficult to establish a representative level of any kind. Nonetheless, the actual wage levels have a bearing on the weights used to combine the different wage relatives into an aggregate series for manufacturing. The starting point is therefore to establish the wage levels for a reference year, in this case 1912. The wage level is derived from the public investigation of cost shares which gives the share of wages in gross output, equivalent to the wage bill (SOU 1923). Dividing the wage bill by the number of workers yields the average annual wage for each industry. Once we have pinned down the annual industry-specific wage levels for 1912, we can proceed by scaling the wage relatives and then weighting the resulting series of annual wages by number of workers as in formula (A.2.1), where W and N are average wages and number of employed in year t and industry i, respectively.

$$\frac{\sum_{i=1}^{n}\left(\frac{W_{t,i}}{W_{1912,i}}W_{1912,i}\right)N_{t,i}}{\sum_{i=1}^{n}N_{t,i}} \qquad \text{(A.2.1)}$$

The series so constructed pave the way for further developments into series that satisfy the requirements of different forms of index numbers. In the following formula (A.2.2) the series has been transformed into a Laspeyres index number where the wage relatives are weighted by the wage bill in the base year b. It shows how wages would have progressed had the sectoral structure become set in a fixed mould.

$$\frac{\sum_{i=1}^{n}\left(\frac{W_{t,i}}{W_{b,i}}\right)W_{b,i}N_{b,i}}{\sum_{i=1}^{n}W_{b,i}N_{b,i}}=\frac{\sum_{i=1}^{n}W_{t,i}N_{b,i}}{\sum_{i=1}^{n}W_{b,i}N_{b,i}} \qquad \text{(A.2.2)}$$

The normal convention is to measure the intra-sectoral wage movement by choosing an early base year, but, as table A.2.2 shows, the difference between

GRAPH A.2.1. Hourly wages for male manufacturing workers, 1868–1912 (1868=100)

Note: the series titled *new* contains sawmill workers' wages and computed as a Laspeyres index with 1868 as base year.
Sources: The series titled *Bagge et al.*: Bagge *et al*. (1933 table 26); the series titled *new* is set out in Appendix 2.1.

TABLE A.2.2. Average percentage growth rates of nominal wages in the manufacturing industry, 1868–1912

	With sawmills	Without sawmills
Laspeyres, base year=1868	1.83	2.17
Laspeyres, base year=1912	1.84	2.18
Chained Fisher	1.77	2.25
Bagge *et al*., hourly	2.19	
Bagge *et al*., annual	1.91	

Note: Annual percentage rate of change has been computed by running a regression of the log of nominal wages on time.
Sources: Bagge *et al*.'s hourly and annual: Bagge *et al*. (1933 table 26); the other series: see Appendix 2.3.

early and late base years is negligible. Annual weights also allows the computation of a chained Fisher index which records a somewhat slower growth, though again the difference between it and fixed early or late base year is quite insignificant. It bears noting that Bagge *et al.*'s wage series of average hourly earnings for manufacturing grew considerably faster than my new series, no matter which of the index formula are in use. The gap appears at the end of the 1870s, is widened up to the turn of the century, and maintained until 1913. This is an expected result considering the larger weight given to the wage series for sawmill workers, which grew appreciably slower than the average. The rapid expansion in the sawmill industry was brought to a halt in 1874, and the drop from the peak in 1874 to the trough in 1891 cut the wage level by half. Between 1870 and 1912 the series grew on average 0.37 percent annually, which was an 80 percent slower progress than for manufacturing as a whole. Since Schön adjusted the level of output for sawmills upwards, and chapter 5 attempted to make the number of workers correspond with this higher level, the wage bill, and thereby the weight assigned to the wage series have inevitably been augmented significantly. The results in table A.2.2 show the visual impact that graph A.2.1 assesses and confirms that the new weighting scheme applied here changes the colours of the Swedish wage picture. It now looks paler. The difference between the old and the new series is large enough to warrant more attention than there is scope for in this minor investigation. It may have been that Bagge *et al*. did not assign the series of wages for sawmill workers the large weight it has been assigned here for reasons they did not communicate to their readers. Perhaps they deemed bizarre the behaviour of the wage series of sawmill workers and therefore degraded the quality and the importance of it. What speaks in favour of the reliability of the series is that there is corroborative evidence of the sluggish growth rate of wages for sawmill workers relative to the average of manufacturing (Cornell 1982). As long as no further evidence defies its usefulness the average should include sawmill workers' wages, weighted with due respect to its great importance in the Swedish economy.

Appendix 2.3. Data sources for the new Swedish wage series for manufacturing

This classification of industries and their corresponding wage data is the same as in Appendix 5.3 which means that sources of gross output and the number of workers used to derive the wage bill in 1912 appear there. Information on the share of wages in gross output comes from the public investigation on cost shares (SOU 1923) which also is presented in Lindahl *et al*. (1937).

1. Iron, metal and engineering

Ironware and engineering
Metal
Shipyards
Electro technical
Source: Series of hourly earnings for male workers at metal manufacturing and engineering works (Bagge *et al*. 1933 p. 115, table 10).

Iron ore
Source: Series of average annual earnings for male workers at iron-ore mines in central Sweden (Bagge *et al*. 1933 p. 104, table 8).

Iron and steelworks
Source: Series of average hourly earnings for male workers at iron works (Bagge *et al*. 1933 pp. 74–5, table 6).

2. Stone, clay and glass

Glass
Source: Arithmetic mean of the following series: daily earnings of glass blowers, stem makers, blowers, glass blowers' mates, various craftsmen and unskilled workers at Kosta Glassworks and daily earnings of glass blowers, glass polishers and glass packers at Eda Glassworks (Bagge *et al*. 1933 p. 430, 434, tables 98–9).

Chinaware and tile
Source: Arithmetic mean of daily earnings of potters, oven men and outdoor workers at Gustavsberg China factory (Bagge *et al*. 1933 p. 425, table 96).

Quarrying and refined stone products
Source: Arithmetic mean of the series of daily earnings of brick makers at Höganäs-Billesholm and the series of hourly earnings of workers at Annetorp Limestone Quarries and Limhamn and Lomma Cement and Brick works (Bagge *et al*. pp. 408, 417, tables 87, 91).

Cement
Bricks
Source: Arithmetic means of the following series: daily earnings of brickmakers at Höganäs-Billesholm and hourly earnings of workers at Annetorp Limestone Quarries and Limhamn and Lomma Cement and Brickworks (Bagge *et al*. pp. 408, 417, table 87 and 91).

Coal
Source: Series of daily earnings of hewers at Höganäs-Billesholm (Bagge 1933 p. 408, table 87).

3. Wood

Sawmills and planing mills
Source: Arithmetic mean of the series of hourly earnings of sawers and plank pilers in the sawmill industry (Bagge *et al*. 1933 p. 143, table 12).

Refined wood products
Source: Since the wage series of sawmills and planing mills exhibit a very sluggish growth before the 1890s the aggregate series of manufacturing is used.

4. Paper

Paper pulp
Source: Series of average hourly earnings of all workers in the wood pulp industry (Bagge (1933 p. 172, table 15).

Paper
Book printing
Source: Series of hourly earnings for skilled paper mill workers (Bagge *et al.* 1933 p. 187, table 16).

5. Food

Flour mills
Source: 1868–1986: weighted index (weights in parentheses) of earnings of male (0.9) and female (0.1) workers in the food industry (Bagge *et al.* 1933 p. 196, table 18); 1886–1912: arithmetic mean of the series of hourly earnings for mill hands and store men at Helsingborg Grinding Mills (Bagge *et al.* 1933 p. 522, table 125).

Pork butcheries
Margarine
Tobacco
Chocolate and candy
Bakery
Dairy
Miscellaneous food industry
Source: Weighted index (weights in parentheses) of earnings of male (0.9) and female (0.1) workers in the Food industry (Bagge *et al.* 1933 p. 196, table 18).

Sugar
Source: Weighted index (weights in parentheses) of the series of hourly earnings of male (0.9) and female workers (0.1) in combined sugar factories. Among male workers skilled (0.2) and unskilled (0.8) (Bagge *et al.* 1933 p. 208, table 19).

Breweries
Spirit
Source: 1868–1896: Series of annual earnings of brewery workers at Pripps Brewery, female (0.2) and male (0.8); 1896–1912: hourly earnings of male brewery workers at Hamburger brewery (Bagge *et al*. 1933 p. 528, table 127).

6. Textile

Textile
Clothing
Source: Weighted index (weights in parentheses) of average hourly earnings of male (0.4) and female (0.6) workers in the textile industry (Bagge *et al*. 1933 p. 220, table 20).

7. Leather, hair and rubber

Tannery
Products of leather and fur
Shoes
Source: 1882–1897: annual earnings of workers at Lilljedahl leather factory, Sölvesborg, and annual earnings of skilled workers at L. A. Matton leather factory, Gävle (Bagge *et al*. 1933 pp. 554, 556, tables 141–2); 1898–1912: hourly earnings of journey men and unskilled workers at Ehrnberg Leather factory, Simrishamn (Bagge *et al*. 1933 p. 552, table 140).

Rubber
Source: Hourly earnings of male (0.8) and female (0.2) workers in the galosh making department at Hälsingborg rubber factory (Bagge *et al*. 1933 p. 557, table 143).

8. Chemicals

Paint
Soap and detergent
Oil
Matches
Explosives
Charcoal
Chemicals and fertilizers
Source: 1868–1870: Series of manufacturing as a whole; 1870–1912: arithmetic mean of the series of average annual earnings of male (0.75) and female (0.25) workers at Zadig Soap factory, Malmö; daily earnings of Nitroglycerine Factory, Stockhom; hourly wage of various workers at Stockholm superphosphate

factory, Gäddviken; hourly earnings of male and female workers at Jönköping Match factory; and hourly earnings of skilled workers (0,75) and female candle moulders (0,25) at Liljeholmen Stearine factory (Bagge *et al*. 1933 pp. 561, 563, 568–9, 571, tables 145–6, 149–51).

Chapter 3

The Swedish Wage-Rental Ratio and its Determinants, 1877–1926

With Jan Bohlin
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3.1. Introduction

Trends in factor prices have recently figured prominently in the literature on globalisation in the late nineteenth century Atlantic economy. An important observation in this literature is the narrowing income gap between the Old and the New World in the latter half of the nineteenth century. The guiding principle behind the division into the Old and New World was relative factor endowments. The New World had plenty of land but scarcity of labour, while the Old World had plenty of labour but scarcity of land. The well-known globalisation story tells us that declining transport costs in the latter half of the nineteenth century made possible huge exports of agricultural products from the New to the Old World, which led to changed relative factor returns on land and labour. For landowners in the Old World, the inflow of cheap grains put downward pressures on their incomes, while exports of grain on a massive scale favoured the income growth for landowners in the New World.

In a seminal article by O'Rourke *et al.* (1996), empirical trends in relative factor prices were represented by trends in wage-rental ratios for a number of countries. Their evidence showed that wage-rental ratios fell abruptly in the New World before World War I. The opposite happened in the Old World, where wage-rental ratios rose. The Old World sample was further divided so that countries entered into either a protectionist or a free-trade group, the idea being that some Old World countries muted the forces of globalisation by erecting tariffs on imports of grain. In protectionist countries wage-rental ratios should therefore have displayed a slower increase than in free-trade countries. Sweden was classified as an Old World free-trade country, whose wage-rental ratio exhibited a markedly upward trend, as did wage-rental ratios in the other Old World free-trade countries.

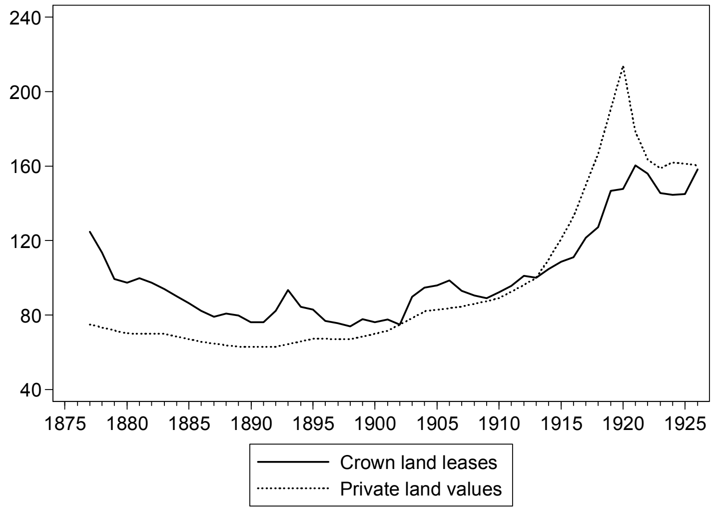
The classification of Sweden as a free-trade country defies what we know about Swedish trade policy (Bohlin 2005). For example, from 1888 Swedish grain tariffs were similar to those in Germany and France, both of which O'Rourke *et al.* (1996 p. 54) classified as protectionist countries. So why did evidence show that the Swedish wage-rental ratio behaved in a way more similar to free-trade countries than protectionist ones? This chapter intends to resolve this seeming contradiction with new evidence of Swedish land prices that indicate land rentals. The new series of land prices covers the years from 1877 to 1926, which captures the impact of late nineteenth century globalisation, the advent of Swedish industrialisation and rapid economic growth and the dramatic distributional changes associated with World War I. It omits though the impact of the new era in Swedish agricultural policy, involving trade regulations and subsidisation, which commenced in 1933.

We begin the chapter discussing the new series of land prices and offer our criticism of the series used by O'Rourke *et al.* (1996). To create a new picture of the Swedish wage-rental ratio also requires representative series of wages for either agricultural or industrial workers. We discuss the available wage series and the choice of an agricultural or industrial wage series as a numerator in the wage-rental ratio. Until World War I agricultural and industrial wages increased at about the same rate. In the aftermath of the war, however, agricultural and industrial wages set out on different courses in the 1920s; for this period, the wage-rental ratio increases more if we use industrial wages in the numerator. When we use our new series of land prices, the new Swedish wage-rental ratio displays a slower increase than the wage-rental ratio reported in O'Rourke *et al.* (1996), whether computed by an agricultural or industrial wage series in the numerator. The Swedish wage-rental ratio evolves similarly to that of other Old World protectionist countries', which is more in harmony with the Swedish protectionist turn in 1888.

Using economic theory and stylised facts about long-term economic development we argue that the wage-rental ratio tends to increase in developing economies such as Sweden from the end of the nineteenth century. The key to understanding short-term fluctuations in the wage-rental ratio lies in the movements of land prices. We therefore turn to a discussion about the determinants of land prices and specifically explore the effects of changes in agricultural productivity and commodity prices on the evolution of land prices. The terms of trade developed favourably for the agricultural sector in the decades before World War I. We ask to what extent the price increase for agricultural products were caused by tariffs or a change in the product mix from grain to animal products.

3.2. Documentation of new land prices

There are two sources for the evolution of Swedish land prices. Both were presented in Åmark's (1923) monograph commissioned by the public investigation committee devoted to exploring the effects of late nineteenth and early twentieth century protectionism. The first source is a series of Crown land leases per hectare between 1861 and 1913 (Åmark 1923 p. 27, table 8). Lindahl *et al.* (1937 p. 393, table 126) extended the series to 1930 and capitalised it to land

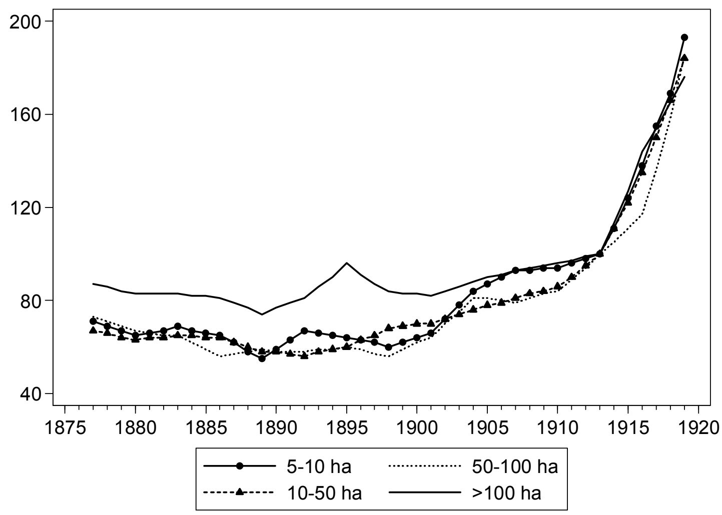


GRAPH 3.1. Crown land leases and private land prices per hectare, 1877–1926 (1913=100)

Note: In 1877–1919, the series of private land prices are based on averages for 3 years. Linear interpolations fill the remaining gaps. Thus, the first year is actually the average of 1876–1878. *Sources*: Crown land leases: Lindahl *et al*. (1937, p. 393, table 126). Private land prices: In 1877–1919, a weighted measure based on series from Åmark (1923 pp. 78–89). In 1919–1926, Höijer (1930 p. 121).

prices by applying an interest rate of five per cent. O'Rourke *et al*. (1996) used that series to compute their Swedish wage-rental ratio. The other source is a series of private land sales between 1876/1878 and 1918/1820. As far as we know this series has been ignored. Land sales data for private land appeared in yet another public investigation in 1930 that allow us to extend the series of private farm sales to 1926 (Höijer 1930 p. 121). Accordingly, we have information for both Crown land leases and private land prices from 1877 to 1926 displayed in graph 3.1. There are two differences that warrant our attention: first, Crown land leases fell more abruptly during the agrarian crises in the 1880s; and second, private land prices grew more briskly during World War I. As the two series display markedly different behaviour, it is necessary to determine which is better to compute the Swedish wage-rental ratio. This requires a minor digression on the judicial status of land.

Three types of landownership existed in Sweden at the end of the nineteenth century that had their origins in the Middle Ages. Private land was owned by freeholders who paid taxes to the Crown (skattejord). Crown land was leased by tenants who paid land dues to the Crown as rent (kronojord). Tax exempted land was owned by rich peasants and noblemen and was cultivated by tenants who paid rents to the owner (frälsejord). Around 1700, these categories of land made



GRAPH 3.2. Private land prices by size classes, 1877–1919 (1913=100)

Note: Based on averages for 3 years. Linear interpolations fill the remaining gaps. Thus, the first year is actually the average of 1876–1878.
Sources: Åmark (1923 pp. 80–9).

up more or less equal shares of the total arable area. However, at the end of the nineteenth century, the proportions of each category of land had changed considerably. In 1878, 60 per cent of the land was owned by freeholders, while the share of Crown land was merely eight per cent (Gadd 2005). Here is the first clue as to why the series representing the leases of Crown land in this period is unrepresentative for the evolution of land prices in Sweden.

There are at least two arguments against using the series of Crown land leases as indicative of the evolution of sales values in the private land market. First, the farms leased on Crown land were generally very large. While most private farms were 5–10 ha in Åmark's sample, the average Crown land unit was larger than 50 ha and if we include forest land they were larger than 90 ha. Second, as the terms of the leases were long (20 years) any potential user of land had to weight carefully the likelihood of change in legislation that might affect their rights to dispose of the land they leased. The most important change in legislation that affected the value of the leases came in 1882, curtailing the right of the Crown land tenants to exploit forest land, and only allowing tenants to collect household firewood. That permission was further restricted in the 1890s (Åmark 1923 pp. 24–6). Åmark tried to remove the influence of the changed legislation by only using arable land and meadows reduced to arable when calculating Crown land leases per hectare. He nevertheless acknowledged that the much more precipitous decline of Crown land leases in the 1880s, compared with sales values of private land, reflected the changed forest legislation.

As Crown land leases give a distorted picture of the evolution of sales values in the overall land market, we turn now to Åmark's investigation of private sales values. Åmark's series of private sales values was constructed from a sample of 4,854 sales transactions. He presented the series in three year averages stretching from 1876/1878 to 1918/1820 for counties in central and southern Sweden.[35] The investigation further excluded farmlands smaller than 5 ha, and farms with forestland and pasture that were more than three times the size of the crop land. The number of purchases varied greatly by the size of the arable land. Purchases of farm properties with more than 100 ha of crop land do not figure prominently in the sample; in some locations and years, there were only a few purchases of properties of that size.

In graph 3.2 we present four separate series of farm prices by size class. The small and medium-sized farms had a more favourable development of sales values than the large and very large farmlands. Small farms relied heavily on family labour. The evolution of sales values on farms above 50 ha that relied on hired labour should be more indicative of the evolution of land rentals. If we disregard the series of farms above 100 ha, all series of land prices nevertheless show the same general contour of development.

We have scanty information about the way land prices have been collected for the years after 1919. Höijer simply states that the sales values were collected in a way that would make them comparable to Åmark's investigation (Höijer 1930 p. 121).

3.3. Agricultural and industrial wages

3.3.1. Agricultural workers

Agricultural wage earners did not represent a homogenous group of rural workers. At least three broad categories of workers can be distinguished. The largest were dayworkers who comprised either landless people or owners of a parcel of land insufficient to provide them with incomes above subsistence. They worked for peasants or nobles and comprised a growing proportion of the rural working class, amounting to 46 per cent in 1870–1880 and 50 per cent in 1920–1930. As dayworkers were largely paid in cash, assessments of wage increases for agricultural workers often refer to this specific category of worker. Dayworkers had the freedom to work wherever they found appropriate employment, in contrast to farm servants, whose freedom was constrained by the Domestic Servants Act. Domestic farm servants were paid an annual or monthly cash wage with free board and lodging. Lack of freedom also characterised the third class of workers,

[35] The investigation included the counties of Östergötland, Halland and Skaraborg.

TABLE 3.1. Distribution of agricultural workers in Sweden, 1870/1880 and 1920/1930 (%)

	Farm servants	Dayworkers	Statare
1870/1880	49	46	5
1920/1930	39	50	11

Source: Jungenfelt (1959 pp. 106–8).

the so-called statare, who worked for nobles on large estates. They were paid a fixed annual cash wage with free housing and benefits in kind (stat) (table 3.1).

Our knowledge of wages for agricultural workers comes from compilations in the Bagge *et al*. (1935), based on market price scales (markegångstaxa) for pre-1913 years and the wage material of the Social Board thereafter.[36] The most homogenous wage series represents day-rates for dayworkers, which O'Rourke *et al*. (1996) used to compute the Swedish wage-rental ratio. However, we need to adjust the wage series to take account of the gradual shortening of the working day during summer, the winter hours remaining stable before 1930, governed by available daylight. In all likelihood no substantial change in working hours took place before the 1870s and the average work day was 14 hours, including breaks. As the 1920s drew to a close, the norm approached 10 hours a day during summer time. If we assume working hours during winter, roughly half of the year, were unchanged the reduction in the annual average work day was 2 hours per day over 60 years. This adjustment results in a wage series for agricultural workers that increase somewhat faster than the series used by O'Rourke *et al*. (1996). Later in this chapter we will use our modified series of daily wages as a numerator when computing the new Swedish wage-rental ratio.

These adjusted day-rates cannot simply be grossed up to annual incomes as many dayworkers had a small piece of land for horticulture and small-scale farming, and in the off-season many of them were principally employed in lumbering. This makes it difficult to compare dayworkers' day-rates to annual wages for farm-servants and statare. Jungenfelt (1959 p. 104), in his pioneering study of the share of wages in national income, tried nevertheless to construct a general series of annual wages for agriculture. We will contrast below his annual series with the annual wage series for manufacturing workers when computing the ratio of agricultural to manufacturing wages.

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36 The referred series in Bagge *et al*. (1935) appears on p. 113, table 169 and p. 152, table 180. An identical series of wages for dayworkers also appears in Jörberg (1972a pp. 710–4). There is also a wage series for dayworkers in the official statistics, see Lundh (2008).

3.3.2. Manufacturing workers

Information on wages of manufacturing workers did not find its way into official statistics until 1913 when the Social Board began its annual report. Industrial wage data before 1913 are scant and we have once again resorted to the wage series that appeared in Bagge *et al.* (1933). These wage data were collected from firms whose wage records had survived. From each firm's wage record, a wage series for a small number of workers from representative occupations were collected to compile occupational averages. In all likelihood, this method probably tracks changes of wages from one year to another better than it pins down actual levels. Many of the aggregate, the regional and the occupational wage series in Bagge *et al.* (1933) have been subjected to scrutiny by Swedish economic historians.[37] Some have objected that the omission of temporary workers renders the wage series in Bagge *et al.* (1933) questionable, but no attempts have so far been made to construct a new national series of wages pre-1913 (Gustafsson 1996). Two series for industrial workers are presented in Bagge *et al.* (1933 p. 260–1, table 26), the first of which represents hourly wages, which is the preferred measure, and the other series represents annual wages. After 1913, the Social Board collected wage data and Bagge *et al.* (1933) used this source to construct a wage series that could be linked to their pre-1913 series.

International wage comparisons frequently rely on samples of so called 'urban unskilled' wages and commonly the wages of construction workers. For Sweden, though, wage data for unskilled construction workers are comparatively scarce before 1913.[38] Furthermore, few wage series of unskilled workers in manufacturing exist for the latter part of the nineteenth century, which means that it is difficult to tell with certainty whether the skilled-unskilled pay ratio exhibited any upward or downward trend.[39] The Swedish wage series in Williamson's (1995b) widely cited article probably overestimate the growth of real wages, being based on only four series of unskilled occupations whose wages grew faster than those for manufacturing workers in general (see chapter 2). We think it safer to stick to the series from Bagge *et al.* (1933) for manufacturing workers as a whole, which better captures our state of knowledge of wage behaviour in manufacturing. This is a more a representative measure of the development of wages in sectors other than agriculture.

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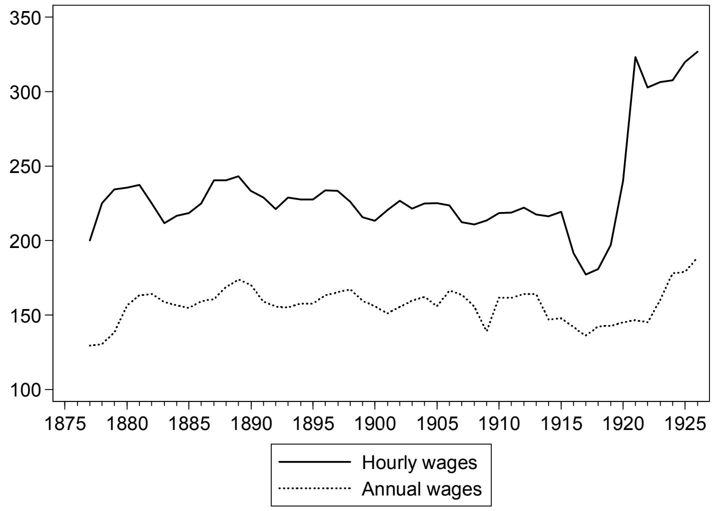
[37] Gustafsson (1965), Berglund (1982), Cornell (1982), Johansson (1988).

[38] As construction workers were largely paid by piece rates, preserved records of hourly wages were more difficult to come by and thereby excluded from the investigation by Bagge *et al.* (1933 p. 8).

[39] Chapter 2 shows that the few existing wage series of skilled and unskilled workers indicate a stable skilled-unskilled pay ratio.



GRAPH 3.3. Ratio of manufacturing to agricultural wages, 1877–1926

Note: The wage gap was estimated for a benchmark in 1877.
Sources: Manufacturing: Bagge *et al*. (1933 pp. 260–1, table 26). Agriculture: hourly wages Bagge *et al*. (1935, p. 113, table 169, and p. 152, table 180); annual wages Jungenfelt, (1959 p. 106–7).

3.3.3. Ratio of agricultural to manufacturing wages

Because the wage-rental ratio can be computed using either agricultural or manufacturing wages as a numerator, the relative movement of wages in the two sectors matters for our interpretation of the wage-rental ratio. Furthermore, the magnitude of the ratio of wages for agricultural to industrial workers and the trend are important components in the transition from agriculture to industry. The ratio represents the opportunity cost for rural workers of staying in agriculture or the cost of migration to find unskilled manufacturing jobs. The ratio of unskilled manufacturing to agricultural hourly wages fluctuated between 2 and 2.5 until the 1890s, narrowed slowly until shortly after World War I, after which the ratio enlarged substantially.[40] After being quite tightly coupled together, the hourly wages in industry and agriculture diverged sharply after World War I. The nominal wage gap between agricultural and urban workers does not translate to a commensurate real income gap, however, because rural dwellers had access to cheaper food and housing. Over time industrialisation and urbanisation

[40] On the basis of the few skilled and unskilled wage series in Bagge *et al.*(1933, 1935), the unskilled-skilled pay ratio in industry was found to have been on average around 84 between 1860 and 1912.

drove a wedge between farm-gate and retail prices as processing and marketing made food in urban areas more expensive than agricultural products in rural areas. That promoted a contraction of the real wage gap. Furthermore, the annual wage gap was smaller because of longer working days in agriculture, and it did not swell after the war because of heavy reductions in working hours in industry[41] (graph 3.3).

3.4. Theory: What determines land rentals?

The wage-rental ratio shows the evolution of the relative reward accruing to labour and landownership. A capitalist tenant expects the same rate of return on his investment as he might expect in any other sector. The rent that he would be prepared to pay to a landowner is therefore dependent on the yield of the rented land. The larger the difference between the yield per land unit and the required rate of return, the more he is willing to pay in rental. Theoretically, as for any asset, the price of a piece of land is nothing but the future stream of income from owning it discounted to present value by applying a suitable rate of interest. Accordingly, land prices serve well as an indicator of land rentals. Experience from asset markets shows that expectations of future incomes are heavily influenced by recent experiences. Therefore, if income from owning land is on the rise, land prices will rise too. If buyers of land expect land prices to increase in the future, land prices may run ahead of rents for speculative reasons, but in the long run they would follow each other closely. To understand the evolution of land prices we therefore have to understand the variables that determine the income of landowners. An important determinant of farmer's revenues is the prices of agricultural goods. The revenue of the farmer, though, is not only determined by the prices he receives but also by how much he sells. In other words, if he can raise the monetary value of his output by reallocating his product mix in the direction of more income elastic goods, and if he can raise productivity, his revenues will rise.

Landowners' income is determined both by revenues and costs. The most important costs to consider are wages for agricultural workers and purchased inputs. However, the effect of agricultural wages on land prices is not so clear-cut. On the one hand, a rise in agricultural wages would increase the cost of hiring labourers. This would affect adversely the income of large landowners, who rely heavily on hired labour. On the other hand, as a majority of farms were small family farms, who only sparingly hired labour, it did not matter whether income was derived from imputed payments to their own labour or from rewards

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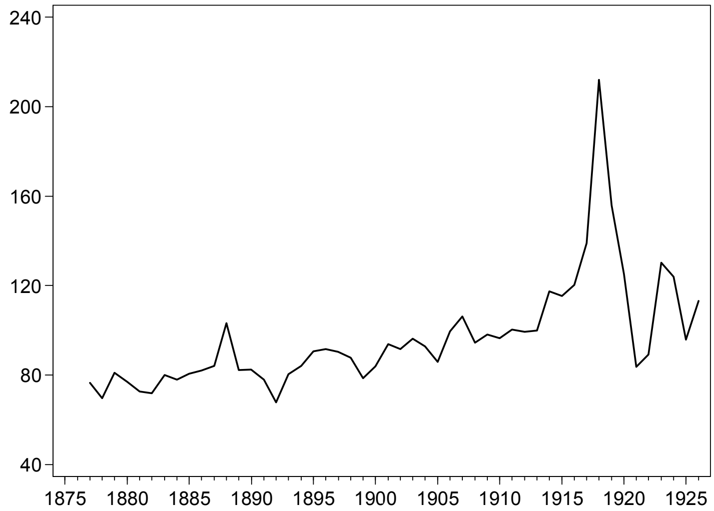
41 Bagge *et al.* (1933 p. 253) report that marked reductions in working hours occurred in 1918-1920. In 1920, hours of work were restricted to 48 hours per week in the manufacturing, commerce and transport sectors.



GRAPH 3.4. Ratio of animal to crop product prices, 1877–1926 (1913=100)

Source: Unpublished series by Lennart Schön, provided by the author on request.

to their landownership. Most important for family farms was their total income. Therefore, if agricultural wages increased they might have been inclined to accept a lower rate of return on their farm capital than large landowners and be willing to bid up land prices.

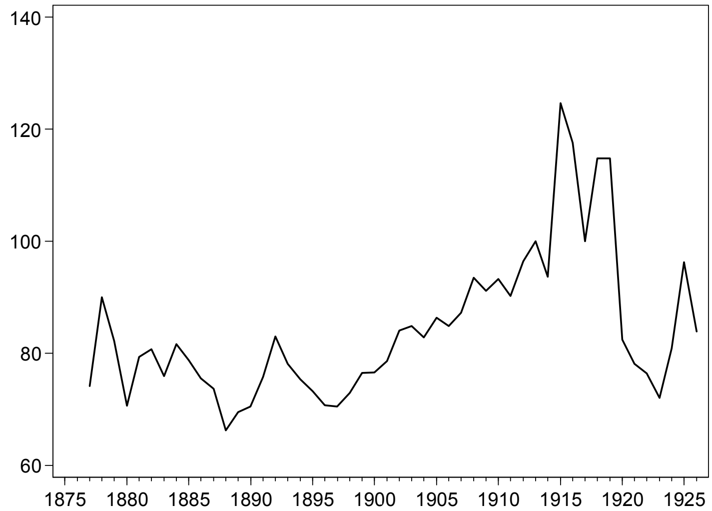
Purchased inputs were another cost item for farms, although they were less important than wages because they only constituted 15 per cent of final sales value. Most of the inputs came from the industrial sector and an increase in industrial prices would increase costs per unit of output for the farmers.

From the above deliberations we may conclude that in order to explore the evolution of farm prices we should look at the evolution of agricultural and industrial prices, agricultural wages, and agricultural productivity. We have already dealt with wages. In the following two sections we take a closer look at commodity prices and agrarian productivity.

3.5. Commodity prices

3.5.1. Agricultural prices

The influx of New World grain into Western Europe after the US civil war put downward pressure on agrarian commodity prices. In Sweden, as in many countries in Europe, landowners successfully campaigned for grain tariffs. From 1888 onwards, the prices of crop products developed more favourably for Swedish farmers than world market prices for grain. The index of agricultural



GRAPH 3.5. Ratio of agricultural to industrial prices, 1877–1926 (1913=100)

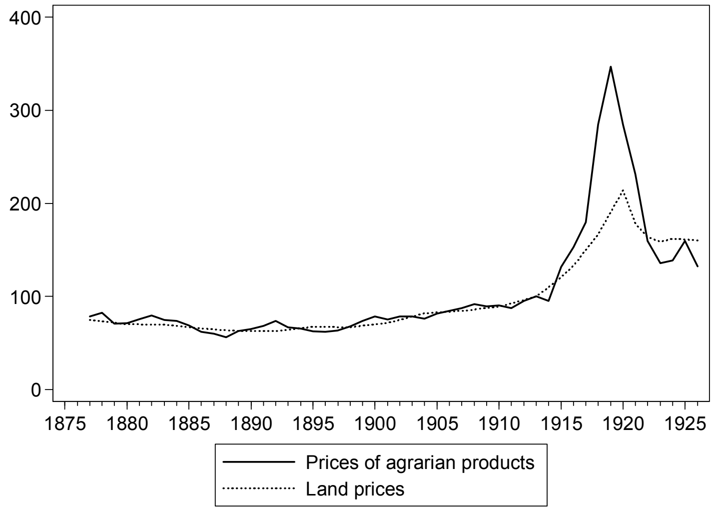
Sources: Agricultural prices: Schön (1995 tables J1 and J6). Industrial prices: in 1877–1912, chapter 5; in 1912–1926, Edvinsson (2005 http://www.historia.se).

prices includes animal products whose prices developed more favourably than grain prices from the mid-1880s, as graph 3.4 shows.[42] In this period Swedish farmers expanded production of animal products while the output of crop products stagnated; between 1870 and 1913 the volume of animal produce grew by 2.3 per cent per year, while crop produce declined 0.2 per cent per year (Schön 1995). The overall index of agricultural prices thus captures the effects of the transition from cropping to animal products. As we argue below, the change in the output mix of the agricultural sector from crop to animal produce was more important for the favourable price trend than the grain tariffs. The more favourable price trend for animal products was intensified during World War I when agrarian prices soared.

3.5.2. Industrial prices

Creating an index of prices for all manufactured goods is a challenge. Works within the field of Swedish Historical National Accounts (SHNA) provide many price series for manufactured goods, especially after 1885 (Ljungberg 1990; Schön 1988). Edvinsson (2005), in his contribution to SHNA, argues that when possible we should use chained Paasche and Laspeyres indices combined into a

[42] The separate series of animal and crop products do not appear in Schön (1995). Instead the separate series were provided by the author on request.



GRAPH 3.6. Prices of agrarian products and land prices, 1877–1926 (1913=100)

Source: See graph 3.1 and 3.5.

Fisher index.[43] Thanks to the Swedish Industrial Statistics, annual current values are readily available for most manufactured goods, which would allow solution to the index-number problem. One of the authors has carried this approach still further for manufactured goods by including more price series, but only in a series that stretches until 1912 (chapter 5). The rest of the period is covered by Edvinsson's series.[44] Prices fell from a peak in 1874 to a trough in 1887, and recovered slowly until 1915. The impression one gets of these pre-war decades is nevertheless one of price stability for industrial goods. The high rate of inflation during World War I brought a dramatic increase in prices of manufactured goods; the index rose from 100 in 1915 to 334 in 1920. Prices then dropped to more moderate levels.

3.5.3. Agricultural terms of trade

In Sweden the two decades before World War I were in Federico's (2005) words a 'veritable golden age' for farmers. The terms of trade for Swedish farmers (the ratio of agricultural prices to industrial prices) improved by 75 per cent between

43 Previous authors contributing to SHNA have used so-called deflation periods, that is, fixed weights for periods of 20–25 years. The present authors agree with Edvinsson that as long as there are annual current production values at hand chained Laspeyres and Paasche indices combined into a Fisher index provide the ideal solution to the index number problem.

44 Edvinsson's series are published on http://www.historia.se

1897 and 1915, which was driven by price increases for agricultural goods, especially animal products, while manufactured goods prices remained fairly stable. If we look only at animal products, the terms of trade improved by 85 per cent, while for crop products the terms of trade improvement were 48 per cent. World War I and its aftermath brought extreme conditions in commodity markets. At the initial stages of high inflation agricultural prices increased faster than industrial prices, but they also fell deeper in the deflation that set in once the war had ended and which adjusted the terms of trade downwards to its pre-war levels (graph 3.5).

Graph 3.6 demonstrates that land prices followed agricultural prices closely. However, the swings in land prices were not as pronounced as those in agricultural prices. When agricultural prices declined precipitously in the 1880s and in the deflation after World War I, land prices did not follow suit, and when agricultural prices rose during the war land prices did not rise to the same extent.

3.6. Productivity in agriculture

Estimates of the evolution of labour productivity in agriculture can be calculated from the available time series data for value added and employment.[45] However, the employment data from the population censuses held every tenth year are of dubious quality. Population census enumerated people according to occupation, but it is well known that many of those classified as employed in agriculture performed other tasks such as rural handicrafts at least part of the year. Employment varied seasonally in agriculture. We simply do not know the exact number of full-time-employed agricultural labourers. Underemployment in the countryside was prevalent, although it declined as industrialisation and urbanisation proceeded. The accuracy of official employment statistics improved gradually, which means we would overstate the growth of labour productivity in agriculture when using employment data derived from the population censuses.

Therefore, to obtain an estimate of the growth of productivity in the agricultural sector we employ another method based on price data. Other authors have used the method for studying the evolution of total factor productivity in agriculture (Hoffman 1991). An estimate of total factor productivity (TFP) can be derived from formula (3.1),

$$p_Y Y = wL + rK \tag{3.1}$$

[45] Value added for agriculture in Schön (1995) and employment in Jungenfelt (1966). For employment, see also Edvinsson (2005).

TABLE 3.2. Growth in total factor productivity and labour productivity in Swedish agriculture, 1876/1878–1912/1914 (% p.a.)

Hectare size of farm unit				Weighted average	Labour productivity
5–10	10–50	50–100	>100		
1.4	1.4	1.3	1.2	1.3	1.4

Sources: Schön (1995 table J19); Åmark (1923); Edvinsson (2005 http://www.historia.se).

where p_Y = price index of value added, Y = volume of value added, w = wage rate, L = number of labour units, r = rate of return on capital invested in farms, K = volume index of farm capital (land, buildings, equipment etc.).

Formula (3.1) is an accounting identity that says that the value of output can be dissolved into payment for the various inputs: wages for employed workers and rentals per hectare for owners of farmlands.

After logarithmic differentiation of formula (3.1) and rearranging, we obtain the formula (3.2):

$$\frac{\dot{Y}}{Y} - \alpha\frac{\dot{L}}{L} - \beta\frac{\dot{K}}{K} = \alpha\frac{\dot{w}}{w} + \beta\frac{\dot{r}}{r} - \frac{\dot{p}_Y}{p_Y} \qquad (3.2)$$

where α and β are cost shares and the dots stand for time derivatives.

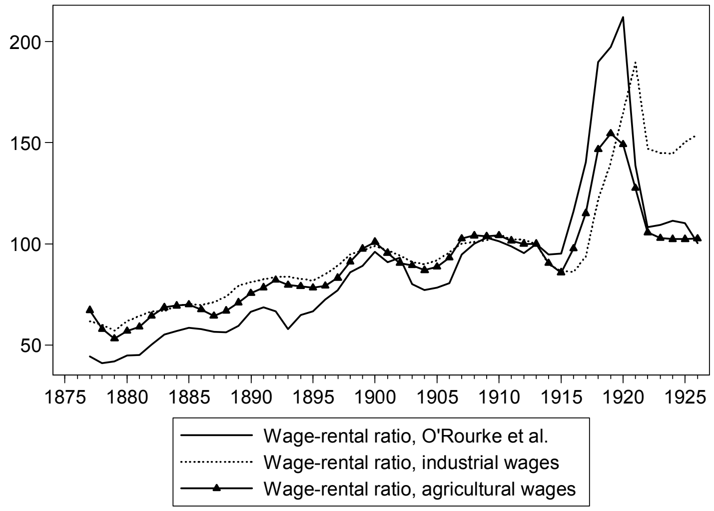
The left-hand side of formula (3.2) is nothing but the growth in TFP as it is defined in the literature. Accordingly, TFP can also be measured by means of price data. Viewed from the side of prices, TFP is the difference between the weighted growth of input prices and the growth of the output price. Productivity growth manifests itself in increased buying power of factor incomes over final goods. As several authors have pointed out this is of considerable interest for economic historians, because we often have much better price data than data on physical volumes of inputs and outputs.

To estimate the expression on the right-hand side of formula (3.2) we need data on factor shares. One of the authors has estimated the wage share in agriculture as 60 per cent in 1913 (Bohlin 2006). According to Jungenfelt (1966 pp. 248–9, table 9), the wage share in the agricultural sector (including forestries and fisheries) was 49 per cent in 1913 and 70 per cent in 1876/1877. According to Åmark (1923), the share of wage costs of total costs in agriculture was 'at least 52 per cent'. We conclude that it seems reasonable to assume a wage share of 60 per cent for the period 1877–1913. We also need a series of prices for agricultural goods, agricultural wages and land rentals. The first two are readily available. We use our new series of sales values for private land as an indicator of land rentals. As the discussion in a previous section of this chapter has revealed, the evolution of land prices varied depending on the size class of farms. A calculation of TFP according to formula (3.2) should be most appropriate for large farms that relied on hired labour. In table 3.2 we present our estimates of TFP growth in Swedish agriculture (column 5 from the left in table 3.2) and we also present separate calculations for four different size classes.

The productivity data presented in table 3.2 indicate that TFP grew by sightly more than one per cent per year between the late-1870s and World War I. The growth figures for TFP on small farms seem suspiciously high. The average size of farms in the size class 5–10 ha was 7 ha, while it was 20 ha in the size class 10–50 ha. Farms of these sizes relied heavily on family labour, especially the smallest. The calculation of TFP from price data presupposes that all labour units are paid at the going market rate. It may have been the case that wages for family members at family farms did not increase at the same rate as those for hired labourers. Owners of family farms were concerned about their total income and did not bother about the extent to which it derived from imputed wages or land rents. In that respect productivity growth might be overestimated for small farms by the right-hand side of formula (3.2). We also have little confidence in the productivity figures for farms in the size class larger than 100 ha because the land price data for these farms are based on a small sample of sales. The TFP figures for farms in the size class 50–100 ha seem more reasonable. Comparison of our estimate for the TFP growth rate and the growth in labour productivity – 1.4 per cent between 1876/1878 and 1912/1914 – indicates our TFP measure is reasonable. As we have noted, land rentals may overstate land prices if buyers speculated in further land price increases. It is therefore of some comfort that our calculated TFP growth rate does not differ too much from other estimates based on alternative methods. For example, van Zanden (1991) gauges that the yearly increase in 'total productivity' in Swedish agriculture between 1870 and 1910 was 1.03 per cent.

3.6.1. Commodity prices, wage costs, productivity, and land rentals

We have assembled evidence on the evolution of commodity prices, wage costs, and agricultural productivity. Together they determined farmers' income. To the extent that prices in the land market reflected income growth, they also determined land prices. An example may illustrate the mechanisms at work. Let us assume a farm whose sale value in 1876–1878 was 100, 60 of which went to the wages of agricultural labourers. Between 1876/1878 and 1912/1914 agricultural commodity prices increased 0.4 per cent per year while agricultural productivity increased 1.3 per cent. With given factor inputs the farm's revenue would have increased to 183.8 in 1912/1914. At the same time wages increased by two per cent per year. On our farm they would have increased to 122.4 in 1912/1914, leaving 61.4 to the owner of the farm. Thus, his income would have grown from 40 to 61.4 or 1.2 per year between 1876/1878 and 1912/1914, which is also approximately the rate at which land prices grew in the period. Our example is of course only another way to illustrate that a productivity increase slightly over one per cent per year was required to motivate the increased land prices in this period.



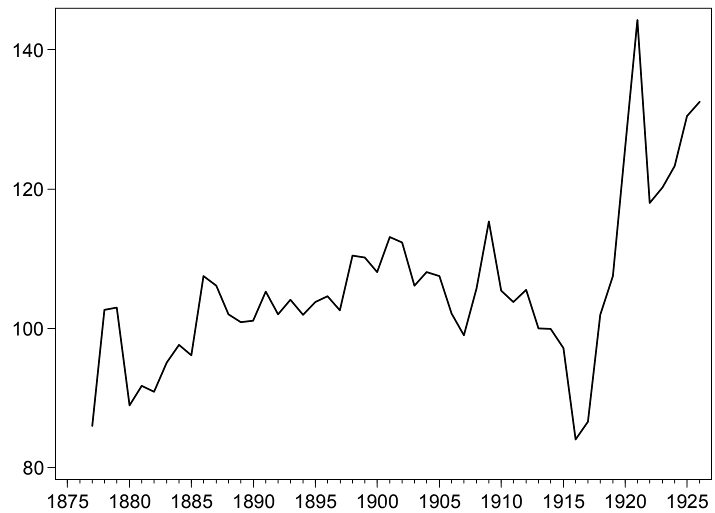
GRAPH 3.7. Different measures of Swedish wage-rental ratios, 1877–1926 (1913=100)

Note: O'Rourke *et al.*'s (1996) ratio is computed by dividing agricultural wages by Crown land leases. Our new wage-rental ratios are computed by dividing either agricultural wages, adjusted for working hours, or manufacturing wages, by private land prices.
Sources: See graph 3.1 and 3.3.

3.7. Evidence and interpretation of the wage-rental ratio

Our new series of land prices show a more rapid increase than previous series, which flattens the steep upturns in the Swedish wage-rental ratio that O'Rourke *et al*. (1996) found. In graph 3.7 we show their Swedish series alongside our new wage-rental series, one with manufacturing and the other with agricultural wages in the numerator.[46] All series show that wages increased faster than land prices, but there are notable differences. Our series of wage-rental ratios did not increase nearly as much between 1877 and 1900 and during World War I as the O'Rourke, *et al.*'s (1996) series. The previous section on land prices identified that they had underestimated the growth of land prices by using the series of

[46] O'Rourke *et al*. (1996) showed the evolution of the Swedish wage-rental ratio in 1870-1914. We have extended to 1926 their series of the Swedish wage-rental ratio that was based on Crown land leases and agricultural wages unadjusted for working hours. A similar extended Swedish series appeared in Williamson (2002 p. 54, table 4).



GRAPH 3.8. Ratio of industrial product wages to labour productivity in Swedish manufacturing, 1877–1926 (1913=100)

Sources: Value added from Schön (1995 pp. 308–9, table I14). Employment: chapter 5; Edvinsson (2005 http://www.historia.se). Wages: Bagge *et al*. (1933 pp. 260–1, table 26). Deflator: see graph 3.5.

Crown land leases, thereby exaggerating the increase in the wage-rental ratio. This accounts for most of the difference between the competing estimates.[47]

The explanation of the wage-rental ratio turns on the rate at which commodity and factor prices rise and fall. The new series reveals that wages grew somewhat faster than land prices until around 1900. Then the ratio levelled off, and wages and land prices grew in tandem until World War I. In the inflationary conditions during the war, wages increased more than land prices. The interpretation of the wage-rental ratio as a measure of income distribution requires caution. During inflationary conditions land prices may not be a representative indicator of the income of farmers and landowners. If market participants do not expect the surge in commodity prices to last, land prices will not increase at the same pace as farmers' incomes, implying that the wage-rental ratio fails to represent accurately distributive shares. That was the case during World War I. According to the wage-rental ratio the lot of workers improved compared with landowners when in fact the opposite happened, as real wages declined because of rapid price increases of agricultural products. Land prices

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[47] A minor part of that difference is offset by our use of a series of wages for agricultural workers that grow somewhat faster, because it has been adjusted to take account for reductions in working hours.

did not increase by nearly as much as agricultural commodity prices apparently because buyers of land did not expect the inflationary conditions to last.

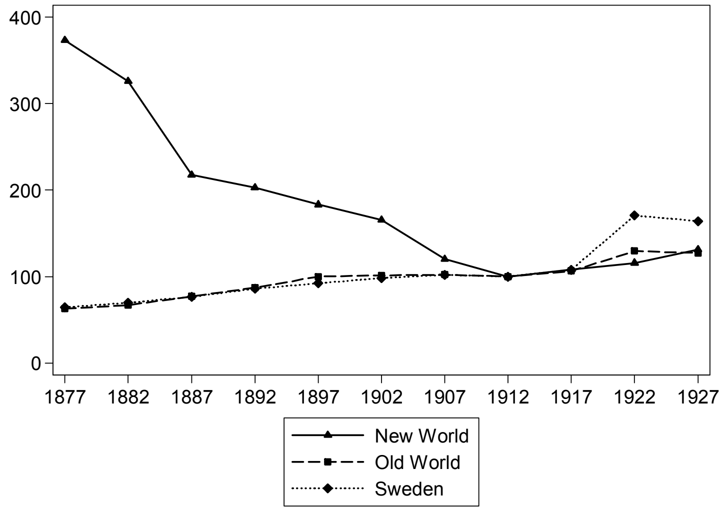
Furthermore, our judgement of the wage–rental ratio depends on the wage series in use. Before World War I, agricultural and industrial wages tended to grow in parallel, but after World War I industrial wages surged ahead. Between 1877 and 1926 the wage–rental ratio increases by 175 per cent if we use the series of industrial wages and by 55 per cent if we use the agricultural wage series. The bifurcation of the path of hourly wages in agriculture and manufacturing after World War I marks a striking redistribution between labour and capital in manufacturing: during 1918–1920, hourly wages rose quickly in the manufacturing industry together with big reductions in working hours. In the ensuing deflation in the 1920s industrial wages did not fall by nearly as much as industrial commodity prices. Graph 3.8 shows that the increase in labour productivity was not high enough to compensate the owners of industrial firms for the reduction in working hours and the increase in product wages. The share of wages in value added expanded, which mirrors a shift in the distribution of power between social classes in favour of workers. It is no coincidence that workers managed to encroach on capital's share of value added after the end of World War I, as it coincided with the introduction of universal suffrage in Sweden and the revolutionary tide in many European countries.[48]

No similar distributional shift in favour of labour took place in agriculture. The terms of trade turned against agriculture in the 1920s, which made it difficult or impossible for landowners to grant agricultural workers wages large enough to maintain the relative wage gap with manufacturing. Mass unemployment and the absence of unionisation weakened the bargaining powers of agricultural workers vis-à-vis landowners. Even though wages sank more in absolute terms in the manufacturing sector during the deflation of 1920s, the percentage rate of decline in wages was larger for agricultural workers. It was almost as large as that for agricultural products. Hence, product wages increased only slightly in agriculture.

3.8. The Swedish wage-rental ratio in international perspective

In the latter half of the nineteenth century mass migration, trade and capital flows – which deserve the prefix global – brought forth a factor-price equalisation between the labour scarce but land abundant New World, and the labour abundant but land scarce Old World. Despite our revision of the Swedish

48 Greasley and Madsen (2007) found a similar dislocation of incomes in favour of labour in Denmark in the aftermath of World War I. They attributed most of that shift to a rise in labour's bargaining power associated with trade union militancy.



GRAPH 3.9. Wage-rental ratios in the Old and the New World, 1875/1979–1925/1929 (1910/1914=100)

Note: Old World countries: Britain, Denmark, France, Germany, Ireland, and Spain. New World countries: Argentina, Uruguay, Australia, Canada, New Zealand, and the USA.
Sources: New and Old World countries: Williamson (2002 pp. 73–4, tables 2 and 3). We have included in the New World sample data for New Zealand from Greasley and Oxley (2005, data appendix). Sweden: our new wage-rental ratio with industrial wages in the numerator.

wage-rental ratio, it still displays the main characteristics of an Old World country. Between 1875/1879 and 1910/1914 wage-rental ratios increased in the Old World and decreased in the New World, as graph 3.9 reveals. These historical trends should come as no surprise. In newly settled areas, such as the USA and Australia, 'virgin land' expropriated from the indigenous population was transformed into private holdings by a soaring number of immigrants and assigned a price. Before the middle of the nineteenth century, land was practically free or could be purchased at very low prices. Eventually the frontier was closed and the land-to-labour ratio decreased. At the same time the transport revolution opened up the world to exports of agrarian products from the newly settled territories. Hence, the price of land rose rapidly from very low levels.[49]

In the Old World the influx of cheap grain brought about a fall in income for landowners, which provoked political reactions. Landowners rallied for protec-

[49] It may be of some interest to compare farmland prices in the USA and Sweden. Using official exchange rates, in 1870 farmland prices on plain-lands in Southern and Central Sweden (in the counties of Östergötland and Skaraborg) were more than five-times higher than in the US. Still in 1910, they were more than two-times higher (Åmark 1923 p. 789, table A; Lindert 1988 pp. 49–51, table 1).

tionist interventions in order to stem the flow of cheap grain from the New World. Tariffs were raised in a number of countries, notably France and Germany, while others like Britain, Ireland, and Denmark, adhered to free trade. O'Rourke *et al*. (1996), in their article on factor price convergence, labelled free trade or protectionist the countries in their Old World sample and found that wage-rental ratios increased faster in free-trade countries than in protectionist countries, indicating that tariffs mitigated the negative influences of cheap grain on land prices. Sweden was labelled a free-trade country despite evidence it had a high rate of protection (O'Rourke *et al*. 1996 p. 504). Their argument rested on Sweden adopting a protectionist stance relatively late. We cannot agree with that argument: the free-trade era in Sweden ended in 1888, only three years after most of the other Old World countries erected their tariffs (O'Rourke and Williamson 1999 ch. 6). If protectionism mattered in these countries, it mattered in Sweden too.

The first steps towards a protectionist trade regime in Sweden were taken in 1888 when custom duties were reinstalled on agrarian and food products, and above all on bread grain and flour. Tariffs came to range over a wide array of agricultural, food and industrial products, while raw materials were generally free from protection. For most years after 1888, the rate of nominal protection for bread grain varied between 20 and 40 per cent (Bohlin 2005). It permitted Swedish farmers higher incomes than would otherwise have prevailed in a free-trade world. Animal products received some protection as well, but this was of little consequence because the most important animal product, milk, was unprotected.[50] The turnaround in trade policy probably slowed the transition from crop to animal production in Swedish agriculture, but it did not change its general direction.

If Sweden is to be classified as a protectionist country, why did its wage-rental ratio behave similarly to the free-world countries, as O'Rourke *et al.* (1996) show? The answer is that it did not, based on our new series for land prices. Graph 3.10 reveals that the pattern of the wage-rental ratio resembles the protectionist France, Germany, and Spain. However, the link between the evolution of the wage-rental ratio and protectionism is questionable in the case of Sweden. Tariffs on bread grain raised the domestic prices of bread grain above the world market level but tariffs did not affect prices of the principal animal products significantly, most of which were non-tradable. Prices of animal products developed more favourably and demand for them was more income

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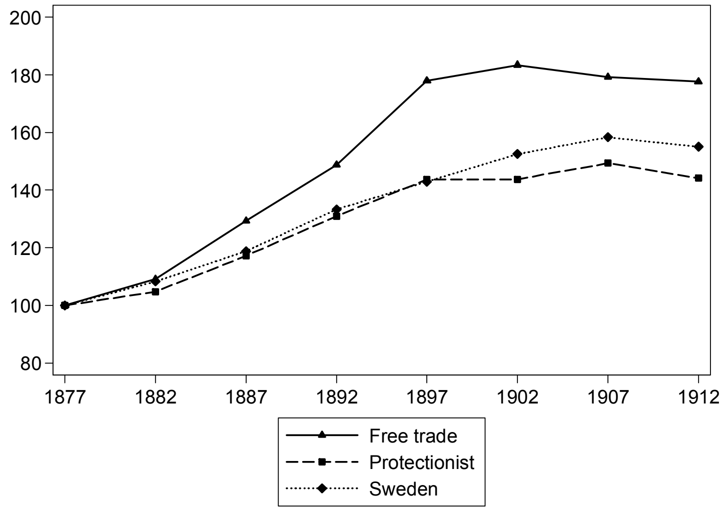
[50] Fresh milk enjoyed a high natural protection anyway because it was not transportable over long distances, but milk was primarily used for making butter. Therefore, because butter enjoyed tariff protection, it may be argued that milk was indirectly protected. However, butter was an important export product at the time and Swedish butter prices followed closely the world market price for butter as argued by Jorberg (1972b p. 211). The butter tariff was largely inconsequential.



GRAPH 3.10. Wage-rental ratios in protectionist and free-trade countries in the Old World, 1875/1879–1910/1914 (1875/1979=100)

Note: Protectionist countries: France, Germany, and Spain. Free-trade countries: Britain, Ireland, and Denmark.
Sources: Protectionist and free-trade countries: Williamson (2002 pp. 73–4, tables 2 and 3). Sweden: our new wage-rental ratio with industrial wages in the numerator.

elastic. A transition towards more animal products would have boosted land prices in a free-trade world too.

Some simple calculations may illustrate the relative importance of price movements and volume changes for the growth of nominal income in agriculture. The rate of growth of output in current prices is the sum of the growth rates of volumes and prices. Table 3.3 shows that total agricultural output grew by two per cent per annum in current values between 1876/1878 and 1912/1914, 30 per cent of which came from price increases and 70 per cent from volume growth. At the same time, farmers changed their product mix towards more animal produce. In 1876/1878 about 50 per cent of the output comprised crop products, in 1912/1914 crop products had contracted to 25 per cent. For animal products, the proportion of current value growth accounted for by volume changes was 72 per cent, while it was slightly less for crop products. A crude counter-factual calculation may shed some light on the importance of grain tariffs for nominal income growth in crop products. If we assume that prices of crop products had been 25 per cent lower in 1912/1914 without tariff protection than they actually were, nominal output growth in agriculture would have been reduced by roughly 0.25 per cent per annum, assuming unchanged product mix. In other words, the agricultural growth rate would have been reduced by one-eighth. We conclude that the most important factor behind

TABLE 3.3. Growth in current values of output in agriculture (% p.a.), decomposed into volume changes and price changes, 1876/1878–1912/1914

	Growth	Percentage share accounted for by	
		Price changes	Volume changes
Agriculture	2.1	30	70
Animal products	3.2	28	72
Crop products	0.1	34	66

Source: Unpublished data of crop and animal output in fixed and current prices, provided by Lennart Schön.

nominal income growth in agriculture after the protectionist turn in trade policy in 1888 was volume increases and, to a minor extent, price increases in animal products.

To sum up, industrialisation from the 1890s set Sweden on a rapid and sustainable growth track, which spurred demand for more income elastic products. Wages for industrial workers accompanied productivity advances in industry and wages for agricultural workers followed suit. Owners of large farms could bear the burden of rapid wages by increasing productivity and switching to animal products. For smaller farmers, commonly more committed to animal production, rapid wage increases did not affect their profitability greatly as they did not rely extensively on hired labour.

3.9. Conclusions

This chapter joins the stream of recent attempts to increase our knowledge of movements in relative factor prices, with a focus on the Swedish wage-rental ratio between 1876 and 1926, and in light of the wider historiography of globalisation and factor price convergence. We document a new series of private land prices in 1877–1926. The new series, in contrast to the series based on Crown land leases, fell by a smaller magnitude during the agrarian crises in the 1880s and increased faster after the turn of the century. A consequence of adopting the new series of land prices is a new picture of the wage-rental ratio, a measure supposedly indicating trends in income distribution. In contrast to earlier evidence, showing that the Swedish wage-rental ratio increased rapidly from 1870 to 1914, our new wage-rental ratio shows a slower increase. This is interesting as industrialisation, which set in motion powerful forces of accumulation, tends to put the wage-rental ratio on an upward track. Sweden enjoyed rapid and sustainable economic growth from the 1870s onwards, which means that *a priori* we should expect the wage-rental ratio to increase. We show a more gradual increase in the wage-rental ratio than previously thought, which highlights the very good conditions that existed for agriculture. Rapid productivity advances in agriculture and favourable prices, especially for animal products, boosted land prices.

Historical trends in wage-rental ratios have figured hugely in discussions of globalisation and its impact on relative factor-price movements in the land-scarce but labour-abundant Old World, and the land-abundant but labour-scarce New World in the latter half of the nineteenth century. Notwithstanding our revision of the wage-rental ratio, the Old World label still comfortably fits Sweden; the wage-rental ratio increased in Sweden and other Old World countries and decreased in the New World. The revised Swedish wage-rental ratio, in contrast to the previous, behaves more like wage-rental ratios in the protectionist countries than in the free-trade countries in the Old World. That view is consistent with the Swedish protectionist turn in 1888. However, while farmers gained from grain tariffs, their income growth had more to do with a change in their product mix from crop to animal products. Real output increases and favourable nominal price movements of animal products served to raise land prices far more than tariffs on bread grain.

Appendix 3.1

TABLE A.3.1 Land values for private land and Crown land, 1877–1926 (1913=100)

	private land					Crown land
	Size class, hectares					
	5–10	**10–50**	**50–100**	**100–**	**average**	
1877	71	67	73	87	75	125
1878	69	66	71	86	73	113
1879	67	64	69	84	72	99
1880	65	63	67	83	70	97
1881	66	64	66	83	70	100
1882	67	64	65	83	70	97
1883	69	65	65	83	70	94
1884	67	65	62	82	69	90
1885	66	64	59	82	67	86
1886	65	64	56	81	66	82
1887	62	62	57	79	65	79
1888	58	60	58	77	64	81
1889	55	58	59	74	63	80
1890	59	58	58	77	63	76
1891	63	57	58	79	63	76
1892	67	56	58	81	63	82
1893	66	58	59	86	64	94
1894	65	59	59	90	66	84
1895	64	60	60	96	67	83
1896	63	63	59	91	67	77
1897	62	65	57	87	67	76
1898	60	68	56	84	67	74
1899	62	69	59	83	68	78
1900	64	70	62	83	70	76
1901	66	70	64	82	72	78
1902	72	72	70	84	75	75
1903	78	74	75	86	78	90
1904	84	76	81	88	82	95
1905	87	78	81	90	83	96
1906	90	79	80	91	84	99
1907	93	81	79	93	85	93
1908	93	83	81	94	86	91
1909	94	84	83	95	88	89
1910	94	86	84	96	89	92
1911	96	90	89	97	93	96
1912	98	95	94	99	96	101
1913	100	100	100	100	100	100
1914	111	111	105	113	110	105
1915	124	122	111	127	121	109
1916	138	135	117	144	133	111
1917	155	150	136	154	150	122
1918	169	166	158	165	167	127
1919	193	184	185	176	190	147
1920					214	148
1921					178	160
1922					164	156
1923					159	146
1924					162	145
1925					161	145
1926					160	158

Chapter 4

Chasing the American and the British Productivity Frontiers

Swedish Comparative Labour Productivity in Manufacturing, 1869–1950

4.1. Introduction

At the end of the nineteenth century, Sweden embarked on a process of intensified industrialisation and sophisticated production of goods in which high value added industries increased their shares of output and employment at the expense of older and raw material-based industries. It was in many ways the birth of the modern Swedish industrial state and the starting-point of an era of swift and sustainable economic growth, putting the Swedish GDP per capita on an equal footing with most of the European countries in the wake of World War II. The quest for explanations of the rapid transition to modernity and the closing of the income gap in relation to the leaders has long preoccupied the minds of Swedish economic historians. The historiography reveals that the establishment of a large number of manufacturing industries in the decades preceding and following the turn of the century is a recurrent theme in many accounts.[51] This preoccupation stems from a perception that modern manufacturing industries had dynamic properties which propelled the economy forward and laid the foundation for Swedish growth of income over most of the twentieth century.[52] In particular, many accounts lay stress on the broad sweep of firms within the mechanical and electro mechanical industry that appeared from the 1890s onwards. The view that manufacturing was the engine of growth from at least the 1890s is firmly rooted. The introduction, adaptation and diffusion of new production techniques are at the forefront in, for instance, Schön (2000b), the most recent and arguably also the most influential account of Swedish economic

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[51] Gårdlund (1942 pp. 63–167), Montgomery (1947 pp. 290–314, 333–8), Jörberg (1961), Kuuse (1977), Olsson (1993 pp. 61–6), Gustafsson (1997), Schön (2000 pp. 220–46).

[52] This view also finds support in Kaldor's (1966) third growth law, establishing a strong positive relationship between the growth of manufacturing output and the growth of productivity outside manufacturing.

history. He stresses the importance of the adoption of electricity from around 1890 onwards, which paved the way for new innovative companies in electricity production and distribution, electromechanical engineering, machine industry, pulp and paper (Schön 2000a).[53] These industries were intensive in their use of human capital and highly competitive in world markets – foremost representatives of the 'Second Industrial Revolution' (Landes 1969). Although some Swedish inventors helped to augment the body of ingenious contrivances applicable in manufacturing, Sweden gained from embracing the progress in science and technology made elsewhere. Swedish entrepreneurs tapped sources of knowledge in the forerunners of industrialisation, especially Britain, and skilfully adapted them to local conditions.[54] This is familiar ground in economic history; in an older strand of convergence literature one finds support for the view that the application of new production techniques matters for relatively backward countries attempting to narrow the gap to the leaders. In keeping with the spirit of Gerschenkron (1962) and Abramovitz (1986), it is easier for relatively poorer countries, latecomers in terms of industrialisation and economic development, to imitate technologies in use in rich countries than it is for the leading countries to advance the frontier through innovation. Merely being backward carries a potential for higher growth rates. Whether that potential will be realised depends on the 'social capability' of a country, in Abramovitz' own words. Most observers agree that Sweden met the requirements underlying the concept of 'social capability'; for instance, Sandberg (1979) wittingly labelled Sweden 'the impoverished sophisticate'.

Nonetheless, a challenge has been thrown down to those endorsing the whole idea of the importance of manufacturing and technology transfer for income convergence. Responsible for this challenge is Stephen Broadberry, who, in a string of important works in the 1990s has documented and explored long-term series for US/UK ratios of labour productivity for manufacturing and other sectors (Broadberry 1993, 1994a, 1994b, 1997). The most noteworthy feature of these series is that relative levels of labour productivity remained largely unchanged over time in the manufacturing sector. Even if there were deviant swings in the ratio, it gravitated towards the two-to-one American lead in its long-run evolution. Although the American level of labour productivity in manufacturing was already twice as high as that of the British in the 1870s, it did not change much throughout the twentieth century. Hence, the manufacturing sector is not the place to look at to capture the forces in operation responsible for the American catch-up and eventual occupation of the leading position in terms of GDP per capita. This belies the crucial role previously attributed to technology transfers in manufacturing as being the force driving economy-wide

53 On the role of electricity, see also Hjulström (1940), Norgren (1992) and Schön (1990).
54 Gårdlund (1942 pp. 233–59); Gustafsson (1996); Bruland (1998).

convergence forward.[55] Instead, Broadberry argues, to understand convergence at the whole-economy level, we need to look carefully at structural transformations and productivity advances in other sectors. Convergence in GDP per capita takes place mostly through re-allocation of resources from low to high value added sectors (Broadberry 1993, 1994b). To bolster his argument Broadberry (1997) also presented evidence of labour productivity ratios in countries other than the US and the UK. Sweden along with Norway, Denmark the Netherlands and Germany constitute a sample labelled 'Northern Europe'. These countries' productivity levels relative to the UK show, firstly, that the level of labour productivity did not fall short of the British level at the beginning of the twentieth century and, secondly, that the ratios remained fairly constant during the twentieth century. The question that begs an answer is thus: did the Swedish economic historians get it wrong in assigning to manufacturing industries the responsibility for the Swedish catch-up with the core? In addition, will a closer look at the Swedish experience confirm Broadberry's different view of convergence or will it rather support an older convergence literature?

This chapter attempts to respond to these challenging questions by charting the long-term movement of comparative labour productivity in manufacturing in Sweden relative to the US and the UK. To do so requires the establishment of benchmarks for comparative levels of labour productivity. The 'industry of origin' approach to benchmarks aims to compare levels of output by industry. As Broadberry did with his pre-World War II benchmarks, I measure physical output per worker, the methodology that is attributed to Lazio Rostas' (1948).[56] The method renders each country's level of output comparable. In cases where the method is inapplicable, I use net output per worker instead, and the average unit value ratio or the official exchange rate converts output in pounds and dollars into Swedish kronor. All information on output and employment comes from each country's official statistics, implying that the earliest benchmark of 1909 coincides broadly with the first British Census of Production in 1907.[57] The two additional benchmarks refer to 1924 and 1935. Time series for real output and employment in 1869–1950 are linked to the benchmarks of 1924 to cover a wider stretch of history. These series, along with series of GDP to capita ratios, make it possible to study the long-term movement of comparable levels of labour productivity in manufacturing in relation to the aggregate. The evidence of long-term labour productivity in this chapter shows that the traditional

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55 Examples of studies which lay emphasis on the spill-over effects from leaders to followers are Gomulka 1971, Cornwall 1977, Nelson and Wright 1992. Abramovitz (1986) and Feinstein (1991) include the transfer of a range of other capabilities too.

56 Hjerppe (2001) used Rostas' method to assess differences in labour productivity among Sweden, Finland and Denmark.

57 In the following, censuses refer to the Swedish Industrial Statistics (Bidrag till Sveriges officiella statistik. D. Manufakturer och fabriker and Sveriges officiella statistik. Industri), the British Census of Production and the US Census of Manufactures.

interpretation reigns supreme; Sweden did enjoy significant convergence gains through the outstanding achievements of manufacturing industries. The series of GDP to capita ratios show, however, that one also needs to take into account structural transformation to paint a more detailed picture of relative performance, supporting Broadberry's alternative vision of convergence.

4.2. Methodological considerations

Although an array of factors other than labour productivity affects the amount of goods and services available for final consumption, labour productivity is arguably the single most important measure of economic performance. International comparisons of labour productivity enable us to gain an insight into relative incomes and hence standards of living in different countries. The methods described below, physical output per worker and net value per worker, are usually referred to as the 'industry of origin' approach (van Ark 1993). They aim to compare output levels by industry, and the long list of productivity comparisons across countries based on the industry of origin approach attests to their wide applicability.[58] It pins down robust comparative levels and many comparisons have proved to endure the test of time. Despite a long pedigree, these methods also suffer from a number of shortcomings that keep their applicability within certain bounds. First, the sample of industries does not remain identical in several consecutive benchmarks. As time goes by new industries crop up while others cease to exist, and changes of classification schemes in each country's census render earlier comparisons difficult if not impossible. Furthermore, a single benchmark of comparative labour productivity may be thought of as a snapshot at a certain point in time hence depending to some degree on contingencies. A well-known problem is that estimated levels of labour productivity are influenced by capacity utilisation. If the benchmark year for a particular industry represents a peak in the business cycle in one country but a trough in the other, the estimated productivity ratio becomes fallacious. Ideally, the choice of benchmark years should reflect considerations of business cycles for the most important industries. In reality, censuses only appeared in selected years, which limits the number of ideal matches. Inasmuch as the Swedish Industrial Statistics appeared annually, I have matched it to either the British Census of Manufactures or the US Census of Manufactures, both of which appeared more occasionally. For instance, in the first benchmark I

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[58] Apart from the ones referred to in the text a few additional examples suffice: Frankel (1957), Jung (2003), Dormois (2004).

compare the Swedish output in 1909 with the American output in 1909 and the British output in 1907.[59]

4.2.1. Physical output per worker

Lazio Rostas' (1948) research on the British labour productivity levels in relation to American, carried out with scrupulous attention to detail, represents a cornerstone in the historiography of productivity benchmarks. He elaborated a method based on comparisons of physical output per unit of labour input. The use of physical indicators renders comparable each country's measure of labour productivity, e.g. metric tons of cement per worker in the US and Sweden. Dividing the one country's level with the others' yields a labour productivity ratio. The method, straightforward though admittedly somewhat crude, is applicable as long as there are fairly homogenous and comparable products at hand. In addition, it requires a wealth of information on output in physical quantities for separate industries. In the Swedish Industrial Statistics, the extent to which physical quantities are reported for separate industries varies from one year to another, which imposes a limit as to the number of potential benchmark years.[60] Furthermore, as the twentieth century progressed, the increasing complexity of the structure of goods made Rostas' method gradually less applicable. Constraints imposed by an insufficient breakdown of the industrial classification, or just different classification schemes, pose just as serious a problem, though. Such is the case as regards matched products given in incommensurable physical units, e.g. matches, given in kilos in Sweden but in number of units in the UK and the US. For many goods, censuses do not report physical quantities.

The censuses in all three countries are based on two classification schemes: by goods and by industry. Physical quantities and corresponding product values appear in the former, employment data and output value per industry in the latter. The total number of workers employed, as given in the censuses, relates to the total value of output for the industry under investigation, whereas we are only interested in the number of workers associated with the products under investigation. The correction factor is given by the ratio of the value of those products included in the comparison to the total value of gross output in the industry. This ratio equals the coverage ratio and is used not only in order to adjust the number of workers but also to indicate whether the estimate is reliable. The assumption underlying this method is that the compared and the

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59 In the text I refer to the benchmarks of 1909, 1924 and 1935 though the true benchmark years are 1907/1909, 1924 and 1935 in the UK/Sweden comparison and 1909, 1924/1925 and 1937/1935 in the US/Sweden comparison.

60 The absence of a detailed classification scheme by industry disqualifies, for instance, the Swedish Industrial Statistics of 1913, an otherwise suitable benchmark year.

TABLE 4.1. Physical output, employment and labour productivity in American, British and Swedish beet sugar industry, 1924 and 1925

	(1) Quanty '000 tons	(2) Value of product '000	(3) Unit value per ton	(4) Value of total output '000	(5) Coverage ratio (%)	(6) Number of workers	(7) Estimated number of workers	(8) Tons per work.
US 1925	1,186	124,026	105	132,339	94	8,872	8,315	143
UK 1924	1,006	44,454	44	53,273	83	11,400	9,513	106
Sweden 1924	153	121,330	793	122,427	99	2,245	2,225	69

Note: Value of product and value of total output are expressed in each country's currency.
Sources: British Census of Production (1924); US Census of Manufactures (1925); Sveriges officially statistik. Industri (1924).

TABLE 4.2. Comparative labour productivity ratio and unit value ratio in the beet sugar industry, 1924 and 1925

	Benchmark year	Labour productivity ratio	Unit value ratio, kronor
US/Sweden	1925/1924	207	7.6
UK/Sweden	1924	154	17.9

excluded products have similar labour input per unit of output. This may be an unrealistic assumption since the manufacturing of different goods requires different kinds of production techniques and hence different labour input per unit of output. Comparing the unit values of the compared and excluded products hints at whether or not the assumption holds; if the unit values differ substantially, it is fraught with difficulty to match product and employment, and thus the number of possible comparisons is circumscribed. Low coverage ratios are likely to be the case when an industry produces a main-product but also a sizable share of by-products and ancillary products. Quite often, the total value of the products under investigation does not account for the major part of the total value of output in that industry. In some cases, a substantial part of the total quantity produced is not manufactured in the industry under review but as by-products elsewhere. An example is the total US production of oleomargarine, a good share of which is manufactured in the meat packing industry, while the estimates refer to the quantity produced in the oleomargarine industry. If labour input per unit of output differs between these industries, then the estimates give a misleading impression.

For readers unfamiliar with Rostas' methodology table 4.1 guides through the different steps to establish productivity ratios in the beet sugar industry.[61] Column (1) and (2) give tons of beet sugar and corresponding product values in Swedish kronor, pounds and dollars, taken directly from each country's census. Dividing column (2) by column (1) gives unit values in column (3). The next column, (4), reports the total production value of the beet sugar industry, and

61 Appendix 4.2 contains the same information for all the industries included in the sample.

TABLE 4.3. Physical output and weighting procedure in the Swedish and American paper pulp industry, 1935 and 1937

Pulp variety		(1) Quantity, Tons	(2) Share of total product value	(3) Unit value	(4) Relative price	(5) New quantity, Swedish relative price	(6) New quantity, US relative price	(7) New quantity, geometric average	(8) Number of workers
						USA 1937			
chanic		1,764,404	0.15	17.2	1.0	1,764,404	176,4404		
Sulphite	white	1,486,628	0.40	53.3	3.1	4,606,818	906,3173		
	grey	872,547	0.15	35.2	2.0	1,785,678	283,3674		
Sulphate	white	237,158	0.04	35.2	2.0	485,347	1,548,771		
	grey	2,120,742	0.26	24.1	1.4	2,971,505	6,559,980		
Total		6,481,479	1.00			11,613,751	21,770,002	15,900,672	21,805
						Sweden 1935			
Mechanic		1,296,357	0.12	31.1	1.0	1,296,357	1,296,357		
Sulphite	white	310,441	0.17	189.6	6.1	1,892,592	962,006		
	grey	1,304,900	0.38	101.0	3.2	4,237,778	2,670,493		
Sulphate	white	54,315	0.03	203.1	6.5	354,707	111,156		
	grey	1,088,582	0.30	96.2	3.1	3,367,254	1,525,281		
Total		4,054,595	1.00			11,148,687	6,565,293	8,555,373	20,670

Note: Dividing the unit value of each pulp quality with the unit value of mechanic pulp gives the relative prices. New quantity is the product of relative price and quantity.
Sources: US Census of Manufactures (1937); Sveriges officiella statistik. Industri (1935).

TABLE 4.4. Comparative US/Sweden labour productivity in the paper pulp industry, 1937/1935 (Sweden=100)

	US/Sweden
Before conversion	152
After conversion	176

dividing column (2) by column (4) gives the coverage ratio. It signals how large a share of total output value the product under consideration, in this case beet sugar, represents in this industry. The higher the share the more solid the ground on which the benchmark rests. The estimated number of workers in column (8) is derived by multiplying column (5) and (6) (divided by 100) and, finally, dividing physical output by the estimated number of workers gives an estimate of tons per worker. Table 4.2 displays the estimated labour productivity ratios along with unit value ratios, the latter obtained through dividing the Swedish unit value by either the British or the American. In 1924 British labour productivity was 54 per cent higher than Swedish while the American advantage was 107 per cent.

Clearly, the method of physical output per head neglects quality differences owing to for instance variety, size, shape, durability and style.[62] Leunig (2003) has demonstrated persuasively the potential pitfalls of adding together quantities

[62] In Appendix 4.2 I discuss briefly some of the major differences in product quality and composition of output.

of different kinds of yarn. Coarser yarn is after all heavier than finer, but a robust weighting of aggregate output fails to take into account that simple fact, which leads Leunig (2003. p. 96) to conclude that Broadberry (1994) had it wrong in asserting that the US had a 17 per cent productivity lead in cotton spinning in 1907. Instead, in a study of Lancashire and New England – the two leading textile industries at that time – Leunig, by estimating all types of yarn separately, finds that the two areas had similar productivity for low counts, while Lancashire was more productive for all counts above 20, the latter of which accounted for the lion's share of the total output. Hence, the UK was the leader of textile industry, not the US. It is, however, a moot point as to whether quality factors really account for the main part of the variations (Rostas 1948; van Ark 1993; Magee 1997). Some of the estimated productivity ratios raise our suspicions that quality differences play an important part but, as Broadberry (1997) argues, it is not reasonable to claim that quality differences are all in the same direction. Hypothetically, if American cement is of a higher quality than Swedish, the opposite might be said about pulp, reducing the risk of arriving at numbers in the aggregate that are significantly biased in one direction or the other.

Simply adding up quantities represents an unnecessarily crude solution if the censuses provide detailed information on the composition of goods. To create heterogeneous units requires the computation of equivalents, as though all countries produced the same commodity. The calculation is done in each country's relative prices and the geometric mean yields the new measure of physical quantity. The conversion serves to iron out inconsistencies stemming from unequal proportions of output. Table 4.3 elucidates an example of conversion in the US/Sweden benchmark of 1937/1935. Column (2) shows the proportions in which the US and Sweden produced different kinds of paper pulp, all of which had different unit values (column 3). The relative price in column 4 expresses the price of all kinds of pulp in relation to mechanic pulp. Multiplying quantity in column (1) by both countries' relative prices gives new quantities, mechanic pulp equivalents, in column (5) and (6). The geometric mean of column (5) and (6) is the new quantity in column (7) which is then used to compute each country's level of labour productivity. Table 4.4 shows how the conversion raises the US-Sweden productivity ratio from 152 to 176. As column (2) in table 4.3 shows, the US proportion of the relatively more expensive white pulp, produced with the sulphite method, is larger than the Swedish proportion. It makes conversion boost the American productivity level. Unfortunately, the descriptions of the products in the censuses do not always make such meticulous investigation straightforward.[63]

[63] Apart from paper pulp, the following products were subject to conversion into equivalents: bulbs, glass, paper, butter, cotton yarn and wool yarn.

4.2.2. Net value per worker

The alternative to Rostas' method is a comparison of net output per worker, the most common solution for post-1945 benchmarks.[64] The definition of net output in the US Census of Manufactures and the UK Census of Production is identical: 'Net output of an industry is derived by subtracting from the value of gross output the aggregate of the cost of materials and fuel used, the amount paid for work given out and other payments recorded'.[65] Prior to 1952, the Swedish Industrial Statistics reported only gross output by industry, although net output could be obtained for manufacturing as a whole from 1947 onwards. The dearth of information on net output excludes the net value per worker method as a primary way to establish productivity benchmarks for the first half of the twentieth century. Yet, inasmuch as Rostas' method fails when no physical indicators exist, it is necessary to circumvent the absence of information on net output in the Swedish Industrial Statistics. Two public investigations report costs shares of materials and fuel for a number of industries in 1913 and 1926 (SOU 1923; Kommerskollegium 1927).[66] These years correspond well to this investigation's benchmarks in 1909 and 1924, but less so to the last benchmark in 1935. I have had to assume that the net output shares were the same in 1935 as in 1924, adding uncertainty to the estimated level of this benchmark. The classification of industries in the public investigations and the Swedish Industrial Statistics is similar.

Net output expressed in each country's currency needs to be translated into a single unit of pay. The use of the official exchange rate has repeatedly been deemed inappropriate because it reflects only the relative values of traded goods (Gilbert and Kravis 1954). Furthermore, short-term capital movements may influence the official exchange rate. The solution to the currency converting procedure is so-called unit value ratios (Paige and Bombach 1959; Maddison and van Ark 1989). Unit value ratios convert net output given in a country's own currency into the currency of the other. Unit values can be obtained from each country's census; dividing the product value by the corresponding quantity gives the unit value. Unit values are so-called ex factory gate prices, not prices of consumer goods, thereby excluding the potential influence of transport costs and distributive margins. Besides, unit values include semi-finished products but exclude imported products. The aggregation of different unit value ratios is a

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64 The methodology of net output per worker was established by Paige and Bombach (1959).

65 Net output is additive over all industries without any appreciable duplication but it does not equal value added, each industry's contribution to GDP, because it contains for instance payments made for repairs, hire of plant, advertising and research work (Historical Statistics of the Census of Production 1907 to 1970).

66 One minus these cost shares multiplied by gross output gives a measure which Lindahl *et al.* (1937 Appendix D table 107) called net value. It should be comparable to net output as defined in the British Census of Production and the US Census of Manufactures.

TABLE 4.5. The share of industries estimated by the method of net value per worker

	US/Sweden		UK/Sweden	
	US	Sweden	UK	Sweden
1909	0.41	0.30	0.25	0.15
1924	0.40	0.46	0.24	0.30
1935	0.45	0.42	0.30	0.37

Note: Gross value of output for industries estimated by the net value per worker method in relation to gross output for all industries

stepwise procedure: from product to industry level, from industry to groups of industries (branch) and from groups of industries to the manufacturing industry as a whole. The literature on the subject suggests the following (van Ark 1990): unit value ratios at product levels are weighted by product values to form weighted unit value ratios at industry level. Each unit value ratio at industry level is then weighted by net output to form unit value ratios at branch level. These unit value ratios are then combined into an aggregate measure using net output for each branch. In each step, unit value ratios are weighted by both countries' weights and the geometric mean combines them into an overall measure[67]. The recent literature on productivity benchmarks has called attention to the inconsistency implied when using unit value ratios so obtained. At the product level, we assume that the ratio of prices for final products equals the ratio of prices for intermediate consumption, which is single deflation. At the industry level we subtract prices of intermediate consumption from gross output, which is double deflation. When old benchmarks have been re-calculated by double deflation techniques at product and industry levels, the perception of comparative productivity in the aggregate has remained unaltered, but the re-calculation has brought forth a different picture of the relative standing of certain industries (Fremdling *et al*. 2007). In order to remain consistent at all levels and circumvent the absence of sufficient information on net output, I weight unit values by gross output at both the product and the industry levels.

Still, a more severe shortcoming of the method of net value per worker is that only the products for which the census gives physical quantities underlie the computation of the unit value ratios. The unit value ratios are likely to suffer from a sample selection bias if we have reasons to believe that the excluded industries performed differently from the industries underlying the unit value ratios. The next section tries to get a grip on this matter.

[67] The formula appears in section 4.3.1 below as the same stepwise procedure transforms benchmarks of comparative labour productivity at industry levels into a benchmark of comparative productivity for the manufacturing industry as a whole.

4.2.3. The relative weight of each method

An inherent characteristic of Swedish industrialisation at the end of the nineteenth century is the increasing share of mechanical engineering whose output in physical quantities the Swedish Industrial Statistics fail to report. The proportion of industries for which productivity levels are estimated by the method of net value per worker thereby increases, as table 4.5 indicates. In the UK/Sweden comparison for instance, the Swedish share jumps from 15 to 37 per cent. This illustrates an important drawback of the industry of origin approach to the measurement of comparative productivity. Apart from spoiling Rostas' method of physical quantities per worker, it also degrades the net value per worker method. The reliability of the unit value ratios, used to translate pounds and dollars into Swedish kronor, diminishes gradually because they do not reflect the relative price of these complex goods; instead, they embody the relative price of more homogenous, and mostly domestic, consumer goods. It seems likely that high tariffs provided shelter for consumer goods industries, which may have hampered incentives to carry on with efficiency improvements.[68] The average unit value ratios, based as they are on mostly those protected industries, appear to be suspiciously high in relation to the official exchange rates, as table 4.6 reports. If the unit value ratios were multiplied by US and UK output they would impart a misleading impression of the gaps between Sweden the US and the UK. There are reasons to suspect that the difference between the exchange rate and the average unit value ratio mirrors inferior Swedish productivity performance in domestic consumer goods industries. The unit value ratio should therefore not be used to represent the relative price of traded goods. The official exchange rate is probably closer to the true unit value ratio for the engineering industry, as it reflects the price ratio of tradable goods.[69] Thus, the official exchange rate transforms dollars and pounds into kronor in the engineering industry and the sawmill industry, while the weighted average of unit value ratios is used for the hosiery industry and glass industry, both representing domestic consumer goods industries, and the matches industry.

68 For information on the degree to which tariffs provided industries with shelter from foreign competition, see Bohlin (2005).

69 In the first and second benchmarks of 1909 and 1924 Sweden stayed on the gold standard. In the last benchmark of 1935, however, the real exchange rate of the Swedish currency probably depreciated after its dissociation from the Gold Standard in 1931 and the concomitant pegging of it to the British pound at 19.4 in 1933 (Bohlin 1999).

TABLE 4.6. Unit value ratios and official exchange rates

	US/Sweden		UK/Sweden	
	unit value ratio	official exchange rate	unit value ratio	official exchange rate
1909	4.23	3.73	20.25	18.21
1924	4.21	3.74	16.89	16.64
1935	4.62	3.97	21.75	19.40

Sources: The different sample years, 1907/1909, 1924/1925 and 1935/1937 are made comparable by adjusting for the overall price movement in a whole sale price index of the UK and the US (Mitchell 2003a, 2003b). Swedish official exchange rate from the database of the Swedish Riksbank: Historical monetary statistics of Sweden 1668–2008: http://www.riksbank.com/templates/Page.aspx?id=27399.

4.2.4. Working hours

Preferably, the denominator in a comparative labour productivity ratio should incorporate differences in working hours. What do we know about working hours in the three countries? The usual reference point is Maddison (1991), who gives data for annual hours worked per person for a sample of countries, including Sweden. Scarce evidence of working hours in the pre-World War I era provoked Maddison to rely on a number of quite heroic assumptions. He assumed that all countries' weekly working hours were on a par with the British in 1870, and that they had the same number of public holidays as in 1950. The movement of annual working hours until 1913 was furthermore assumed to have followed the British path (Maddison 1995 pp. 255–9). This assumption is at odds with what one may expect from differences between rich and poor countries; diminishing working hours tend to go hand in hand with growth of income.[70] More importantly though, the assumption is at variance with the existing evidence of average weekly working hours in Sweden in relation to Britain. Weekly working hours for Swedish industrial workers were on average 58.9 in 1905 (Arbetsstatistik 1911), in fact only slightly shorter a working week than the British in 1850. The British working week in 1906 was on average 53.3 (Bienefield 1972). A recent study by Huberman (2004), who draws on alternative sources, confirms our suspicions that Maddison underestimated the disparity in pre-World War I levels and movements of annual working hours.[71] He also presents a series of working hours for Scandinavia. In an unpublished study, Tegle (1982) puts together the scattered and incomplete observations of weekly work hours in Sweden from 1860 to 1913. His picture diverges somewhat from what Huberman's picture of Scandinavia tells us. The use of

[70] There are notable exceptions to this logic in the post-World War II era, in particular in the US (Gordon 2004b).

[71] Reports of British trade offices give Huberman (2004) a measure of workdays and a study by the US Department of Labor furnishes him with evidence of hours of work per week.

TABLE 4.7. Estimates of annual hours worked per person, 1870–1950

	Sweden	US	Great Britain
1870	3399	3096	2755
1880	3232	3044	2740
1890	3113	2983	2669
1900	2960	2938	2656
1913	2831	2900	2656
1929	2342	2286	2283
1938	2062	2267	2204
1950	1867	1958	1951

Sources: 1870–1913: Sweden: Tegle (1982 p. 22); United States and Great Britain: Huberman (2004, table 6); 1929–1950: Maddison (1991 Table C.9).

Tegle's Swedish evidence instead of Huberman's Scandinavia tempers somewhat the rate at which work hours were cut between 1870 and 1913. I am inclined to trust Tegle's estimate more because it comprises the Board of Trade's benchmark in 1905, our most solid evidence of pre-1913 weekly work hours (Arbetsstatistik 1911). Table 4.7 shows Huberman's pre-1929 estimates for the US and the UK along with Tegle's estimate for Sweden. Maddison's data are used for the years which ensue. Maddison's figures for later years refer to weighted averages of different sectors, which is far from ideal as we seek a measure of working hours for the manufacturing industry proper. Still, as time went by the reduction of working hours progressed more uniformly among different sectors of the economy, which makes the figures most probably reflect the movement of working hours pertaining in manufacturing.

The years between 1870 and 1950 witnessed a pronounced reduction of the differences in working hours among the three countries. I have adjusted all the labour productivity ratios by industry and the time series used to extrapolate from the benchmark in 1924 (section 4.4.1) to incorporate these differences in working hours.

4.3. Evidence of relative productivity for benchmark years

For each benchmark year comparative productivity levels by industry have been established. On the one hand, the aim is to build up an aggregate picture of relative performance and, on the other, to uncover the pattern of comparative advantage at industry levels. The usefulness of a benchmark of comparative productivity turns on how large a share of the manufacturing industry it comprises. In this investigation the captured share of total output in manufacturing ranges from 29 to 47 per cent, as the coverage ratios in table 4.8 report. In the UK/Sweden comparison of 1924 for example the included industries account for 44 per cent of gross output in the UK but just 37 per cent

TABLE 4.8. Total coverage ratios for each benchmark

	US/Sweden		UK/Sweden	
	US	Sweden	UK	Sweden
1909	0.41	0.52	0.47	0.41
1924	0.29	0.42	0.44	0.37
1935	0.44	0.49	0.37	0.45

Note: Total gross value of output from industries under investigation divided by total gross value of output for the manufacturing sector as a whole.

of gross output in Sweden. The reason is that an industry included may have a large weight in one country but less weight in the other. The coverage in this study is similar to Broadberry (1997) and Rostas' (1948) pre-World War I benchmarks. In general, as production has become more complex in the post-World War II epoch, the coverage ratios have fallen (van Ark 1993).

Every industry is allocated to a group of industries (branch). Apart from a few exceptions, the allocation of each industry into one of the seven branches follows the classification in the different censuses. The large weight the sawmill industry constitutes in the American and Swedish manufacturing sector makes it a suitable if sole representative of the wood industry. Table 4.9 shows the full sample of estimates of comparative productivity, where the bold figures are arithmetic means for each branch. The interpretation of the result requires caution because the sudden appearance of a previously excluded industry may markedly change the arithmetic mean of each branch and manufacturing at large. Furthermore, some results are open to objections, for instance the sudden contraction of the US/Sweden ratio in the sawmill industry: from 266 in the first benchmark to 140 in the second, and then to 236 in the third benchmark. It may illustrate how susceptible a benchmark is to the choice of benchmark year. With those caveats in mind, the results do cast light on relative performances by industry.

In relation to Britain, some Swedish industries, mostly export-oriented ones such as paper, mechanical engineering and electro mechanical, stand out because they had surpassed the British level of productivity by the first benchmark of 1909. Over time, the impression one gets is that Swedish domestic consumer industries moved in parallel with the British or lost ground, while export oriented industries surged ahead. These counteracting forces operate to keep the two last benchmarks, with a British lead of around 15 per cent, unchanged. In relation to the US, no noteworthy Swedish industry outperformed its American counterpart. In most industries, the gap was wide even though many ratios tended to contract, especially from 1924 to 1935, suggesting that convergence forces were at work after all.

The large distance in labour productivity performance between the US and Sweden is an echo of what previous authors have concluded about the US/UK gap in productivity, both for particular industries like paper (Magee 1997) and

TABLE 4.9. The full sample of comparative productivity ratios by industry (Sweden=100)

	US/Sweden			UK/Sweden		
	1909	1924	1935	1909	1924	1935
Mechanical engineering*	232	253	185	91	75	65
Electro mechanical*	170	238	219	80	86	71
Bulbs			415			112
Shipbuilding*	242	215	169	138	89	78
Engineering	**215**	**235**	**247**	**103**	**83**	**82**
Glass*	270	370			162	172
Cement	251	242	110	120	112	118
Bricks				232	202	169
Stone, clay and glass	**260**	**306**	**110**	**176**	**159**	**153**
Sawmills*	266	140	236			
Wood	**266**	**140**	**236**			
Paper pulp			159			
Paper and board	207	219	146	83	84	81
Paper	**207**	**219**	**153**	**83**	**84**	**81**
Grain milling	410	271	192	195	143	120
Slaughter and meat packing	210	158	141			
Margarine	148	126	144			101
Beet sugar	169	192	121	297	159	150
Brewery	275		271	191	161	184
Spirit distillery			117		104	116
Biscuits		341	285			92
Fish curing						296
Dairy products	238	29	227	133		145
Food, beer and spirit	**242**	**186**	**187**	**204**	**142**	**151**
Cotton	156	192	176	130	160	151
Wool				82	124	110
Jute	262	434	377			
Binder Twain	208	112	104	112	70	70
Hosiery*	188	187	171	87	81	103
Hats and bonnets						124
Shoes	183	195	239	110	138	156
Textiles, clothing and footwear	**199**	**224**	**214**	**104**	**115**	**119**
Paints and varnishes	317	316			100	132
Soap, candles and perfumery	233	260	200	110	91	75
Seed crushing	81			110		
Matches*				160		214
Fertiliser	169	178	99	111	78	57
Explosives					135	
Chemical	**200**	**251**	**149**	**123**	**101**	**120**
Total manufacturing	**227**	**218**	**185**	**132**	**114**	**117**

Note: Asterisks indicate that productivity ratios have been estimated by the method of net value per worker; otherwise Rostas' method of physical quantity per workers has been used. Bold figures are the arithmetic mean for each branch. Each benchmark is adjusted for the different years for which data were collected and differences in working hours among the three countries. The time series of labour productivity in (see section 4.4.1 and Appendix 4.1) are used to indicate the direction of change between the sample years. For instance, the original US/Sweden ratio for paper pulp was 176 (table 4.4). Adjusting it for working hours (table 4.7, extrapolations between the years) gives a new ratio of 167 (176*0.95) because in the US working hours were on average 5.5 per cent higher than in Sweden, and adjusting it furthermore for the sample years (the American productivity grew by five per cent from 1935 to 1937, see Appendix 4.1) gives 159 (167*0.95).for manufacturing as a whole (Rostas 1948; Broadberry 1994). The persistent and wide gap in labour productivity between the US and the UK, established in the nineteenth century, has long attracted unabated attention.[72] What appears so remarkable is that this gap in labour productivity in manufacturing had already been established before the UK lost its economy-wide lead in the closing decades of the nineteenth century.[73] An intriguing question is whether our measure of productivity systematically overestimates the US output per unit of input, or assigns too low a weight to European goods produced with higher quality content. Probing into the matter requires detailed investigations of product varieties and qualities.

4.3.1. Aggregation

The weighting of industry specific productivity ratios permits compositional effects between industries to have a full impact on the size of the overall ratio of labour productivity in manufacturing. In addition, aggregation of the full set of productivity ratios aims to build three benchmarks that track, as precisely as possible, the movement of ratios of time series of labour productivity. The choice of weights for the benchmarks should therefore mirror the way output series used for extrapolation are constructed. As will become clear in a moment (section 4.4.1), both gross output and net output weights satisfy this requirement while employment weights cannot because none of the three countries' series of output was constructed mainly using employment weights.[74] The lack of information on Swedish net output justifies the use of gross output as weights for benchmarks, but the sensitivity test shows that net output and gross output weights lead to similar results. As with unit value ratios, the weighting proceeds stepwise: from industry to branch, and then from branch to the aggregate. The weights assigned to each industry, the lowest level, represent that industry's gross output as recorded by the census (column 4 in table 4.1). For the next level, the weights represent the gross output of each branch as given by the census. For instance, the weight given to chemical industries does not amount to the sum of gross output for the industries included in the sample of chemical industries but gross output of all industries labelled chemical in each country's

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72 The literature on the American advantage is vast. Few issues in economic history have been so extensively covered. See for example Habakkuk (1962); Landes (1969); David (1975); Lazonick (1983); Chandler (1990); Wright (1990).

73 There are disagreements as to when the US overtook the UK's leading position at the economy-wide level. Direct benchmarks at the end of the nineteenth century gives an impression of an earlier American superiority than if Maddison's methodogy of extrapolations backwards from a benchmark in 1990 is used (Ward and Devereux 2003, 2004; Broadberry 2003).

74 For a discussion of the construction of historical real output series in manufacturing in the US and the UK, see Thomas and Feinstein (2004).

TABLE 4.10. Weighted labour productivity ratios at branch level and manufacturing as a whole (Sweden=100)

	US/Sweden			UK/Sweden		
	1909	1924	1935	1909	1924	1935
Engineering	226	249	189	97	78	68
Stone, clay and glass	262	309	110	194	170	159
Wood	266	140	236			
Paper	207	219	151	83	84	81
Food	282	223	181	199	151	146
Textile	175	193	194	109	138	130
Chemical	188	258	167	120	95	94
Total manufacturing	238	223	182	144	125	111

Note: Based on the productivity ratios in table 4.9, thus adjusted for working hours and different sample years, and weighted by gross output shares according to formula (4.1).

census. To compile these weights in a systematic manner I have paid due attention to the way the different censuses classify industries, and some adjustments have been made along the way. For instance, matches belong to the wood industry in the US Census of Manufactures, but belong to the chemical industry here. The branch weights thus constructed circumvent the problem posed by the irregularity with which industries appear in the different benchmarks. For each comparison, there are two country weights. The literature on comparative estimates recommends the use of both countries' weights, and the geometric mean of the two weighted ratios then gives a solution reminiscent of the Fisher price index formula (van Ark 1993). Formula (4.1) illustrates how this works, where α_i represents output per worker in industry i in the US or the UK and α_i^* the corresponding number in Sweden; Q_i represents gross output in industry i in the US or the UK and Q_i^* the corresponding number in Sweden.

$$\text{US-UK/Sweden* benchmark} = \left[\left(\frac{\sum_{i=1}^{n}(\alpha_i/\alpha_i^*)Q_i}{\sum_{i=1}^{n}Q_i}\right)\left(\frac{\sum_{i=1}^{n}(\alpha_i/\alpha_i^*)Q_i^*}{\sum_{i=1}^{n}Q_i^*}\right)\right]^{1/2} \quad (4.1)$$

Table 4.10 testifies to the significance of weighting as it changes our impression of the evolution of relative labour productivity. With reference to the UK/Sweden comparison, the size order of the benchmarks now coincides with the chronological order; the picture conveys a message of unbroken Swedish convergence. Swedish industries, with good relative performance, expanded their shares of gross output, which points to the favourable change in the composition of output. New and modern production technologies that fostered rapid productivity advances were taken up by industries epitomizing the 'Second Industrial Revolution'. Even if these industries absorbed increasing shares of gross output in all the three countries, this transformation was more pronounced in Sweden than Britain. This evidence may evoke the readers' memories of the lively and longstanding discussion of the British climacteric.[75] Some of those claiming that the late Victorian and Edwardian Britain slid into decline have adduced evidence of the British slowness to adopt the techniques of mass production and the far from impressive growth rates of steel, automobile and mechanical and electro mechanical engineering. Since it is beyond the scope of this chapter to examine the changing composition of output in detail it suffices here to say that a closer look at the UK/Sweden comparison may cast some fresh light on this old and intriguing debate.

4.4. The long-term picture

Series of output and employment for manufacturing are used to indicate the movement of labour productivity in each country between 1869 and 1952. The ratio of any two countries' series of labour productivity linked to one of the benchmarks permits exploration of long-term comparative performance. Before turning to the historical evidence, a note on the construction of historical time series of output in constant prices is warranted.

4.4.1. Series of output and employment

Ideally, the series of output should represent volume net output, constructed by deflating both the current value of gross output and the current value of intermediate inputs, and subtracting the volume of intermediate inputs from the volume of gross output.[76] In historical national accounts a second best – and more commonly found – solution is series of volume gross output for separate industries combined into a series of manufacturing at large by using value added shares for benchmark years. If neither of these options is viable we have recourse to series of gross output in constant prices weighted by gross output shares.

The second best solution was mostly used in the construction of the British and American output series used by Broadberry.[77] For Sweden, Schön (1988) presents two options: either a series labelled volume net output or a series labelled volume gross output. The lack of net output in the Swedish Industrial Statistics before 1952 forced Schön to construct the series of volume net output

[75] For an overview of the discussion of the British climacteric, see Magee (2004).

[76] The expressions output in constant prices and volume output are used interchangeably.

[77] Braodberry (1993) based his comparisons on output data from Kendrick (1961) and Feinstein (1972). For a discussion on the construction of these series, see Thomas and Feinstein (2004).

TABLE 4.11. Correspondence between time series projections for 1924 and the additional benchmarks of 1909 and 1935 (Sweden=100)

	UK/Sweden		US/Sweden	
	benchmark	Projection	benchmark	projection
1909	144	167	238	263
1935	111	108	182	182

largely on the basis of the second best solution.[78] It means that the Swedish series called volume net output rests in fact on the same methodological foundation as the British and American series, making it a better counterpart to the American and British series than the series labelled volume gross output. Furthermore, the Swedish output series needs to be purged of mining, public utilities and handicraft production to render it comparable to the American and British. My own work on manufacturing output in 1868–1912 (chapter 5) makes this adjustment straightforward for pre-1912 years but the way in which Schön's (1988) output series are presented complicates matters from then on. He divides manufacturing into nine groups of industries. While public utilities constitute a separate series, mining does not; it is included in the series titled mining and metal industries. To purge the series I have subtracted from current net output of manufacturing the value of public utilities as given by Schön and the estimated value of current net output of mining and handicraft. Figures on gross output of mining are taken from the Swedish Industrial Statistics and multiplied by net output shares, the latter taken from benchmarks in 1913, 1926, and 1952, with linear interpolations filling in the gaps between these years.[79] Then, I have adjusted Schön's implicit deflator of gross output for the manufacturing industry to account for the absence of mining, public utilities and handicraft production, the weights being their respective annual shares of gross output in 1912 and 1930.[80]

Based on the information on working hours in table 4.7, the three series of employment have been adjusted to incorporate movements of working hours. The Swedish pre-1912 series of employment goes back to my own exercise to estimate the number of manufacturing workers in chapter 5. This series is then spliced to Jungenfelt's (1959) series of manufacturing workers less workers in

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78 See chapter 5 for a more detailed discussion.

79 Net output shares in 1913 from SOU (1923); in 1926, Kommerskollegium (1927); and in 1952, Sveriges officiella statistik. Industri (1952). The exclusion of handicraft production was made by subtracting, in Schön (1988), the value added for handicraft workers (shares of value added on pp. 101–5 times the value of gross output for handicraft production, table 15) from the series of value added for manufacturing and handicraft production (table I2). The deflator is an index which increases by a factor of two from 1890 to 1950 (see chapter 5 for a more detailed discussion).

80 The years correspond to the deflation periods Schön (1988 pp. 196–8) used to construct the deflator.

public utilities, mining and handicraft. Moreover, Broadberry (1993) has made the American and British series of employment from Kendrick (1961) and Feinstein (1972) comparable. Linear interpolation between the benchmarks of annual working hours per worker yields a series of working hours for the three countries. These indices are then multiplied by the employment series (number of workers) to yield a factual measure of the movement of total working hours. The output series divided by the series of total working hours indicates the movement of output per unit of comparable labour input in each country. The ratios of the American and the British to the Swedish series of labour productivity are linked to the respective benchmarks in 1924; the additional benchmarks in 1909 and 1935 can be used to verify the consistency between the benchmarks and time series projections. As table 4.11 shows, the benchmarks are reassuringly close to the time series extrapolations – well within the suggested margin of errors in the range from 10 to 20 per cent – which lends credibility to what has been accomplished hitherto.

The American and British series of GDP in constant prices originate from Maddison's (2003) latest compilation. The Swedish series there has, however, been superseded by two revisions, the most recent being Krantz and Schön's (2007) eagerly awaited, and definitive, Swedish Historical National Accounts (SHNA). It was, however, long overdue and in the meantime an alternative option, Edvinsson (2005), saw the light of day.[81] It represents a major attempt to construct alternative historical national accounts on the basis of the latest standard of national accounting, thereby achieving consistency over time. Although both these Swedish series of GDP are viable options, their different characteristics exert an influence on the long-term picture this section tries to establish. As the time series in this case captures a wide time span – Maddison's methodology rests on extrapolations backwards from 1990 – small departures in one direction or the other accumulate into large gaps the further back in time the series stretches. It turns out that the estimated level of GDP between 1869 and 1913 is on average no less than 20 per cent higher if Edvinsson's series of constant GDP is used instead of Krantz and Schön's, and on average 11 per cent higher between 1914 and 1950.[82] In so far as the choice between the two series is concerned, a final affirmation as to their usefulness will have to await future work. In the meantime Edvinsson's series is used. I divide the series of GDP by population, although in the ideal measure of economy-wide productivity performance GDP is divided by working hours or at least persons engaged. The

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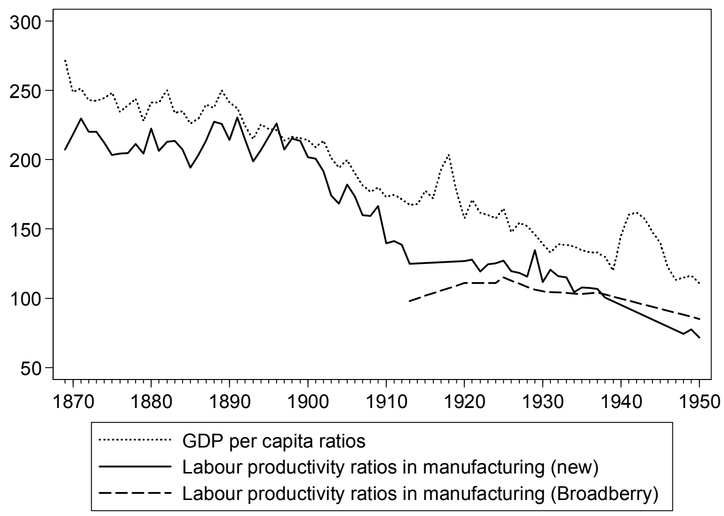
81 For a review of Swedish Historical National Account in general and more detail information on Krantz and Schön's project, see Bohlin (2003). See also Bohlin (2008).

82 The difference between the two Swedish GDP options was, however, less than one per cent in 1990 so it did not significantly affect the new benchmark that year. To make the new Swedish GDP level in 1990 comparable to the British and American I have divided it by 8.979, the price, expressed in Swedish kronor, of a Geary-Khamis dollar (Maddison 2001 p. 189).



GRAPH 4.1. UK/Sweden labour productivity ratios in the manufacturing sector, 1869–1950 (Sweden=100)

Note: The series of comparative labour productivity (new) is linked to the new benchmark for 1924 (table 4.10). The lack of annual British data explains the straight lines during the First and Second World War. The series of GDP per capita ratios is based on extrapolations from Maddison's benchmark in 1990. The series underlying the graph appear in Appendix 4.1.
Sources: Employment: Sweden: Appendix 5.1 and Jungenfelt (1959 tables 3a and 4); the UK: Broadberry (1997 table A3.1(a)). Output in manufacturing: Sweden: Appendix 5.1 and Schön (1988 table I14); the UK: Broadberry (1997 table A3.1(a)): Working hours: see table 4.7 (extrapolations between the years); GDP per capita: Sweden: Edvinsson (2005 http://www.historia.se); the UK: Maddison (2003).

difficulties in finding reliable and comparable data for employment, unemployment and annual working hours for all sectors of the economy and for the three countries justify the rejection of working hours and persons engaged in favour of population.

4.4.2. Historical evidence of long-term comparative performance

We are now ready to pass judgement as to whether the Swedish labour productivity growth in manufacturing outperformed the British and American between 1869 and 1950. Before doing so, let us first focus on Broadberry's (1997) previous evidence of the UK/Sweden productivity ratios between 1913 and 1950 (graph 4.1). Broadbery put Sweden in a group of five countries labelled 'North European' whose level and movement of productivity were set in relation to the UK.[83] He concluded that 'twentieth-century data for all five countries suggest that labour productivity in manufacturing was never far below British levels' (pp. 54–5). Thus, if these countries' levels of labour productivity never caught up with that of Britain, although they were already close behind, forces of convergence at the whole economy level in all likelihood operated elsewhere. The Swedish benchmark from which the time series are extrapolated refers to 1935, and is based on a sample of eight industries. The origin of this benchmark is Källström's (1947) minor investigation conducted in order to track the movement of productivity in Swedish manufacturing. Källström divided physical quantities by number of workers for eight industries for a number of years. His intention was never to use the information for the purpose of international comparison, yet Rostas used Källström's productivity estimates for 1935 to compute a UK/Sweden benchmark, which came to 103 (Rostas 1947 p. 40). Broadberry (1997) then used that benchmark, along with a time series projection based on series of output and employment from Statistics Sweden from 1913 to 1989, to document the movement of the UK/Sweden productivity ratio. In fact, it turns out that Rostas' original UK/Sweden benchmark of 103, although resting on a tenuous evidential basis, is not that far off from the new benchmark of 111 (table 4.10).

What makes Broadberry's UK/Sweden evidence lead us astray is instead the failure to capture the latter half of the nineteenth century. As graph 4.1 brings out in full relief, the new series of UK/Sweden productivity ratios conveys the message of a considerable Swedish productivity lag in the manufacturing industry in the decades preceding the turn of the century. Before Swedish industrialisation gained momentum in the 1890s, British labour productivity in manufacturing was more than twice as high. A broad sweep of productivity improvements set Sweden on track towards convergence with Britain around the turn of the century.[84] The spurt in productivity down to World War I contracted the ratio to no more than 125, and a second acceleration at the end of the 1930s erased the remaining part; in 1938, the Swedish labour productivity was on a par with the British, and it pulled ahead in the aftermath of World War II. The movement of relative GDP per capita looks familiar: over these eighty years relative GDP and relative labour productivity in manufacturing progressed at similar rates, with the UK/Sweden gap at the whole economy level remaining roughly twenty per cent higher than the gap in manufacturing.

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83 The other countries were Germany, the Netherlands, Denmark and Norway (Broadberry 1997 pp. 54–5).

84 See chapter 5 for a discussion of the acceleration of Swedish labour productivity after 1900.

GRAPH 4.2. US/Sweden labour productivity ratios in the manufacturing sector, 1869–1950 (Sweden=100)

Note: The series of comparative labour productivity ratios (new) is linked to the new benchmark in 1924 (table 4.10). Lack of annual American data explains the straight lines in 1869–1879 and 1879–1889 and during the First and Second World Wars. The series of GDP per capita ratios is based on extrapolations from Maddison's benchmark in 1990. The series underlying the graph appear in Appendix 4.1.
Sources: Employment: Sweden: Appendix 5.1 and Jungenfelt (1959 tables 3a and 4); US: Broadberry (1997 table A3.1(a)). Output in manufacturing: Sweden: Appendix 5.1 and Schön (1988 table I14); US: Broadberry (1997 table A3.1(a)): Working hours: see table 4.7 (interpolations between the years); GDP per capita: Sweden: Edvinsson (2005 http://www.historia.se); the US: Maddison (2003).

The US/Sweden comparison, whose constituent components are visualised in graph 4.2, contains a recognisable pattern. The ratio of American to Swedish labour productivity contracted slowly until around the turn of the century when a short era of rapid convergence set in, and lasted until the outbreak of World War I. The ratio then expanded somewhat in the 1920s, but fell quite steeply after the Great Depression.[85] At the end of the period, American labour productivity was still fifty per cent higher than Swedish. However, the ratio of the series of GDP per capita shows a different pattern. Before the 1930s it was not subjected to any forces of convergence at all. It dropped along with relative labour productivity in

[85] The Swedish labour productivity outgrowing the American in the 1930s is worth an examination of its own given all the attention devoted to the rapid technological progress which took place in the US in the interwar years (Gordon 2000; Field 2003; David and Wright 2003).

manufacturing after the Great Depression but soon returned to even higher levels during World War II. Although it dropped again to its lowest level in the wake of the war, it is doubtful whether it is possible to argue that the GDP per capita ratio contracted for the period as a whole. The substantial benefits the US economy reaped during the years preceding and spanning World War II explain why the Swedish catch-up era in the 1930s was suddenly broken.[86] Furthermore, before the Swedish catch up commenced at the beginning of the 1930s the benefits of structural transformations, accruing to the aggregate performances in both Sweden and the US, probably explains why Sweden failed to narrow the economy-wide gap (further explored in section 4.5 below).

Three aspects of this investigation into long-term productivity movements require commenting on. First, the similar evolution of the series of UK/Sweden and US/Sweden productivity ratios confirms Broadberry's evidence of a stable US/UK productivity ratio. By inference, if the UK/Sweden and US/Sweden productivity ratios contrast at similar rates the US/UK ratio remains stable over time.[87] Second, the Swedish catch-up with respect to labour productivity in manufacturing casts doubt on Broadberry's (1993, 1994b, 1997 p. 71) conjecture, based on the evidence of long-term comparative productivity movements in the UK, the US and Germany, that convergence at the whole economy level comes about mainly through structural transformation and productivity advances in sectors other than manufacturing. The story here stresses the vital part played by dynamic manufacturing industries, thereby confirming earlier literature on income convergence preoccupied with technology transfer from developed to less developed countries and emphasising the manufacturing industry as a force propelling convergence forward. It also confirms a Swedish historiography in which manufacturing in general, and progress by mechanical engineering in particular, have taken central stage. The quantitative evidence here puts flesh on the bare bones of the argument that progress by manufacturing from 1890s onwards was crucial for the rapid Swedish growth record in the twentieth century. Third, the relative size order of the two ratios, in manufacturing and in the aggregate, varies. In the UK/Sweden comparison, the economy-wide ratio is larger than that of manufacturing throughout, while in the US/Sweden comparison the opposite holds for most of the period. Sectoral shares of employment and levels of value added per worker in different sectors provide the key to understanding the relative size of the two

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[86] For an overview of American productivity gains as a result of World War II, see Field (2008).

[87] Between 1898 and 1913 the UK/Sweden ratio fell from 215 to 125 (42 per cent) and the US/Sweden ratio fell from 327 to 202 (38 per cent). Between 1920 and 1950 the UK/Sweden ratio dropped 44 per cent while the US/Sweden dropped 30 per cent. The steeper fall in the UK/Sweden ratio reflects American gains from World War II. The US/UK productivity ratio in manufacturing reached an all time high in 1950, see Broadberry (2006 p. 22).

productivity measures, which turns the searchlight on structural transformation, the theme of the next section.

4.5. Structural transformations

The changing composition of employment in different sectors over time is an unmistakable characteristic of modern economic growth. The rate of economic maturity at the outset of the period significantly affects the path economy-wide convergence follows, because the levels of value added per worker vary by sector. In general, the private service sector has the highest value added per worker, followed by manufacturing and then agriculture. A large share of labour devoted to agriculture thus implies a potential to release labour to manufacturing or private service sectors, where value added per worker tends to be larger, boosting the average level of value added per worker.[88] In addition, a large agricultural sector may also indicate that labour is almost freely available to be transferred to modern sectors of the economy. If there is surplus labour in agriculture, this transfer permits rapid growth of labour inputs in high value added industries without affecting agricultural output.[89] No direct evidence exists as to the prevalence of surplus labour in Sweden but the unusually large share of agriculture is at least indicative of the large potential gain from structural transformation (Gadd 2005). Here it suffices to tabulate the changing shares of employment in the three countries to illustrate the bearing of structural transformation on the movement of relative GDP to capita ratio. Sectoral shares of employment also give clues as to why the size orders of the ratios, in manufacturing and GDP per capita, are reversed as we change the numerator from the US to the UK.

In the UK and the US, the share of agriculture dwindled, that of manufacturing stayed constant and the share of services grew. Sweden deviated somewhat from this pattern because the share of manufacturing increased, thus underscoring again the significance we ought to attach to this sector; its productivity grew swiftly and it absorbed labour that was set free from agriculture.

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88 I refer for simplicity to the release, transfer or shift of the labour force. In practice though the change in the distribution of the labour force has been brought about primarily by changes in the distribution of new entrants into employment and not by migration of workers.

89 The argument that structural transformations matter for comparative growth rates can be traced to Kindleberger (1967), and was reiterated in a more explicit context of convergence by for instance Feinstein (1991), Broadberry (1997) and Temin (2002). It is however based on the insights of Lewis (1954) and Kuznets (1966).

TABLE 4.12. Sectoral shares of employment in the US, the UK and Sweden, 1890–1950

	1890		1910	1930	1950
		US			
Agriculture	39	Agriculture	32.0	20.9	11.0
Manufacturing/Constr./Mining	27	Manufacturing/Mining	25.0	23.5	26.5
Service	34	Construction	6.3	5.9	5.5
Total	100	Utilities	0.5	0.8	0.9
		Transport/Commun.	8.1	8.6	6.0
		Distribution/Finance/Service	26.2	33.1	40.0
		Government	1.9	7.2	10.1
		Total	100.0	100.0	100.0
		UK			
Agriculture	16	Agriculture	11.8	7.6	5.1
Manufacturing/Constr./Mining	44	Manufacturing/Mining	38.4	37.1	38.6
Service	40	Construction	5.1	5.4	6.3
Total	100	Utilities	0.6	1.2	1.6
		Transport/Commun.	7.7	8.3	7.9
		Distribution/Finance/Service	32.3	35.2	31.7
		Government	4.1	5.2	8.8
		Total	100.0	100.0	100.0
		Sweden			
Agriculture	58	Agriculture	49.6	36.6	21.7
Manufacturing/Constr./Mining	24	Manufacturing/Mining	25.1	28.0	35.4
Service	19	Construction	8.1	9.7	8.4
Total	100	Transport/Commun.	4.5	6.1	7.8
		Distribution/Finance/Service	8.2	14.0	17.7
		Government	4.5	5.6	8.9
		Total	100.0	100.0	100.0

Sources: Sweden: Jungenfeldt (1966 Appendix B table 1); the US and the UK: 1890: Maddison (1991 table 2.1); 1910–1950: Broadberry (1997 table 5.1)

In the UK, the remarkably high degree of economic maturity by the beginning of the period hampered the potential gain from structural transformation; the British potential for productivity gains accruing from reallocation of labour seems to have been exhausted as far back as the beginning of the twentieth century. Besides, the remaining part of that potential was offset by a reallocation of labour into the governmental sector in which the potential for productivity progress was circumscribed. By contrast, the large share of agriculture in Sweden implied significant gains from structural transformation. The different order of magnitude of agriculture's share of labour explains why the economy-wide UK/Sweden gap remained larger throughout than the productivity ratio in manufacturing. It also provides an explanation of the Swedish economy-wide convergence, completed around 1950. Yet, the potential for further income gains from structural transformation was still very large in Sweden at that time, but that untapped productivity potential may belong to a future story of mine.

Two distinguished American attributes go a long way to explaining the way in which the US/Sweden economy-wide ratios tended to differ. First, and similarly to Sweden, the US had a large share of the work force in agriculture at the beginning of the period. Second, much of the subsequent release of labour from agriculture was channelled into the high value-added service sectors. Both countries benefited from reallocation of labour into sectors with high value added per employee; in the US, from agriculture into distribution and finance and in Sweden, from agriculture into manufacturing and distribution and finance. However, the relatively larger contraction of agriculture in Sweden combined with more rapid rates of labour productivity in manufacturing did not result in a sustainable reduction of the American economy-wide lead. The Swedish catch-up potential was never fully realised suggesting that counteracting forces may have been at work. The answer probably concerns growth rates of productivity in sectors other than agriculture. More rapid progress in American service sectors may have offset the benefits of the Swedish backwardness, and therefore the Swedish attempt to reduce the economy-wide gap in productivity came to nothing.[90]

4.6. Conclusions

This chapter adds the Swedish catch up experience to the growing number of convergence studies preoccupied with comparative levels of labour productivity by industry. It attempts to establish benchmarks of comparative labour productivity in Sweden vis-à-vis the UK and the US for 1909, 1924 and 1935 using the industry of origin approach, mostly Rostas' method of physical quantities per worker but at times also net output per worker. Time series of output and employment are linked to the benchmark of 1924 to cover the years from 1869 to 1950. The correspondence between the time series extrapolation and the additional benchmarks in 1909 and 1924 falls well within reasonable margins of error. The long-term picture shows that the Swedish labour productivity in manufacturing grew appreciably faster than the British and American. The first episode of manifest catch-up occurred around the turn of the century, persisting until World War I. The second took place in the 1930s, right after the Great Depression. These two episodes of productivity convergence in manufacturing brought Sweden on a par with the UK in 1940s, surging ahead further until 1950. The remaining American productivity lead in manufacturing stood at 50 per cent at the end of the period.

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[90] Broadberry (2002, 2006) has recently devoted special attention to the productivity performance of market services. He shows that the superior American productivity performance in market services served to expand the economy-wide US/UK productivity gap.

In order to assess comparative performance in manufacturing in relation to that of the aggregate the chapter also presents series of GDP per capita ratios. In the UK/Sweden comparison they accompanied the contraction of labour productivity ratios in manufacturing, although the economy-wide distance exceeded that of manufacturing. GDP per capita convergence came about in the aftermath of World War II. In the US/Sweden comparison, the economy-wide ratios remained largely unchanged, but they were smaller than the productivity ratios for manufacturing at the outset of the period. Structural transformation offers clues as to why Sweden erased most of the British lead in the aggregate while failing even to narrow the American. In relation to the UK, Sweden benefited from a large flow of labour from agriculture to services and manufacturing owing to Swedish relative backwardness and British maturity. The US enjoyed the benefits of relative backwardness too, which thwarted the Swedish attempt to narrow the economy-wide distance. More rapid growth of productivity in American sectors other than manufacturing may also have played a part.

The evidence of manifest Swedish convergence of labour productivity in manufacturing contrasts with Broadberry's evidence of stability in the long-term British, American and German comparative labour productivity ratios in manufacturing. The steady comparative productivity levels prompted Broadberry to suggest downplaying the role played by technology transfers in manufacturing and instead attributing the propelling force of convergence to structural transformation and catch-up in sectors other than manufacturing. The Swedish experience speaks in favour of an older convergence literature, laying stress on the relevance of manufacturing and spill-over effects of modern technologies developed in the leading countries. It also reiterates an argument, the norm in the Swedish historiography, that the rise of a wide array of manufacturing industries around the turn of the century, especially modern ones like mechanical and electro mechanical engineering, established the foundation for prosperity and modernisation in the century which lay ahead.

Finally, the economy-wide picture confirms that a sizeable agricultural sector was one of the fundamental conditions from which the initial – and continuing – Swedish advantage of subsequently catching-up from behind arose, supporting Broadberry and others' vision of convergence. This chapter adds to the list of Swedish fundamental conditions a propensity to foster dynamic manufacturing industries outgrowing those in the leading countries. So in a sense the Swedish experience unites the two visions of convergence. We need, however, an extended list of country studies of long-term comparative productivity ratios in manufacturing to tell us whether the Swedish case was unique or commonplace.

Appendix 4.1. Output, working hours and productivity in manufacturing

TABLE A.4.1. Output in constant prices, employment and labour productivity in manufacturing in the UK, the US and Sweden, 1869–1950 (1924=100)

	UK			US			Sweden		
	Output	Work. hours	Prod.	Output	Work. hours	Prod.	Output	Work. hours	Prod.
1869	34	81	41	10	28	35	11	44	25
1870	36	83	44				11	45	25
1871	40	86	46				12	47	25
1872	41	87	47				13	50	27
1873	41	87	47				14	52	27
1874	42	87	49				15	53	29
1875	42	87	48				16	55	29
1876	42	87	48				16	55	30
1877	43	86	50				17	55	30
1878	42	85	49				15	52	29
1879	40	82	48	14	37	38	15	52	30
1880	46	87	53				16	53	30
1881	48	89	53				18	55	32
1882	51	91	56				18	56	33
1883	51	92	56				19	57	33
1884	49	87	56				19	58	34
1885	46	87	53				20	59	34
1886	46	87	53				19	58	33
1887	50	90	56				19	58	33
1888	54	93	58				20	62	32
1889	58	97	59	25	52	48	22	66	33
1890	58	100	58	27	54	50	23	67	34
1891	59	98	60	28	55	50	23	71	33
1892	55	96	57	30	58	51	24	71	33
1893	55	99	55	26	56	47	25	71	35
1894	57	97	59	26	53	48	26	73	35
1895	60	99	61	31	58	53	27	77	35
1896	68	101	67	28	57	49	31	83	37
1897	66	103	64	30	59	51	34	88	38
1898	69	104	67	34	60	57	36	93	39
1899	72	106	68	37	67	56	38	95	40
1900	71	106	68	38	70	54	40	96	42
1901	71	105	67	42	73	57	40	95	42
1902	71	106	68	48	80	61	42	94	44
1903	70	106	66	48	83	58	45	95	47
1904	70	106	66	47	78	60	48	97	49
1905	76	108	71	40	87	45	47	97	49
1906	80	110	72	57	92	62	53	102	52
1907	82	111	74	57	96	60	60	104	58
1908	75	107	70	46	86	54	55	101	55
1909	76	108	70	59	95	62	52	98	53
1910	77	112	68	61	100	62	62	101	61
1911	83	115	72	58	99	59	65	101	64
1912	87	116	74	70	104	67	69	103	67

TABLE A.4.1 – continued

	UK			US			Sweden		
	Output	Work. hours	Prod.	Output	Work. hours	Prod.	Output	Work. hours	Prod.
1913	92	120	77	73	105	70	83	108	77
1914							83	108	76
1915							96	113	85
1916							109	119	92
1917							101	119	85
1918							87	112	78
1919							87	113	77
1920	94	121	77	90	118	76	88	115	76
1921	73	94	77	73	90	81	67	89	76
1922	85	98	87	93	97	96	79	87	91
1923	91	99	92	105	108	97	88	96	92
1924	100	100	100	100	100	100	100	100	100
1925	103	100	103	112	101	110	103	101	102
1926	100	96	104	117	102	115	113	104	109
1927	110	101	109	119	99	120	119	103	115
1928	110	100	110	123	98	125	131	110	119
1929	115	101	114	136	103	132	143	135	106
1930	110	93	118	117	92	127	146	111	132
1931	102	87	118	98	78	126	126	103	122
1932	103	88	117	73	66	112	120	95	127
1933	110	90	122	86	71	121	122	92	133
1934	120	94	128	94	82	115	155	102	153
1935	131	96	137	113	87	130	170	107	159
1936	144	101	142	132	94	140	185	112	165
1937	152	106	144	141	103	136	200	118	169
1938	148	104	142	110	89	124	209	118	177
1939							232	120	192
1940							211	120	175
1941							202	119	170
1942							200	122	164
1943							221	127	174
1944							235	128	184
1945							237	133	178
1946							293	133	220
1947							342	135	254
1948	178	111	160	251	132	190	359	133	270
1949	190	112	169	236	121	195	358	131	273
1950	203	114	178	274	127	217	406	130	311

TABLE A.4.2 UK/Sweden and US/Sweden labour productivity ratios in the manufacturing industry and GDP per capita, 1869–1950 (Sweden=100)

	UK/Sweden			US/Sweden	
	New ratios, manufacturing	Broadberry's ratios, manufacturing	GDP per capita ratios	New ratios, manufacturing	GDP per capita ratios
1869	207		272	311	
1870	218		249		191
1871	230		251		188
1872	220		243		185

TABLE A.4.2 – continued

	UK/Sweden			US/Sweden	
	New ratios, manufacturing	Broadberry's ratios, manufacturing	GDP per capita ratios	New ratios, manufacturing	GDP per capita ratios
1873	220		243		185
1874	212		245		188
1875	203		248		191
1876	204		235		184
1877	205		239		191
1878	211		244		199
1879	204		228	286	192
1880	222		241		200
1881	206		241		198
1882	213		250		204
1883	214		234		193
1884	208		235		198
1885	194		226		196
1886	203		229		201
1887	213		240		208
1888	227		238		202
1889	226		250	328	207
1890	214		241	331	204
1891	230		237	341	207
1892	215		224	341	217
1893	199		215	301	196
1894	207		225	303	185
1895	217		222	332	197
1896	226		221	292	183
1897	207		214	296	189
1898	215		216	327	185
1899	214		216	311	191
1900	202		214	288	195
1901	201		209	305	210
1902	192		214	307	209
1903	174		201	277	206
1904	168		194	271	193
1905	182		200	208	205
1906	174		190	265	209
1907	160		182	232	197
1908	159		177	218	181
1909	167		180	263	200
1910	140		173	226	186
1911	141		175	204	187
1912	139		171	224	187
1913	125	98	167	202	180
1914			168		164
1915			178		163
1916			172		174
1917			193		187
1918			204		211
1919			177		207
1920	127	111	158	223	193
1921	128		171	239	205

TABLE A.4.2 – continued

	UK/Sweden			US/Sweden	
	New ratios, manufacturing	Broadberry's ratios, manufacturing	GDP per capita ratios	New ratios, manufacturing	GDP per capita ratios
1922	119		162	235	193
1923	125		160	235	207
1924	**125**	111	158	**223**	200
1925	127	115	165	241	201
1926	120		148	237	198
1927	118		155	232	191
1928	116		152	235	187
1929	135	106	146	279	183
1930	112	105	139	215	159
1931	121		133	230	147
1932	116		139	197	132
1933	115		138	204	125
1934	105		138	168	125
1935	108	**103**	135	182	127
1936	108		133	189	137
1937	107	104	133	180	138
1938	101		130	156	127
1939			120		126
1940			145		148
1941			160		176
1942			162		206
1943			158		234
1944			148		246
1945			140		233
1946			122		167
1947			113		152
1948	74		115	157	155
1949	78		116	159	150
1950	71	85	111	155	153

Note: Bold figures refer to benchmark years from which time series of relative productivity have been extrapolated.

Appendix 4.2. Output, employment and productivity by industry

The following account covers the data underlying the computation of productivity ratios by industry and lists the different industries forming the gross output weight at branch level, used to build up overall benchmarks. An industry which appears in italics signals the exact definition of it in each country's official statistics. Physical quantities are given in commensurable units while product value and total output value of industry are given in each country's currency. Unless otherwise stated all information is taken from the US Census of Manufactures (1909, 1925, 1937), the UK Census of Production (1907, 1924,

1935) and Bidrag till Sveriges officiella statistik. D. Fabriker och manufakturer (1909) and Sveriges officiella statistik. Industri (1924, 1935).

1. Engineering

Apart from the estimate of comparative productivity of bulbs in 1935, all labour productivity estimates in the group of engineering industries are based on the method of net value per worker. The official exchange rate converts dollars and pounds into kronor. The weight given to the group of engineering industries is the sum of gross output for the industries included below.

1.1. The mechanical engineering industry

This is a heterogeneous category including a variety of different products. Information on quantities exists to some extent in all countries, but in Sweden and the UK, they are given in number of units and in the US in weights. In the UK, data come from *mechanical engineering*; in the US for 1909, from *industries making more highly elaborated products* (a subgroup of *iron and steel and their products*); *agricultural implements*; *windmills* (belong to *miscellaneous industries*); *the automobile industry; bicycles, motorcycles, and parts;* and *the carriage and wagon industry*. For 1925 and 1937, data come from *machinery* and *transportation equipment, air, land and water* less *ship yards*. In Sweden, data refer to *mekaniska verkstäder*; *järnvägs- och spårvagnsfabriker;* and *andra vagnfabriker*.

TABLE A.4.3 Net output, employment and labour productivity in the mechanical engineering industry

	Net output	Number of workers	Net output per worker
US 1909	1,186,186	895,088	1,325
US 1925	4,194,256	1,178,500	3,559
US 1937	5,353,238	1,579,820	3,389
UK 1907	72,600	713,200	102
UK 1924	179,500	844,800	212
UK 1935	184,900	810,300	228
Sweden 1909	49,666	23,703	2,095
Sweden 1924	191,854	39,283	4,884
Sweden 1935	441,507	67,465	6,544

1.2. The shipbuilding industry

No comparable data for quantities exist. The earliest UK benchmark refers to 1912. Only private companies are included.

TABLE A.4.4. Net output, employment and labour productivity in the shipbuilding industry

	Net output	Number of workers	Net output per worker
US 1909	42,146	40,506	1,040
US 1925	110,883	50,224	2,208
US 1937	149,046	62,274	2,393
UK 1912	20,665	177,309	117
UK 1924	24,443	132,530	184
UK 1935	15,924	75,058	212
Sweden 1909	6,776	4,304	1,574
Sweden 1924	32,510	9,111	3,568
Sweden 1935	57,731	11,405	5,062

1.3. The electro mechanical industry

No quantitative data is available. The US data for 1909 refer to *electrical machinery, apparatuses and suppliers*, for 1925 and 1937 to *electrical machinery, apparatuses and suppliers* and *radios, tubes and phonograph* (both subgroups to the engineering industry). In the UK, data come from the *electrical engineering industry*. Data for Sweden, come from *elektriska maskiner och apparater.*

TABLE A.4.5. Net output, employment and labour productivity in the electro mechanical industry

	Net output	Number of workers	Net output per worker
US 1909	112,742	87,256	1,292
US 1925	903,310	239,921	3,765
US 1937	979,231	257,660	3,800
UK 1907	6,800	57,000	119
UK 1924	35,600	131,049	272
UK 1935	51,600	218,600	236
Sweden 1909	8,595	3,080	2,791
Sweden 1924	17,797	3,249	5,478
Sweden 1935	34,290	5,526	6,205

1.3.1. The bulbs industry

In both countries, the quantities produced consist of bulbs for ordinary use and for vehicles; in Sweden, only the first category was produced. The relative prices convert the different kinds of American bulbs into bulbs for ordinary use. The American data are taken from Rostas (1948 p. 183).

TABLE A.4.6. Physical output, employment and labour productivity in the bulbs industry

	Quantity '000 bulbs	Product value '000	Gross output of industry '000	Coverage ratio, per cent	Number of workers	Estimated number of workers	Bulbs per worker
US 1937	585,000	65,600				7,400	79,054
UK 1935	87,450	3,400				6,000	14,575
Sweden 1935	13,341	8,331	8360	100	779	776	17,192

2. Stone, clay and glass

Apart from the industries included below, a couple of other industries traditionally belong to the group of stone, clay and glass industries, and their gross outputs have therefore been added to form the gross output weight for the group of stone, clay and glass industries. For the US, for 1909, I have added the *clay products industries* and *the manufacture of glass* and for 1925 and 1937, the *stone clay and glass products*. For the UK, the gross output weight includes the wholesale value of *bricks, pottery, glass, cement etc* and for Sweden *jord och stenindustrin*.

2.1. The glass industry

Comparable quantities for *lamp chimney* and *bottles* exist for 1935. On the basis of relative prices these are converted into *bottles*. The coverage ratio is unfortunately very low owing to the large proportion of the kinds of glass for which no comparison is possible. For the earlier benchmark years the net output per worker method is used and the weighted average of unit value ratios convert pounds and dollars into kronor.

TABLE A.4.7. Physical output, employment and labour productivity in the glass industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Coverage ratio per cent	Number of workers	Estimated number of workers	Tons per worker
UK 1935	455,999	6,718	17,209	39	40,818	15,934	28,618
Sweden 1935	38,343	11,787	28,623	41	5,789	2,384	16,083

TABLE A.4.8. Net output, employment and labour productivity in the glass industry

	Net output	Number of workers	Net output per worker
US 1909	59,976	68,911	870
US 1925	182,307	69,371	2,628
UK 1924	8,200	34,179	240
Sweden 1909	6,678	4,992	1,338
Sweden 1924	13,579	5,250	2,586

2.2. The cement industry

The cement industry probably represents the epitome of an industry whose output suits the method of physical output per worker. The overwhelming proportion of output in all countries consists of Portland cement. The coverage ratio is large in all benchmark years.

TABLE A.4.9. Physical output, employment and labour productivity in the cement industry

	Quant. '000 tons	Value of product '000	Gross output of industry '000	Coverage ratio per cent	Number of workers	Estimated number of workers	Tons per worker
US 1909	11,019	53,611	63,205	85	26,775	22,711	485
US 1925	27,008	296,691	300,895	99	38,437	37,900	713
US 1937	19,509	173,315	183,201	95	26,426	25,000	780
UK 1907	2,831	3,439	3,735	92	13,860	12,762	222
UK 1924	3,189	6,987	8,071	87	12,522	10,840	294
UK 1935	5,854	8,794	9,706	91	8,278	7,500	781
Sweden 1909	220	7,064	7,064	100	1,160	1,160	190
Sweden 1924	407	16,915	16,751	101	1,478	1,492	273
Sweden 1935	740	20,299	20,624	98	1,174	1,155	641

2.3. The bricks industry

The British classification of brick production is divided into three main categories: building bricks, fire bricks and silica bricks. The Swedish output in 1909 is given in number of units, without considering types of brick, which makes the comparison crude. For the successive benchmark years the comparisons are based on a variety of building bricks.

TABLE A.4.10. Physical output, employment and labour productivity in the brick industry

	Quantity '000 bricks	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Num. of workers	Estimated number of workers	Bricks per worker
UK 1907	4,795,000	6,373	8,324	77	65,866	50,428	95,086
UK 1924	4,066,000	11,636	21,101	55	65,508	36,124	112,557
UK 1935	7,310,000	15,909	27,951	57	86,442	49,201	148,574
Sweden 1909	332,971	9,677	11,874	81	9,753	7,948	41,894
Sweden 1924	326,348	22,725	32,301	70	8,019	5,642	57,843
Sweden 1935	454,657	24,796	36,920	67	7,973	5,355	84,903

3. Wood

3.1. The sawmill industry

For the US, data come from *lumber and timber products*, including *sawmills*, *planing mills* and *logging*, while for Sweden it includes only sawmill*s* (*sågverk*) and planing mills (*hyvlerier*).

TABLE A.4.11. Net output, employment and labour productivity in the sawmill industry

	Net output	Number of workers	Net output per worker
US 1909	648,011	695,019	932
US 1925	1,149,322	585,327	1,964
US 1937	640,439	390,742	1,639
Sweden 1909	62,439	48,653	1,283
Sweden 1924	207,083	42,635	4,857
Sweden 1935	146,954	59,229	2,481

4. Paper and pulp

The total gross output weight given to the group of paper industries includes the industries below but excludes the printing and graphical industries which usually count as paper industries.

4.1. The paper pulp industry

For Sweden, data refers to the overall paper pulp quantities produced; for the US, it refers to quantities produced in *paper mills* whose production does not include *paper*. The assumption is that productivity levels of paper pulp are similar in *paper and pulp mills* and *pulp mills*. For the weighting procedure, see table 4.3.

TABLE A.4.12. Physical output, employment and labour productivity in the paper pulp industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Num. of work.	Estimated number of workers	Tons per worker
US 1935	15,901	199,673	247,192	81	26,994	21,805	729
Sweden 1935	8,555	346,686	269,817	128	16,087	20,670	414

4.2. The paper and board industry

These comparisons are based on paper and board products produced at paper mills. A variety of differently shaped products makes non-weighed comparisons rather crude. Converting the heterogeneous composition of output into comparable equivalents is only possible for 1935, however. It raises the Swedish quantity in relation to the US because of the large American share of the heavier, and less expensive, board. The UK and Sweden had similar composition of output.

TABLE A.4.13. Physical output, employment and labour productivity in the paper and board industry

	Quant. '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Number of workers	Estimated number of workers	Tons per worker
US 1909	4,500	262,918	267,657	98	75,978	74,633	60
US 1925	9,038	862,589	971,882	89	123,384	109,509	83
US 1937	12,635	887,920	957,940	93	110,809	102,709	123
UK 1907	854	13,026	13,621	96	38,642	36,954	23
UK 1924	1,285	34,869	36,981	94	47,979	45,239	28
UK 1935	2,218	38,524	40,624	95	54,515	51,697	43
Sweden 1909	214	43,807	43,807	100	7,484	7,484	29
Sweden 1924	524	171,717	175,816	98	15,360	15,002	35
Sweden 1935	864	190,535	191,710	99	16,978	16,874	51

5. Food and beverages

Total gross output of the group of food and beverages industries includes more industries than those which appear below. The US data for 1909 also includes *slaughtering and meat packing*; *butter, cheese and condensed milk industry*; *canning and preserving*; *flour-mill and gristmill industry*; *glucose and starch industry*; *manufactured-ice industry*; *rice cleaning and polishing*; *manufacture of salt;* and *sugar industry*. For 1925 and 1937, it also includes *food and kindred products*. For the UK, it includes *food, drink and tobacco* less *tobacco*, and for Sweden, *livsmedelsindustrin* less *tobaksindustrin*.

5.1. The grain milling industry

Merchant mills are considered big plants for mostly commercial activities and custom mills are small and mostly self-supporting units. The share of each category affects the comparisons in the sense that levels of output per worker are considerably higher in merchant mills. The UK and the US data for 1925 and 1937 refer only to merchant mills, making it necessary to exclude the Swedish custom mills. Problems arise though when dealing with the Swedish data. Employment is given for each category while quantity is lumped together. An estimate of the share of merchant mills' quantity is done under the assumption of equal unit values, thus the total product value of the merchant mills divided by unit value yields the estimated quantity of *merchant mills*.

TABLE A.4.14. Physical output, employment and labour productivity in the grain milling industry

	Quant. '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Num. of worker	Estimated number of workers	Tons per worker
US 1909	22,349	871,456	883,584	99	39,453	38,911	574
US 1925	17,983	1,211,366	1,298,015	93	31,988	29,853	602
US 1937	15,945	803,776	856,310	94	26,390	24,771	644
UK 1907	7,572	65,291	65,697	99	29,112	28,932	262
UK 1924	7,191	99,798	106,365	94	26,826	25,170	286
UK 1935	8,478	70,313	92,500	76	29,600	22,500	377
Sweden 1909	353	70,333	111,436	63	4,064	2,565	138
Sweden 1924	673	181,616	186,885	97	3,353	3,258	207
Sweden 1935	581	131,189	139,947	94	2,051	1,923	302

5.2. The slaughter and meat packing industry

A good share of the value of sales in the US meat packing industry consists of by-products such as hides, oleomargarine and food for cats and dogs etc. implying low coverage ratios. The assumption is that labour input per unit of by-product is similar to the labour input per unit of main product. Swine and cattle account for most of the total value of slaughtered and cured products in both countries.

TABLE A.4.15. Physical output, employment and labour productivity in the slaughter and meat packing industry

	Quantity tons	Value of product '000	Gross output of industry '000	Cov ratio per cent	Number of workers	Est. num. of worker	Tons per worker
US 1909	1,987,216	486,845	1,148,036	42	76,637	32,499	61,147
US 1925	1,283,879	516,469	3,050,286	17	120,422	20,390	62,966
US 1937	5,604,724	1,922,611	2,787,358	69	127,477	87,929	63,741
Sweden 1913	8,892	9,574	22,421	43	728	311	28,592
Sweden 1924	28,926	36,140	75,090	48	1,624	782	36,990
Sweden 1935	132,180	158,437	169,757	93	3,464	3,233	40,885

5.3. The margarine industry

The US production of margarine is closely related to the *meat packing industry* and the margarine produced consists of oleo oil, lard, milk and cream and is called *oleomargarine*. This kind of margarine is produced in Sweden too but in a minimal proportion. Differences attributed to quality are said to be in favour of the kind of margarine mainly produced in Sweden (Rostas 1948 p. 211). The UK data only exists for 1935 because margarine was earlier accounted for in the same industry as *butter* and *cheese* and represented a very small share.

TABLE A.4.16. Physical output, employment and labour productivity in the margarine industry

	Quant. '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Number of workers	Est. num. of work.	Tons per worker
US 1909	19,474	5,964	8,148	73	606	444	43,860
US 1925	76,263	34,407	39,856	86	1,639	1,415	53,896
US 1937	107,789	31,032	44,563	70	1,214	845	127,561
UK 1935	179,332	6,341	8,000	79	2,700	2,140	83,800
Sweden 1909	12,251	14,330	14,330	100	421	421	29,100
Sweden 1924	29,771	45,366	46,643	97	773	752	39,589
Sweden 1935	55,900	41,750	45,119	93	757	700	79,857

5.4. The beet sugar industry

The Swedish beet sugar industry is engaged in the production of raw sugar and in refining it, while the US plants only refine raw sugar. In the UK, beet sugar was imported until the interwar period when the government – in order to increase the rate of self sufficiency – decided to protect and subsidise home producers (Kitson and Solomou 1990). In Sweden, separate data for employment and quantities are to be found for both raw sugar and refinement, but this is not the case in the UK. Since the comparisons are based on refined beet sugar, the UK quantities for 1935 are converted on the basis of British relative unit values. The by-products, such as molasses, treacles and beet mass, are excluded.

TABLE A.4.17. Physical output, employment and labour productivity in the beet sugar industry

	Quant. '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Number of workers	Estimated number of workers	Tons per worker
US 1909	547	45,646	48,122	95	7,204	6,833	80
US 1925	1,186	124,026	132,339	94	8,872	8,315	143
US 1937	1,418	99,557	107,396	93	9,366	8,682	163
UK 1907	574	8,995	12,315	73	5,836	4,263	135
UK 1924	1,006	44,454	53,273	83	11,400	9,513	106
UK 1935	2,380	36,355	42,506	86	14,653	12,533	190
Sweden 1909	131	67,494	68,063	99	2,848	2,824	46
Sweden 1924	153	121,330	122,427	99	2,245	2,225	69
Sweden 1935	246	77,957	81,593	96	2,109	2,015	122

5.5. The brewing industry

For the UK, the employment data excludes bottling, which appears as a separate industry. The correction factor is given by the value of bottling of beer, ale, porter and stout and the brewing of beer, ale, porter and stout divided by the value of the wholesale bottling industry and the brewing and malting industry. This correction factor times the total employment of the bottling and brewing industry yields the estimated number of workers associated with the UK production of beer, comparable with Swedish and American output. Since the value of products might be influenced by taxes, the unit values are considered of no use. No American data for the brewing industry appear for 1925.

Table A.4.18. Physical output, employment and labour productivity in the brewing industry

	Quantity '000 litres	Value of product '000	Value of total output '000	Cov. ratio per cent	Num. of work.	Est. num. of workers	Litres per worker
US 1909	6,597,291	374,730	374,730	100	54,579	54,579	120,876
US 1937	6,509,159	521,881	537,105	97	47,037	45,704	142,420
UK 1907	5,645,981	65,270	80,045	82	85,749	69,921	80,748
UK 1924	3,357,249	156,476	196,561	80	69,999	55,724	60,248
UK 1935	3,580,139	110,198	122,400	90	43,946	39,565	90,488
Sweden 1909	264,082	39,349	39,349	100	6,113	6,113	43,200
Sweden 1924	207,052	80,446	83,642	96	5,556	5,344	38,745
Sweden 1935	252,996	92,688	102,575	90	5,900	5,331	47,458

5.6. The spirit distilling industry

Spirit quantities are given in litres of 50 % pure spirit. If the type of spirit affects the productivity – in the UK and the US a large share of the quantities distilled are different kinds of whisky, whereas in Sweden they mostly consist of Scandinavian vodka – then the estimates are biased. As in the case of the brewing industry, unit values are affected by taxes. The US data for 1909 is taken from Fabricant (1940 p. 412).

TABLE A.4.19. Physical output, employment and labour productivity in the spirit distilling industry

	Quantity '000 litres á 50 per cent	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Num. of work.	Estimated number of workers	Litres per worker
US 1937	627,237	98,148	113,103	87	6,215	5,393	116,306
UK 1924	154,655	5,458	7,070	77	3,979	3,072	50,343
UK 1935	232,660	3,644	4,662	78	2,757	2,155	107,963
Sweden 1924	20,076	30,928	36,814	84	478	402	49,940
Sweden 1935	22,322	33,313	37,177	90	278	249	89,647

5.7. The biscuits industry

The biscuits industry produces a variety of products with different unit values. No detailed information on the composition of output is available and the comparisons therefore must be considered quite crude.

TABLE A.4.20. Physical output, employment and labour productivity in the biscuits industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Num. of work.	Estimated number of workers	Tons per worker
US 1925	530,855	242,986	244,527	99	32,377	32,173	16,500
US 1937	638,294	197,348	208,298	95	28,791	27,277	23,400
UK 1935	244,936	16,680	16,900	99	36,495	36,020	6,800
Sweden 1924	1,186	3,351	3,713	90	293	264	4,492
Sweden 1935	3,973	5,478	6,228	88	609	536	7,412

5.8. The fish curing industry

In the UK and in Sweden around 70 per cent of the fish cured consists of herring. That does not grant straightforward comparability since different treatments, salt, smoke, pickled etc might vary considerably. The British lead is surprisingly large which might indicate that the comparison is susceptible to the manner in which the herring has been preserved.

TABLE A.4.21. Physical output, employment and labour productivity in the fish curing industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Number of workers	Est. num. of workers	Tons per worker
UK 1935	144,786	4,099	4,324	95	4,974	4,715	30,708
Sweden 1935	2,693	2,527	2,411	105	257	269	10,011

5.9. The dairy industry

Butter and cheese are the products given in physical quantities, but the comparisons aim to compare butter. For the US, quantities and employment data for butter and cheese are given separately, but for Sweden and the UK employment data includes both. Furthermore, the UK data for 1907 also includes margarine in the wholesale value of the dairy industry, which explains the low UK coverage ratio. The dairy industry did not enter the Swedish Industrial Statistics until 1913, hence the earliest benchmark year is based on Swedish data for that year. The Swedish and British output of cheese and butter is converted to butter equivalents on the basis of relative prices.

TABLE A.4.22. Physical output, employment and labour productivity in the dairy industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Num. of workers	Estimated number of workers	Tons per worker
US 1909	351,396	222,751	274,558	81	18,431	14,953	23,500
US 1925	789,117	753,777	802,271	94	21,156	19,877	39,700
US 1937	749,511	542,926	586,767	93	19,437	17,985	41,674
UK 1907	57,652	6,033	10,164	59	7,754	4,603	12,525
UK 1935	116,531	11,328	11,253	101	4,668	4,699	24,799
Sweden 1913	39,007	81,372	80,830	101	4,007	4,034	9,670
Sweden 1924	41,229	132,351	169,410	78	4,107	3,209	12,848
Sweden 1935	83,836	181,180	181,829	100	5,082	5,064	16,555

6. Textiles

The total gross output weight given to the group of textile industries includes the following: for the US, for 1909, *combined textiles* and *boots and shoes*, for 1925 and 1937, *textiles and their products* and *boots and shoes*. For the UK, *textiles* and *clothing and footwear*; and for Sweden, for 1909, *spånadsämnen* and *skofabriker* and for 1924 and 1935, *textil- och beklädnadsindustri* and *skofabriker*.

6.1. The cotton spinning and weaving industry

In general, there are two kinds of processes involved: the spinning part aiming at producing yarn and the weaving part producing woven goods. In Sweden and the US, the plants are generally integrated; yarn produced in one plant is used in the same plant as an intermediate product to produce the main product cloth, while in the UK there are separate units. It is therefore very difficult to produce separate estimates of spinning and weaving. The coverage ratio for Sweden for 1924 exceeds 100 per cent implying double counting of intermediate products. All output is converted to yarn on the basis of relative prices.

TABLE A.4.23. Physical output, employment and labour productivity in the cotton spinning and weaving industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Cov ratio per cent	Number of workers	Estimated number of workers	Tons per worker
US 1909	945,368	565,404	628,392	90	378,880	340,902	2,773
US 1925	1,159,043	1,558,199	1819,886	86	468,352	401,006	2,890
US 1937	1,324,500	1,099,637	1272,954	86	435,428	376,143	3,521
UK 1907	1,138,016	159,808	174,601	92	559,573	512,163	2,222
UK 1924	1,049,431	349,962	367,545	95	512,582	488,061	2,150
UK 1935	851,275	128,147	143,672	89	336,900	300,495	2,833
Sweden 1909	20,515	50,844	51,209	99	11,811	11,727	1,749
Sweden 1924	24,681	153,102	125,929	122	14,570	17,714	1,393
Sweden 1935	34,668	146,909	141,206	104	18,426	19,170	1,808

6.2. The wool spinning and weaving industry

As in the case of cotton, a large share of the Swedish plants is integrated making it difficult to produce separate estimates for spinning and weaving. These comparisons are based on yarn and woven goods. The yarns consist of wool, worsted or wool mixed with other kinds of fibres. All output was converted to yarn on the basis of relative prices.

TABLE A.4.24. Physical output, employment and labour productivity in the wool spinning and weaving industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Number of workers	Estimated number of workers	Tons per worker
UK 1907	163,341	53,822	75,905	71	254,378	180,372	906
UK 1924	192,556	124,250	196,771	63	261,783	165,301	1,165
UK 1935	390,008	177,386	129,716	137	227,686	311,359	1,253
Sweden 1909	12,640	64,217	65,955	97	11,524	11,220	1,127
Sweden 1924	15,743	159,483	122,040	131	12,388	16,189	972
Sweden 1935	14,913	120,802	118,677	102	13,345	13,584	1,098

6.3. The jute industry

In all countries' official statistics, the jute industry is treated as a subgroup of the line, hemp and jute industry, but the value of jute goods is by far the most important. The jute industry deals with both yarn and textiles but these comparisons are based on yarn. It implies low coverage ratios and estimates of less accuracy.

TABLE A.4.25. Physical output, employment and labour productivity in the jute spinning industry

	Quantity '000 tons	Value of product '000	Value of total output '000	Cov. ratio per cent	Number of workers	Estimated number of workers	Tons per worker
US 1909	68,731	5,434	10,795	50	6,664	3,355	20,486
US 1925	97,025	19,287	27,517	70	6,312	4,424	21,932
US 1937	115,946	14,787	25,565	58	6,522	3,772	30,739
Sweden 1909	5,560	3,093	6,523	47	1,528	725	7,669
Sweden 1924	4,129	4,099	6,768	61	1,453	880	4,692
Sweden 1935	7,030	5,349	7,399	72	1,324	957	7,346

6.4. The binder twine industry

Repslagerier in Sweden is the closest equivalent to the production of binder twine and twine in the UK and the US. The earliest benchmark year is based on Swedish data for 1913 since the productions of binder twine entered the Swedish Industrial Statistics that year. Since parts of the quantities produced come from the jute industry, the coverage ratios in Sweden exceeded one hundred per cent in 1913. In the US, the most common fibres are Manila and Sisal hemp. No such detailed information is available for the UK and Sweden.

TABLE A.4.26. Output, employment and labour productivity in the binder twine industry

	Quant. '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Num. of work.	Est. number of workers	Tons per worker
US 1909	229	42,865	61,020	70	25,820	18,138	12.6
US 1925	260	107,959	139,122	78	24,492	19,006	13.7
US 1937	190	64,158	66,142	97	14,043	13,622	13.9
UK 1907	72	3,289	3,953	83	13,323	11,085	6.5
UK 1924	101	7,495	8,556	88	14,965	13,109	7.7
UK 1935	102	4,584	5,536	83	13,956	11,556	8.8
Sweden 1913	3.3	3,215	2,694	119	463	553	5.9
Sweden 1924	6.8	7,860	8,104	97	617	598	11.3
Sweden 1935	8.8	6,590	7,110	93	788	730	12.1

6.5. The hosiery industry

There is no data for physical quantity available which means the net output per worker method is used instead. The weighted average of unit value ratios converts dollars and pounds into kronor.

TABLE A.4.27. Net output, employment and labour productivity in the hosiery industry

	Net output	Number of workers	Net output per worker
US 1909	89,156	128,708	693
US 1925	356,034	186,668	1,907
US 1937	330,485	231,064	1,430
UK 1907	3,139	47,687	66
UK 1924	15,421	90,092	171
UK 1935	17,262	105,622	163
Sweden 1909	4,966	3,077	1,614
Sweden 1924	16,540	4,460	3,709
Sweden 1935	32,341	9,672	3,344

6.6. The hat and bonnet industry

TABLE A.4.28. Physical output, employment and labour productivity in the hat and bonnet industry

	Quantity '000 dozen	Value of product '000	Value of total output '000	Coverage ratio Per cent	Num. of workers	Estimated number of workers	Dozen per worker
UK 1935	4,891	8,599	10,719	80	28,133	22,569	217
Sweden 1935	381	15,055	14,617	103	2,198	2,264	168

6.7. The shoes and boots industry

In the US, the production of shoes is divided into three parts, *boot and shoes*, *boot and shoe cut stock* and *boot and shoe findings*. The latter two are specialists whose products are bought by the main industry, the first one, boot and shoe industry. An adequate procedure is to treat them as one industry and add the employment of the two together.

TABLE A.4.29. Physical output, employment and labour productivity in the shoes and boots industry

	Quantity '000 pair of shoes	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Number of workers	Estimated number of workers	Pair per worker
US 1909	285,017	442,631	512,798	86	198,297	171,164	1,665
US 1925	323,553	923,279	1,061,667	87	222,794	193,753	1,670
US 1937	424,971	765,621	900,590	85	234,193	199,095	2,135
UK 1907	99,387	20,225	23,011	88	117,565	103,331	962
UK 1924	118,956	47,496	55,637	85	131,247	112,042	1,062
UK 1935	132,468	37,619	40,180	94	108,649	101,724	1,302
Sweden 1909	6,422	41,044	41,990	98	7,357	7,191	893
Sweden 1924	7,851	93,800	92,877	101	9,770	9,867	796
Sweden 1935	8,201	72,584	74,277	98	10,423	10,185	805

7. Chemical and allied products

In the US data for 1909, the gross output weight for the group of chemical and allied industries includes *chemical and allied industries*; the *coke industry*; the *manufacture of gas*; *petroleum refining*; the *soap industry;* and the *turpentine and rosin industry* and for 1925 and 1937, the *chemicals and allied products* and *products of petroleum and coal*. For the UK, it includes the *chemicals and allied industries* and *coal and petroleum products*. For Sweden it includes *kemisk-teknisk industri*.

7.1. The paint and varnish industry

In all three countries paint and varnish are recorded jointly in the paint and varnish industry, but the physical quantity of varnish is given in incomparable physical units. Therefore the comparisons are based only on paint which gives low coverage ratios

TABLE A.4.30. Physical output, employment and labour productivity in the paint and varnish industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cnet	Num. of workers	Estimated number of workers	Tons per worker
US 1909	413,771	43,500	94,572	46	11,864	5,457	75,824
US 1925	968,082	164,029	470,736	35	25,490	8,882	108,994
UK 1924	251,673	10,842	17,950	60	13,523	8,168	30,812
UK 1935	530,000	16,080	22,140	73	15,597	11,328	46,787
Sweden 1909	3,471	1,414	3,591	39	375	148	23,453
Sweden 1924	7,206	4,335	8,798	49	457	225	32,027
Sweden 1935	16,857	11,674	21,679	54	918	494	34,123

7.2. The soap, candle and perfumery industry

Soap is the only product given in physical quantity. In the UK and Sweden, soap has for some years been treated as a subgroup in the soap, candles and perfumery industry. In Sweden, this is the case for 1924 and 1935; for 1909, there is separate data for soap and the same is the case for all US benchmark years. To make the estimates more accurate the same products are included in wholesale value of the trade, which yields more similar coverage ratios in the three countries if somewhat less accurate estimates for a particular country.

TABLE A.4.31. Physical output, employment and labour productivity in the soap, candle and perfumery industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Num. of workers	Estimated number of workers	Tons per worker
US 1909	413,771	43,500	94,572	46	11,864	5,457	76
US 1925	968,082	164,029	470,736	35	25,490	8,882	109
UK 1924	251,673	10,842	17,950	60	13,523	8,168	31
UK 1935	530,000	16,080	22,140	73	15,597	11,328	47
Sweden 1909	3,471	1,414	3,591	39	375	148	24
Sweden 1924	7,206	4,335	8,798	49	457	225	32
Sweden 1935	16,857	11,674	21,679	54	918	494	34

7.3. The seed crushing industry

The comparison is based on the main product oil and the by-product cake. The only benchmark year is 1909 because Swedish employment data for the by-products cake and meal and the main product oil is missing for later years. In Sweden, linseed oil, cocoa oil and soya oil are produced in equal proportions while in the US, the refinement of cotton seed accounts for the major part. In the UK, all these products appear. Thus, there is no perfect match making the comparisons crude.

TABLE A.4.32. Physical output, employment and labour productivity in the seed crushing industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Number of workers	Estimated number of workers	Tons per worker
US 1909	1,601	91,100	147,868	62	17,071	10,517	152
UK 1907	1,349	12,940	12,961	100	6,805	6,794	199
Sweden 1909	28	6,175	6,804	91	167	152	184

7.4. Matches

Matches are given in physical quantity but in different units, by weight in Sweden and by number of units in the UK and the US. The net output per worker method is used instead. The weighted average of unit value ratios converts pounds and dollars into kronor.

TABLE A.4.33. Output, employment and labour productivity in the matches industry

	Net output	Number of workers	Net output per worker
UK 1907	446	3,865	115
UK 1935	1,517	3,384	448
Sweden 1909	9,963	6,799	1,465
Sweden 1935	11,297	2,574	4,389

7.5. The explosives industry

The estimates are based on different kinds of blasting powders and dynamite.

TABLE A.4.34. Physical output, employment and labour productivity in the explosive industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Number of workers	Estimated number of workers	Tons per worker
UK 1924	24,029	2,457	5,328	46	7,681	3,542	6.8
Sweden 1924	3,742	9,947	9,313	107	674	720	5.2

7.6. The fertiliser industry

This category includes fertilisers of different kinds: superphosphates made from minerals, bones, ammoniated fertilisers, concentrated phosphates and ready-made fertilisers. In Sweden, most of it is superphosphates; in the US, mostly ready-made fertilisers; and no detailed information is available for the UK. Most of the quantities in the UK are produced by manufacturers not classified as part of the fertiliser industry; hence, the comparison includes only the amount produced by the fertiliser industry. For the UK, the low coverage ratios for 1907 and 1924 are due to by-products and ancillary products produced by the fertiliser industry.

TABLE A.4.35. Physical output, employment and labour productivity in the fertiliser industry

	Quantity '000 tons	Value of product '000	Gross output of industry '000	Cov. ratio per cent	Number of workers	Estimated number of workers	Tons per worker
US 1909	4,604	92,370	103,960	89	18,310	16,269	283
US 1925	9,070	195,040	206,773	94	19,644	18,529	490
US 1937	10,250	167,901	195,759	86	20,893	17,920	572
UK 1907	1,166	3,542	5,861	60	10,802	6,528	179
UK 1924	753	3,662	8,347	44	8,912	3,910	193
UK 1935	2,101	7,005	7,348	95	7,148	6,814	308
Sweden 1909	144	6,742	6,742	100	876	876	164
Sweden 1924	222	14,450	15,975	90	960	868	256
Sweden 1935	281	14,121	13,896	102	528	537	523

Chapter 5

Yeast or Mushrooms?

Productivity Advances in the Swedish Manufacturing Industry, 1868–1912

5.1. Introduction

Arnold C. Harberger, in his 1998 presidential address to the American Economic Association, made a distinction between growth processes characterised as either mushrooms or yeast. In a 'yeast-like' process the parts of a system expand simultaneously in response to common stimuli while in a 'mushroom-like' process the parts expand randomly without any identifiable, single cause. The analogy draws inspiration from the evenness with which yeast causes bread to expand whereas mushrooms tend to crop up in a very unpredictable fashion. Harberger deployed this dichotomy for real cost reductions at the firm or industry level, as measured by a large residual in growth accounting, where yeast symbolises a balanced and mushrooms an unbalanced growth process. Behind this metaphoric and admittedly witty characterisation lurks a particular vision of how cost reductions at the level of the firm or industry are really achieved. If magnitudes of real cost reductions tend to be uniformly distributed among different industries, and particularly among different firms in the same industry, it is appropriate to think of a factor x, let us say human capital, or just knowledge, shifting production functions of firms economy wide. This vision of progress may be captured in a simple model allowing outcomes of different policies to be predicted. If, however, cost reductions are largely concentrated to a few industries, perhaps also to a few firms within an industry, one may rather think of cost reductions as 'stemming from 1001 different causes' (Harberger 1998 p. 5). If this latter picture of reality is more apt, the importance of generalised externalities so often claimed by authors cannot be justified. Based on some late (1970–1994) twentieth century evidence of total factor productivity (TFP) growth rates, broken down into a mosaic of experiences in American industries and Mexican firms, that is what Harberger endorses; the growth process resembles mushrooms rather than yeast. High rates of TFP growth were largely localised to a few industries, while the majority of industries and firms achieved modest real cost reductions or even real cost increases. Also, there was no persistence in the rank of industries. Leading industries in one time period slid into decline in the other.

However, as an economic historian, one would like to know more about what a fuller record would reveal, one that extends the limitation in time and place of Harberger's minor investigation. Will it, too, confirm the mushroom-like advance of cost reductions that Harberger envisions? A cursory scan of the literature preoccupied with past experiences of TFP growth rates in manufacturing industries discloses two things: First, evidence of TFP growth rates in separate manufacturing industries is scarce, especially in the pre-World War I era. Second, the literature has mainly been engaged with the idea of general purpose technology (GPT), and the whole idea of GPT is partly at odds with Harberger's vision of real cost reductions popping up like mushrooms in a field. For instance, David and Wright (2003) have called attention to the steep economy wide acceleration in TFP growth rates in the decades ensuing World War I, both in Britain and the US, with particular emphasis on the marked improvements in the manufacturing sector. Not only did growth rates of TFP accelerate for manufacturing as a whole, but 13 out of 14 separate groups of industries experienced acceleration in multifactor productivity, or what Harberger would call real cost reductions. Moreover, the overachievers were scattered over a wide array of industries, evidence of which, according to David and Wright, reflected broad and generic responses to common underlying mechanisms. They trace the factors impinging so widely on the rate of progress among different industries to engineering and organisational advances associated with the electrification of industry. For them 'the dynamo' embodies the idea of a general purpose technology and the interwar years the era when the diffusion and application of electricity culminated, which paved the way for fixed-capital savings and increased labour productivity. Thus their vision of the growth process, closely resembling the yeast-like expansion of uniform progress, stands in sharp relief against the Harberger's pro-mushroom evidence for the late twentieth century.

While the evidence of growth rates from the US and the UK in the interwar years seems to contradict the mushroom side of the dichotomy, the scattered evidence of growth rates in the pre-World War I period shows a less uniform pattern; more resembling the mushroom metaphor (Crafts 2000).[91] In fact the revisionists' view of the industrial revolution in Britain lends support to Harberger's vision of growth, although it must be conceded that evidence of TFP growth for particular industries is in scarce supply. For revisionists, the story of the industrial revolution is centred on the role played by a few new and dynamic

91 Sokoloff's (1986) exploration of early (1800-1860) productivity growth in American Northeast is an exception. He found that all industries grew at rates that were similar. The lack of an unbalanced growth pattern came as a surprise as the sample included both capital and labour intensive industries.

sectors of the economy, industries which made use of new technologies and sources of energies. The rest of the economy was dominated by older modes of production, mostly with handicraft-like techniques. It would take many decades for the more dynamic sectors to make an appreciable impact on the aggregate when the traditional sector was growing slowly, less than one per cent or so (Mokyr 1993). In the late nineteenth century, the British and the American evidence indicates that high growth rates were localised to few industries (Kendrick 1961; Matthews *et al*. 1982).

For the pre-Word War I era there is scarce evidence of TFP for manufacturing industries to bring to bear on the challenging issues raised by Harberger's vision of the growth process, owing to the scarceness of early censuses of manufactures and the laborious effort required to uncover old firm records from archives. The purpose of this project is therefore to add the Swedish experience to the short list of countries for which evidence of TFP growth rates in manufacturing industries exists, and to discuss how that experience relates to the previous discussion on the (past) nature of progress in manufacturing industries. While a peripheral country largely unaffected by the First Industrial Revolution in Britain at the end of the eighteenth century and the advent of industrialisation in some neighbouring countries a few decades later, Sweden entered a path of rapid growth and industrialisation as the nineteenth century drew to a close. The growth of the Swedish economy was manifestly linked to the progress made by the manufacturing industry, which makes it an object suited for close study. What facilitates this effort is the annual publication of the Swedish Industrial Statistics since its appearance in the mid-nineteenth century.

However, the empirical ground needs to be established before the intriguing issues of growth patterns can be addressed. At the risk of boring the reader, a fairly long detour to gather consistent evidence of output and employment for a large sample of industries is required before a systematic treatment of labour and total factor productivity is possible. As previous writers have made clear to the entire readership of Swedish economic history, our knowledge of manufacturing output based on the Swedish Industrial Statistics is patchy.[92] The reason is that a number of important industries were omitted or covered inadequately until at least 1896. The chapter therefore combines with previous attempts within

[92] Three of these previous efforts made by distinguished Swedish scholars represent pillars in the historiography of Swedish economic history. They have all prepared the ground for what has been accomplished here. In being more narrowly concerned with manufacturing output as given by the Swedish Industrial Statistics, Jörberg (1861) antedates and resembles this project. The other two, Lindahl et al. (1937) and Schön (1988), are parts of a larger project within Swedish Historical National Accounts (SHNA). As this project relates closely to what these previous studies contain, I am sometimes inclined to look at them with painstaking attention to details. The few critical notes which found their way into the final text are by no means intended to disparage these authors' great achievements.

Swedish Historical National Accounts (SHNA) to construct reliable series of output in the Swedish manufacturing industry. These previous attempts have contributed mainly through adopting ingenious methods to fill in the many gaps and deficiencies in the Swedish Industrial Statistics pre-1913. Holes and insufficiencies are in plenty. Thanks to these efforts we now have more reliable evidence of gross output and value added for groups of industries and manufacturing as a whole. What we do not have is, however, corresponding estimates of the number of workers. A first objective of the data collecting part of this chapter is therefore to match output as given by the Swedish Industrial Statistics and complementary studies with estimates of the number of workers. A second objective is to create a series of manufacturing industries proper, thus excluding the value of handicraft production and public utilities that previously was included in the series of output (Schön 1988). This requires the construction of new price deflators. The third objective is to establish net output in current and constant prices. Thereafter, to pave the way for the final analytical part of the chapter, I address the problems of estimating TFP when there is a conspicuous absence of information on capital investments. The preferred solution in much economic history literature is to compute TFP by using prices of wages, capital and final products, commonly referred to as the dual approach. It turns out to be impracticable because there is no information on capital returns for separate industries. The closest we can get to the true value of TFP is labour productivity times labour's share of value added while invoking the assumption of constancy in the movement of output to capital ratio. The estimates of TFP so constructed are used in the final, analytical part of the chapter to lay bare the pattern of real cost reductions among industries.

5.2. Gross output in the Swedish Industrial Statistics

The Swedish Industrial Statistics[93] represents a unique source of information on output in manufacturing industries. The uniqueness lies in its early and frequent publication. It was published for the first time in 1858 and has appeared annually since.[94] In contrast, the British Census of Production was published in 1907 and appeared every second year thereafter. The US Census of Manufactures was first published in 1810 and appeared decennially until 1909. The Swedish Industrial Statistics requested firms to return information on gross output and number of workers in surveys. It excluded all industries closely related to forestry and

93 Bidrag till Sveriges officiella statistik. D. Fabriker och manufakturer.

94 The Swedish Industrial Statistics began to be published in 1858 but the primary material is available annually in archives for the whole nineteenth century. Thus the statistical agency requested firms to send in returns long before it was made available in published form. The quality of that material deteriorates the further back in time we go, however.

agriculture, which implied the omission of, for instance, dairies (incorporated in 1913) and sawmills (incorporated in 1896). Over the course of time it gradually improved the coverage, yet remained filled with lacunas until at least 1896. Some industries were not recorded at all and others inadequately so.

Patching the holes in the Swedish Industrial Statistics has occupied two out of six generations of SHNA.[95] The starting point was to estimate gross output for unrecorded industries by drawing on alternative sources, such as trade statistics and various public investigations, or by using movements of intermediate input materials as proxies for final products. The pioneering undertaking was started in 1937 by the authors of the first generation of SHNA, Lindahl *et al.* (1937). They estimated gross output for the following industries: sawmills (1860–1896), brickworks (1860–1872), book printing (1896–1930), flour mills (1860–1895), slaughter houses (1885–1890), spirit factories (1890–1981), dairies (1860–1912, and charcoal manufacturing (1860–1895). They divided the manufacturing sector into nine broad categories, a division which followed the more modern, post-1913 version of the Swedish Industrial Statistics. It would take more than fifty years before the next major revision was undertaken. With meticulous care Schön (1988) revised some of Lindahl *et al.'s* (1937) estimates of output and incorporated more of what the Swedish Industrial Statistics left unrecorded. He retained their nine-sector division. The scholarship and authority with which we associate these efforts affirm that the many gaps in the Swedish Industrial Statistics have been bridged satisfactorily, thereby improving our knowledge of movements in gross output for separate industries and the aggregate.

After briefly describing these authoritative efforts to escape our reliance on the Swedish Industrial Statistics it may seem paradoxical to return to it again, but that is the only option at hand if we want to explore productivity advances at the level of separate industries. There is great scope to expand our knowledge by looking more closely at the Swedish Industrial Statistics. Jörberg (1961), in his magisterial enquiry into the growth and fluctuations of Swedish industry, for the period 1869–1912, was to my knowledge the first scholar to make more systematic use of the detailed if fragmentary evidence of output and employment it provides. He argued persuasively that it could be used to assess the performance of the various manufacturing industries because the coverage was, if defective, at least representative. He was fully aware of all the weaknesses and gaps in the material of the Swedish Industrial Statistics since he subjected it to close scrutiny. To ensure the usefulness of it he consulted the primary sources underlying the final publications of the following volumes: 1872, 1880, 1889, 1897, 1903 and 1912, and furthermore collated information on some large enterprises' internal bookkeeping and the figures they submitted to the statistical

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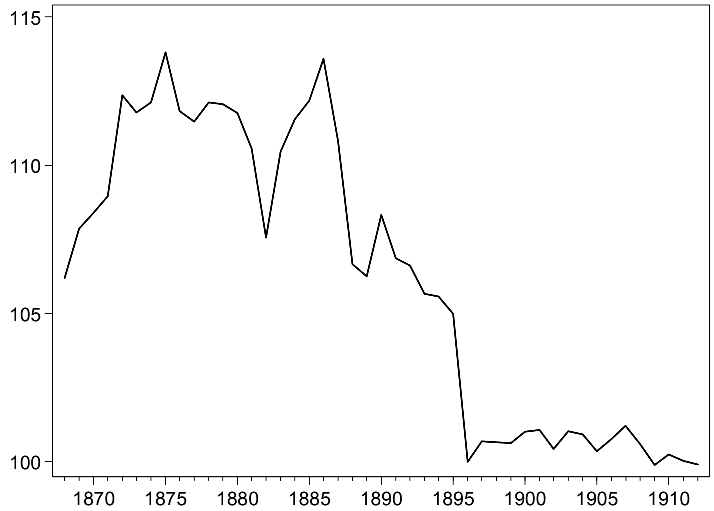
[95] Bohlin (2003), in a review article, dealt with five generations of SHNA but Edvinsson (2005) has since contributed to what may in fact be the sixth generation.

TABLE 5.1. The classification of manufacturing industries

	Output and employment from the Swedish Industrial Statistics	Output elsewhere
1. Iron, metal and engineering		
1.1. Mechanical eng, ironware and foundry	1868–1912	
1.2. Metal	1868–1912	
1.3. Shipyard	1872–1912	1868–1871
1.4. Electro mechanical	1885–1912	
1.5. Iron mines	1868–1912	
1.6. Iron and steel work	1868–1912	
2. Stone, clay and glass		
2.1. Glass	1868–1912	
2.2. Chinaware and tile	1868–1912	
2.3. Quarrying and refined stone products	1868–1912	
2.4. Cement	1874–1912	
2.5. Bricks	1873–1912	1868–1872
2.6. Coal	1868–1912	
3. Wood		
3.1. Sawmills and planing mills	1896–1912	1868–1895
3.2. Refined wood products	1872–1912	
4. Paper		
4.1. Pulp	1868–1912	
4.2. Paper	1868–1912	
4.3. Book printing	1868–1912	1896–1912
5. Food		
5.1. Flour mills	1896–1912	1868–1912
5.2. Pork butchery	1891–1912	1885–1890
5.3. Margarine	1894–1912	
5.4. Sugar	1868–1912	
5.5. Tobacco	1868–1912	
5.6. Chocolate and candy	1868–1912	
5.7. Brewery	1872–1912	1868–1871
5.8. Spirit	1892–1912	1868–1891
5.9. Bakery	1890–1912	
5.10. Dairy		1868–1912
5.11. Miscellaneous food industry	1868–1912	
6. Textile and clothing		
6.1. Textile	1868–1912	
6.2. Clothing	1868–1912	
7. Leather, hair and rubber		
7.1. Tannery	1868–1912	
7.2. Products of leather and fur	1868–1912	
7.3. Shoes	1868–1912	
7.4. Rubber	1868–1912	
8. Chemical		
8.1. Paint	1868–1912	
8.2. Soap and detergent	1868–1912	
8.3. Oil	1868–1912	
8.4. Matches	1868–1912	
8.5. Explosives	1868–1912	
8.6. Charcoal	1898–1912	1868–1912
8.7. Chemicals and fertilizers	1868–1912	



GRAPH 5.1. The ratio of the new gross output level to Schön's gross output level, 1868–1912

Sources: Gross output in current prices for manufacturing and handicraft from Schön (1988 table I1) minus gross output in current prices of handicraft production (table 15) gives the denominator. The numerator is set out in Appendix 5.1 and Appendix 5.3 contains a detailed description of the sources.

authorities. He concluded that there was a good measure of agreement and that we have no grounds to expect that the exclusion of some production units implies any systematic bias. Thus, Jörberg's detailed account of the Swedish Industrial Statistics and final affirmation of its usefulness justify the reuse of this rich source of information. His work precedes much of what forms the basis of my effort and it supplies complementary information from primary sources. At the time his research was conducted, Jörberg lacked adequate series of prices for final and intermediate goods, which prevented him from exploring labour and total factor productivity. Today we are better equipped, thanks to Jörberg himself (1972a) and Ljungberg (1990), who have provided a wealth of information on prices for single products and price indices for various groups of industries.

My compilation of output and employment sticks to the allocation into 9 separate groups of industries which was established by SHNA, though I have excluded handicraft production and public utilities such as heating and power plants, since they are not generally considered manufacturing industries. Each group of industry is furthermore subdivided so as to comprise 41 industries in total (table 5.1).[96] The exclusion of handicraft production merits a brief note. Schön (1988) estimated gross output of handicraft production on the basis of assumed incomes for handicraft workers. As no evidence of wages for handicraft workers exists, wages for workers in similar manufacturing industries were used as proxy. In other words, average annual wages for manufacturing workers times the number of handicraft workers were used to estimate current gross output for handicraft production. I have no objection to this solution, but it is desirable to exclude the value of handicraft production as the intention here is to address productivity advances for manufacturing industries proper. The value of handicraft production is processed; hence, we do not know its true production value or growth rate of labour productivity needed to transform the series in current prices into volumes. Handicraft production constituted a large if declining share of the manufacturing industry in the latter half of the nineteenth century, so Schön's decision to incorporate it affects our perception of productivity growth in the manufacturing industry. In all likelihood the growth of labour productivity in handicraft production was unimpressive.

The reliability and coverage of the information given by the Swedish Industrial Statistics is of uttermost concern to this investigation. A large gap in the Swedish Industrial Statistics manifests itself as a wide margin between a gross output level based on only the Swedish Industrial Statistics and Schön's (1988) gross output level which incorporates all additional information. However, after adding all the additional estimates to the series based on the Swedish Industrial Statistics, I have in fact established levels of gross output which at times surpass Schön's levels of gross output.[97] In for instance the iron, metal and engineering industry my level of gross output exceeds Schön's by around 20 per cent in 1870–1880, and in the food industry it exceeds his by on average 13 per cent before 1896. It is difficult to uncover the reasons for this discrepancy because of the high level of aggregation in both Lindahl *et al.* and Schön. In the iron, metal and engineering industry a potential source of divergence concerns the multiplication of price indices by series of physical quantities. Output and employment for mining and closely related parts of manufacturing, for instance the production of pig iron and bar iron, appear in a volume separate from the rest of manufacturing.[98] Before 1896 it gives physical quantities instead of current value of gross output. To assign these quantities a monetary value comparable to the other series of current gross output, I have

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[96] My classification of these 40 industries is almost identical to Ljungberg's (1990 pp. 512-24), which makes the application of his price deflators to establish volume gross output straightforward. All information on gross output and employment is taken directly from the Swedish Industrial Statistics unless otherwise stated.

[97] In Appendix 5.3 I discuss the extent to which my different groups of industries' gross output levels differ from Schön's.

[98] Bidrag till Sveriges officiella statistik. C. Bergshandteringen.

multiplied series of quantities by series of corresponding prices. In historical national accounts this procedure is more common the farther off in history we direct our attention because physical quantities are easier to come by than current gross output value.[99] The same series of prices are then used to convert these series of current gross output to series of constant gross output.[100]

Over time the Swedish Industrial Statistics incorporated a growing share of the manufacturing sector. This gradual incorporation of more establishments implies a spurious impression of surging growth rates. The problem appears above all in 1891, 1892 and 1896, when the Swedish Industrial Statistics underwent a number of revisions, and has in my view not been properly dealt with by either Lindahl (1937) or Schön (1988).[101] I have tried to even out some series of current gross output and employment, for instance book printing, for which there existed a striking discontinuity in 1896. The solution was to extrapolate backwards from that year when the Swedish Industrial Statistics sharply improved the coverage or in any other way changed its classification, assuming that the movement of output and employment for previously excluded industries followed the included ones. In many cases this amounts to nothing but pure guesswork. However, this quick fix does not affect significantly the relation between output and employment over time for that particular series though it raises the levels of output and employment. It attributes to that particular series a larger weight in the combined measure, which in turn implies that its rate of productivity change leaves a more visible mark in the aggregate record. After all, that is one of the things we want to achieve.[102]

5.3. Employment

Whereas Lindahl *et al.* and Schön have sufficiently remedied the shortcomings of the pre-1913 output figures provided by the Swedish Industrial Statistics, the

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99 Most of the British historical national accounts for the nineteenth century have been constructed by multiplying indices of quantities by indices of prices.

100 As Broadberry (2003) points out, it is important to deflate the series of current gross output thus constructed by the same series of prices. Otherwise one may run into difficulties defining what the series of constant gross output really represent.

101 Admittedly, for the large industries entering the Swedish Industrial Statistics at different stages, first Lindahl *et al*. and then Schön have filled the vacuum for the preceding years. For instance, in 1891 pork butcheries accounted for around 80 per cent of the new industries that year; in 1892 spirit distilleries accounted for eighty per cent; and in 1896 sawmills and flour mills accounted for ninety per cent (Lindahl *et al*. pp. 174–7). For smaller industries the problem with discontinuities persisted.

102 The crucial problem concerns the rate of change between the year of increased coverage and the previous one. In some cases it is possible to infer from the movement of similar industries the likely rate of change for that particular year. If that option is unavailable, a prediction based on previous years' growth rates may serve as a guideline.

corresponding number of workers has faded into the background, implying that there is scarce evidence to bring to bear on issues of labour and total factor productivity advances within and between industries.[103] Paucity of employment data, moreover, makes it hazardous to say something about the share of wages in value added.[104] In sum there are two problems that are urgently in need of solutions. First, when the coverage of an industry's output and employment in the Swedish Industrial Statistics was defective and Lindahl *et al.* and Schön raised the level of gross output. Second, when the Swedish Industrial Statistics failed to record output altogether and Lindahl *et al.* and Schön filled that output gap with complementary information. Jungenfelt (1959, 1966), in his pioneering studies of the share of wages in value added, was the first author who attempted to bridge the gap between the number of workers as given by the Swedish Industrial Statistics and the higher level of gross output as estimated by Lindah *et al.* (1937). The part of his work that concerns employment is therefore the predecessor of my attempt here to make the number of workers given by the Swedish Industrial Statistics correspond with the even higher level of output as estimated by Schön (1988). Like Lindahl *et al.* (1937), Jungenfelt (1959) divided the manufacturing sector into three parts. The first concerned employment given by the Swedish Industrial Statistics. The second and more challenging part dealt with the industries it ignored and whose gross output was estimated by Lindahl *et al.* (1937). The third part, which this study disregards, dealt with small-scale production units and above all handicraft workers. Let us start with the former and easier to handle problem. To derive the number of workers in industries with faulty coverage, Jungenfelt and I depend on the basic assumption that the gross output to worker ratios for the production units included in the Swedish Industrial Statistics do not differ significantly from the gross output to worker ratios for the production units left out of account. The assumption works so long as the Swedish Industrial Statistics did not systematically exclude small and mainly handicraft-like production units with likely different gross output per worker ratios, whose output was estimated and incorporated by either Lindahl *et al.* (1937) or Schön (1988). Formula (5.1), where Q represents gross output, E represents employment and the subscript *census* signals that the information refers to the Swedish Industrial Statistics, and the subscript *estimated* that it was attained from Schön or Lindahl *et al*, elucidates the procedure at work as long as this basic assumption holds. The *correction factor*, put there to reckon with the

[103] Holmquist (2003) may serve to illustrate the drawback of studying productivity without reliable employment figures. He constructed capital stocks for groups of industries and manufacturing as a whole for 1870-1930, but lack of employment figures prevented him from computing TFP growth rates for the same groups of industries before 1890.

[104] Schön (2004b) may serve to highlight the problems of studying the wage share for manufacturing as a whole without employment figures. He based the estimate of the wage share on only the industries whose employment figures were reported in the Swedish Industrial Statistics.

eventuality that it does not, then becomes one. However, in for instance the flour mill industry the Swedish Industrial Statistics excluded all small production units.[105] One may infer from Jörberg's (1961 appendix III) compilation of industries classified by size groups that the excluded firms' productivity levels were substantially inferior to the included industries' because the gross output to worker ratio for the largest size group was approximately 250 per cent of the gross output to worker ratio for the smallest size group. The correction factor in formula (5.1) then becomes 2.5, thus raising the estimated level of employment above the level that would have been established had we invoked the assumption of equal productivity.

$$Employment = E_{census} + Q_{estimated} * \frac{E_{census}}{Q_{census}} * \text{correction factor} \qquad (5.1)$$

Let us now turn to the latter and arduous problem that appears as a result of a complete output gap in the Swedish Industrial Statistics and was later filled in by Lindahl *et al.* and Schön. Jungenfelt employed a variety of assumptions and techniques. In some cases he assumed that the constant gross output per worker ratio as found in the Swedish Industrial Statistics for later years held for earlier years too (brickworks, shipyards, slaughter houses, spirit factories and breweries). For flour mills he assumed that constant gross output increased by a factor of two from 1870 to 1896 and for charcoal manufacturing in 1870–1898 he assumed that the average annual change in productivity was the same as between 1898 and 1930. For sawmills and dairies he assumed a constant cost share of wages in gross output. In the sawmill industry he used the year 1896, when the number of workers appeared for the first time in the Swedish Industrial Statistics, to compute the wage sum and the wage share of gross output. He concluded that wages accounted for 23 per cent of gross output in 1896 and assumed that this ratio did not change between 1870 and 1896. Then he divided the wage bill by the average annual wage to derive the number of workers.[106] The heroic assumption of a constant wage share cannot be corroborated with what scarce evidence there is on the development of the profit share. Gårdlund's (1947) investigation of financing in Swedish industry included six sawmill firms. The gross profit margin of these companies fluctuated considerably with a

[105] The Swedish Industrial Statistics did not report gross output and employment for flour mills until 1896. After 1896 it excluded all smaller production units and the significance of these industries can be attained by comparing the reported gross output with Schön's estimate, the latter based on the likely consumption of grain (Schön 1988 p. 51). In 1896 the excluded grain mills accounted for fifty per cent of Schöns estimate of total consumption. It decreased to 38 per cent in 1912.

[106] Jungenfelt derived the annual wage by linking the series of annual wages from Bagge *et al.* (1933) to a benchmark in 1913. The wage benchmark in 1913 was based on the official wage statistics (Social Board).

trend pointing slightly downwards. If the share of profit varied, so did the share of wages. Furthermore, the series of wages for workers in the sawmill industry used to compute the wage sum exhibits a very slow growth. Between 1870 and 1912 annual wages in the sawmill industry increased by 0.8 per cent annually, in contrast to 1.9 per cent for manufacturing as a whole. By inference, the slow growing wage series brings a high wage level for earlier years and lowers the estimated number of workers.[107] A more serious objection to this method is that the estimates of employment relate to gross output in current prices. That makes the employment figures highly susceptible to price changes of final products. Instead, changes in employment should be related to changes in the volume of gross output.

Whereas Jungenfelt's approach to matching is adaptable, mine is uniform and based on the idea that there exists a relationship between movement in output and movement in productivity. When output goes up, so does productivity. If this relationship can be identified it is possible to associate a change in the volume of gross output with a change in the volume of gross output to labour ratio, and hence a change in employment. Econometrically the relationship is very simple, thus

$$ln(Q / L) = \alpha + \beta lnQ \quad (5.2)$$

where Q represents the volume of gross output and L number of workers.[108] The model produces significant coefficients in most instances, whether the sample consists of time series for single industries or cross sections of a sample of industries. As both output and labour productivity are expressed in natural logarithms β shows the elasticity of output with respect to labour productivity; it indicates how much labour productivity changes in response to a one percentage change in output. The estimated elasticity usually ranges from 0.6 to 0.8 (Cornwall 1977). Informed readers recognise this model as Verdoorn's law or Kaldor's second growth law according to which productivity growth in manufacturing is positively correlated with growth of output in manufacturing (Verdoorn 1949; Kaldor 1967). The model has also been used to bolster the argument that positive externalities flow from accelerating rates of output growth in the manufacturing sector.

The econometric model implied by Verdoon's basic idea has not eluded criticism. A number of arguments have been raised against its applicability, some of which relate to the econometrics involved. The most serious objection is the presence of output on both the right and left hand sides, violating the assumption of independence between x and y variables. In response to this,

[107] Graph A.5.1 (Appendix 5.3) shows the difference between Jungenfelt's and my series for employment in the sawmill industry.

[108] First difference of the time series was used to remove unit-root problems.

models regressing employment against output have been proposed as an alternative, but they suffer from the same violation of basic assumptions. To escape the problems of endogeneity we would have to use instrument-variable estimation techniques but finding suitable instruments for output or employment is a challenge that has not yet met with success. Furthermore, there are theoretical objections closely related to the specification problems. They question is whether we can really infer from the model that causation runs from higher rates of output growth to higher rates of productivity growth? It may be that causation runs the other way around. In defence of the model, the use of it to match output and employment escapes the intricate problem of causation. It is beyond the scope of the present study to make inferences from the model as to the importance of externalities in the growth of output. The model produces coefficients applied to guesstimate the number of workers associated with a particular level of output.

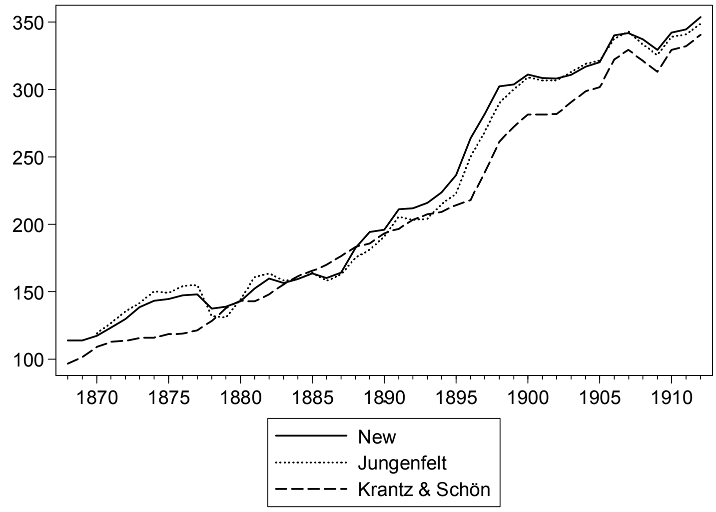
Each estimated elasticity imposes a particular rate of productivity change on the estimated series of employment; the higher the elasticity the higher the rate of productivity change, and the smaller the estimated number of workers for earlier years. I have assigned a unique elasticity to each industry by running a regression on time series of productivity and employment for a sufficient number of years after the industry appeared in the Swedish Industrial Statistics, assuming that the estimated elasticity is applicable for earlier years too. The simplicity and usefulness of the model for estimating employment are revealed most clearly after logarithmic differentiation of formula (5.2), which gives formula (5.3), where dots represent time derivatives:

$$\frac{\dot{Q}}{Q} - \frac{\dot{L}}{L} = \beta \frac{\dot{Q}}{Q} \tag{5.3}$$

$$(1-\beta)\frac{\dot{Q}}{Q} = \frac{\dot{L}}{L} \tag{5.4}$$

Then one minus the elasticity times the growth in output yields the growth in the number of workers, as in formula (5.4). This information can be utilized in backward extrapolation of employment from the year in which the Swedish Industrial Statistics started recording output and employment.

The industries for which employment needs to be estimated constitute a significant if diminishing share of total gross output in manufacturing, falling from 62 to 45 per cent between 1868 and 1895. The share of sawmills and flour mills alone fell from 44 to 26 per cent. The large shares of these industries signify the great extent to which Swedish economy relied on raw material based industries closely related to the agricultural and forestry sectors, both of which remained unnoticed by the Swedish Industrial Statistics before 1896. It is therefore somewhat of a surprise to find that the *movement* of the new series for manufacturing workers sticks closely to Jungenfelt's (1959) (handicraft workers



GRAPH 5.2. Estimates of employment in the Swedish manufacturing industry, 1868–1912

Note: The estimates exclude handicraft workers and public utilities.
Source: The series titled *new* is set out in Appendix 5.1 and Appendix 5.3 details the sources; the series titled *Jungenfelt*: Jungenfelt (1959 tables 3a and 4) public utilities excluded but complemented with employment in brickworks and shipyards (pp. 31–2); the series titled *Krantz & Schön*: Krantz and Schön (2007 table 5B) less handicraft workers from Schön (1988 table 14) and workers in public utilities from Jungenfelt (1959 table 3a).

TABLE 5.2. Industries not represented in the Swedish Industrial Statistics for which employment is estimated

Industry	Time period
Shipyards	1868–1871
Brick works	1868–1872
Sawmills	1868–1895
Flour mills	1868–1895
Slaughter houses	1885–1890
Breweries	1868–1871
Spirit factories	1868–1891
Dairies	1868–1912
Charcoal manufacturing	1868–1897

excluded), as graph 5.2 brings out in full relief. In addition, the *level* of my series is quite congruent with the level of his series, which deserves a remark. My new estimate of employment relates to Schön's (1988) higher level of gross output, while Jungenfelt's estimate relates to Lindahl *et al.*'s (1937) lower level of gross output. For 1868 Schön's estimated level of current gross output is fifteen per cent higher than Lindahl *et al.*'s, though the difference declines gradually and disappears altogether around the turn of the century. My method thus results in fewer workers per unit of output which, *ceteris paribus*, gives way to an interpretation of the share of wages in value added that is different from Jungenfelt's.[109] Graph 5.2 also includes Krantz and Schön's (2007) series of employment for manufacturing workers. I have purged it of handicraft workers and workers in public utilities to make it comparable. There is a gap between their series on the one hand and Jungenfelt's and my new series on the other, especially for the mid-1870s and around the turn of the century. They give no detailed information on the construction of their series, but elsewhere we are informed that Jungenfelt's (1966) employment series has been used to interpolate between an early benchmark in 1870, based on the population census, and a second in 1896, based on the Swedish Industrial Statistics (Schön 2004a). The justification for this solution is the claimed incompleteness of Jungenfelt's pre-1896 series. Yet, in relation to Jungenfelt's series, theirs seems incomplete.[110]

5.4. Single deflation

The construction of price indices to deflate current gross output represents a first step to remove the influence of prices from the movements of volumes of goods and services. There are various sources of information on prices that may be used to compute representative price indices. Four compilations of prices have been particularly useful. Ljungberg's (1990) comprehensive lists of prices for particular goods and for groups of industries, based on a countless number of sources, cover most of the needs for the years after 1885. Three other sources cover the years before 1885: Jörberg's (1972a) voluminous lists of market price scales (*markegångstaxor*), Myrdal's (1933) supplementary list of prices underlying the computation of his cost-of-living index and Åmark's (1921) early list of prices based mostly on market price scales. For most groups of industries it is necessary to combine a number of price series, inevitably calling for

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109 Several authors, who have surveyed, from a macro economic perspective, the Swedish economic development in the latter half of the nineteenth century have to some extent put their faith in the accuracy of Jungenfelt's series of workers. Edvinsson (2005) uses backward extrapolation from a benchmark in 1950, based on the number of manufacturing workers given by the Statistics Sweden and the number of handicraft workers given by Schön, to 1870 by using Jungenfelt's series as an indicator of employment. Schön (2004a) uses the population census in 1870 and the Swedish Industrial Statistics in 1896 to pin down the number of workers and uses Jungenfeld's series to interpolate between these end points. Thus, both rely on the accuracy of the trend in Jungenfelt's series. Vikström (2002), in his study of the share of wages in the manufacturing industry, uses Jungenfelt's number of workers proper and Schön's revised number of handicraft workers to compute the wage bill, thus putting his trust in the level of Jungenfelt's series.

110 In Krantz and Schön (2007 p. 24) the reader is directed to Schön (2000b p. 14) but in fact no description is available there. Information on the construction of the series was instead found in Schön (2004a p. 276).

considerations of what is frequently referred to as the index number problem. That consideration becomes even more delicate at higher levels of aggregation. Previous authors working within SHNA were guided by the principle of finding consecutive time periods of around 20–25 years that share common characteristics, especially stable relative prices. These time periods have been imposed on the data by using them as deflation periods, i.e. applying the same weights to 20–25 years. Healthy scepticism about this method has been put forward by for instance Edvinsson (2005) and Vikström and Lindmark (2004), who argue that it presupposes an idea of the underlying process of economic growth, in this case the preconception of the existence of long swings with duration of 20–25 years.[111] But what if this idea is plainly wrong – is it not better then to apply a more neutral deflation method to divert suspicion from the fact that we have imposed on our data a fixed and ready structure? I feel free to pursue a different strategy, although it is important to remember that some price indices for groups of industries that I make use of have, in their turn, been constructed by other authors employing different methods.

There are two points of departure for the construction of price indices to deflate current production values, and a combination of them, which gives a third, ideal one. Because a Laspeyres price index applies the same weight for the entire period, it generally records a more rapid increase of prices when relative prices change than a Paasche price index, where quantities are changed each year.[112] If relative price tendencies are cumulative, the gap between the two indices tends to expand as our study period lengthens. They represent an upper and lower bound of price increases. A preferred method should therefore be to even out the discrepancy between the Paasche and the Laspeyre price indices, and one well-known solution is to use a Fisher index, which is the geometric mean of the two indices. If in addition the indices are rebased for each consecutive year, the discrepancy between the two choices slips away even more (System of National Accounts 1993). The difference between chained Paasche and Laspeyres indices is negligible in most cases. Still, it is convenient to compute their geometric mean yielding a chained Fisher index. In many cases it is impossible to compute a Paasche, or chained indices in general, because they take annual weights as a prerequisite. The weights used to combine price indices of final products to form price deflators for groups of industries and manufacturing as a whole should be based on gross output. The data collecting part of this project supplies the annual gross output weights needed to compute chained Paasche and Laspeyres indices combined into chained Fisher. Formula (5.5) and (5.6) show the Laspeyres and Paasche methodology, where P and Q represent prices for final products and gross output in the ith industry in the base

[111] In their latest contribution to SHNA, Kranzt and Schön (2007) have substituted a chained Paasche index for their previous deflator based on deflation periods.

[112] This regularity only applies if the Laspeyres index has been constructed by early-year weights.

year, $t-1$, or the year of comparison, t. This results in binary comparisons (links) between year t and $t-1$ of Laspeyres and Paasche type. The geometric mean of the two links gives links of Fisher type, as in formula (5.7). In the final stage, the Fisher index is formed by multiplying each year's binary comparison, the first year being set to 1.

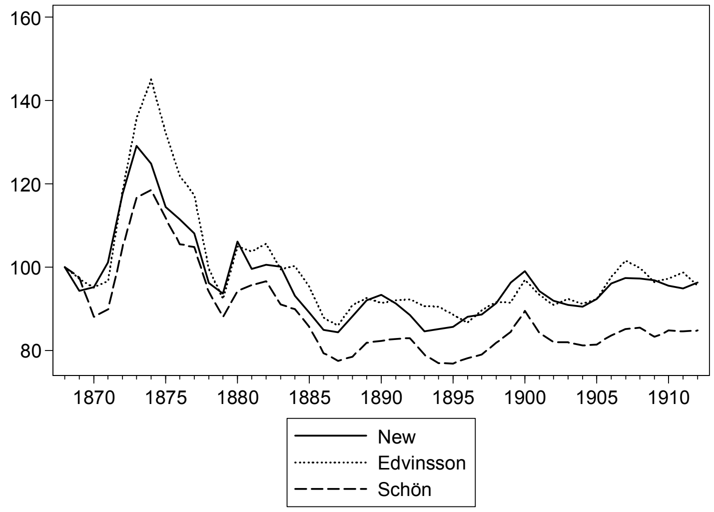
$$Laspeyres_{t-1,t}^{price\ link}\ (L_t) = \frac{\sum_{i=1}^{n}\left(\frac{P_{t,i}}{P_{t-1,i}}\right)P_{t-1,i}Q_{t-1,i}}{\sum_{i=1}^{n}P_{t-1,i}Q_{t-1,i}} = \frac{\sum_{i=1}^{n}P_{t,i}Q_{t-1,i}}{\sum_{i=1}^{n}P_{t-1,i}Q_{t-1,i}} \quad (5.5)$$

$$Paasche_{t-1,t}^{price\ link}\ (P_t) = 1 \Bigg/ \frac{\sum_{i=1}^{n}\left(\frac{P_{t-1,i}}{P_{t,i}}\right)P_{t,i}Q_{t,i}}{\sum_{i=1}^{n}P_{t,i}Q_{t,i}} = \frac{\sum_{i=1}^{n}P_{t,i}Q_{t,i}}{\sum_{i=1}^{n}P_{t-1,i}Q_{t,i}} \quad (5.6)$$

$$Fisher_{t-1,t}^{price\ link}\ (F_t) = (L_t * P_t)^{1/2} \quad (5.7)$$

$$Fisher_{t}^{price\ index} = 1 * F_2 * F_3 \cdots F_{t-1} * F_t \quad (5.8)$$

Apart from the different weighting scheme applied in the construction of the new deflator it is also purged of the influence of handicraft production. Schön (1988) assumed that handicraft production did not enjoy any gains in productivity before 1890, hence the deflator was simply the same series of annual wages used to estimate current gross output. For the period between 1890 and 1955 he assumed that productivity increased by a factor of two. The deflator is thus the wage series divided by an index that moves from 1 to 2 in 65 years. A modest improvement of productivity it would seem, but it matters as craftwork in 1890 accounted for between 10 and 80 per cent of the weights given to different price series for each group of industries (Schön 1988 pp. 193–4). Graph 5.3 shows unequivocally that a gap between Schön's and the new deflator slowly appears after the mid-1880s; between 1885 and 1912 Schön's deflator decreases by one per cent while my new deflator increases by 8 per cent. It is hard to tell whether it is the weighting scheme or the absence of a deflator for handicraft production that induces a different movement of the new deflator. Schön himself, in a joint effort with Kander (2002 pp. 206–8), has computed a chained Paasche deflator for manufacturing, which also records a faster increase of prices than his deflator with fixed deflation periods, at least for the period between 1895 and 1910. Likewise, in the most recent work within SHNA, Krantz and Schön (2007) show that after the 1880s their new chained deflator for GDP increases faster than their previous one based on fixed deflation



GRAPH 5.3. Price deflators for the Swedish manufacturing industry, 1868–1912, (1868=100)

Source: The series labelled *new* is set out in Appendix 5.1 and Appendix 5.3 details the sources. The series labelled *Edvinsson*: (www.historia.se). The series labelled *Schön*: the ratio of current gross output to the volume of gross output in Schön (1988 tables I1 and I13).

periods. Graph 5.3 also shows Edvisson's (2005) price deflator, based on chained Fisher index methodology, which is very similar to the new one, thus reinforcing the impression that weighting counts. The more rapid increase of prices recorded in the new deflator will at any rate temper estimated increase of the volume of gross output in the latter half of the period.

5.5. Double deflation

This project shares with all historical national accounts the objective of establishing measures of the volume of value added. Ideally, value added should be measured at constant prices by deflating the current value of gross output and the current value of intermediate consumption with separate deflators, after which the volume of intermediate consumption is subtracted from the volume of gross output. Formula (5.9), where p_Q represents a price index of final products, Q the quantity of gross output, p_M a price index of intermediate consumption and M the quantity of intermediate consumption, describes the ideal way to establish value added in constant prices. This is also known more commonly as value added by double deflation, V_d.

$$V_d = p_Q Q / p_Q - p_M M / p_M = Q - M \qquad (5.9)$$

Following this procedure in historical national accounts has proved a great challenge, as it requires more data than our sources can provide. In most cases official sources give information on current gross output ($p_Q Q$), or simply quantities (Q), which can be reflated by an appropriate indicator of output prices (p_Q), but they remain silent when it comes to the volume of intermediate consumption (M). The Swedish Industrial Statistics fail to give information on cost shares of intermediate consumption pre-1952; hence the method of double deflation as in formula (5.9) is not applicable. To circumvent the constraints imposed by the lack of information on intermediate consumption, authors have often resorted to movements of the volume of gross output. Series of the volume of gross output for separate industries have been weighted by value added shares for a benchmark year in which information on cost shares of intermediate consumption appear and are combined into an aggregate series which has served to indicate the movement of the volume of value added to the next benchmark year. This, for instance, has been the response in the construction of historical output series for manufacturing in Britain (Hoffman 1955; Lewis 1978) and the US (Fabricant 1940). The accuracy of the method turns on the frequency with which the shares of value added are updated. The inherent problem with historical studies is that shares of value added for a particular benchmark year have served as weights for wide stretches of history. Rebasing appears more frequently for more recent times. Infrequent rebasing may turn the series of the volume of gross output into a poor indicator of the volume of value added. The tacit assumption is that the ratio of the volume of material inputs to the volume of gross output remains unchanged over time. That ratio is sometimes referred to as a technical coefficient, which indicates how much inputs of material per unit of output change as a result of new technologies or changed composition of goods. To presume that the technical coefficients are time invariant implies a strong, if for practically reasons clarified below, necessary assumption. Even if no new products appear, structural transformation in a modern economy goes on in every bit of its constituent parts; it is in the very nature of economic growth to change the composition of output perpetually, because the proportions in which consumers allocate their growing incomes to different categories of expenditure change as time goes by. A change in the composition of output within an industry may affect technical coefficients in both directions: either through the use of more materials and fuels per unit of final produce or through the use of fewer materials. It is only on rare occasions that the study object in historical analysis of output in manufacturing represents a single homogenous product. The evidence of output by industry that researchers obtain from official sources is an aggregate of many products, in the first place, and, in addition, further aggregation is often necessary to circumvent the lack of related information on, for instance, prices of final products and intermediate consumption and capital stocks. The changing composition of final goods is probably what bears mostly on the technical coefficients.

TABLE 5.3. Cost shares of material, labour and capital in gross output, 1913

	Material	Labour	Capital
Mines, iron and steel and machinery	0.48	0.30	0.22
Quarrying	0.24	0.37	0.39
Wood	0.58	0.22	0.20
Paper	0.54	0.22	0.25
Food	0.74	0.09	0.17
Textile	0.59	0.20	0.21
Hides	0.73	0.15	0.12
Chemical	0.40	0.18	0.41
Total manufacturing	0.54	0.23	0.23

Source: SOU (1923).

Focusing instead on a single product, an assumption of a fixed relationship between M and Q can only be justified as long as no major technological innovations substantially alter the amount of material required to produce a unit of output. Some new production methods may imply the use of less material per unit of output. In that case the assumption of a fixed input-output relationship will underestimate the growth of the volume of value added. Innovations may as well lead to more intensive use of material, which results in an overestimation of the growth of the volume of value added. An example of a more material-using technique which came to be widely used from the 1880s onwards, is chemical paper pulp. To produce a unit of paper pulp with the sulphite and sulphate methods requires twice as much forest products as with the mechanical pulp method (Lindahl *et al*. 1937 p. 152). With material saving scenarios in mind, Thomas and Feinstein (2005) discuss and simulate the potential bias of assuming a fixed input-output relationship for a long period of time. In the first scenario major technological breakthroughs occur, markedly reducing the use of material. In this case we may think of a brief and quite dramatic change in technology which implies new ways to combine materials, labour and capital. The bias, if our measure of the volume of value added does not capture this change in technology, may be large enough to give a false impression as to the movement of the true measure of the volume of value added. In the other scenario the potential for material saving is in the gradual reduction of waste. Firms are able to economize on the use of material by learning by doing and gradual refinement of given technologies. The scope for material saving by the reduction of waste is more limited than material saving associated with major new technologies, leading to a smaller bias when our measure ignores its impact. Thomas and Feinstein, however, overlook the third scenario in which the use of material per unit of output increases as a result of product innovations or through changed composition of output.

To get a grip on the change in the technological coefficient as a response to a completely new technology, we need to know a great deal about all the conditions under which the shifts in technology occur. That is beyond reach in most cases. Besides, older modes of production and new technologies often coexist. Before superior technology eventually leads to the demise of an older one, the latter keeps a tenacious hold on the future path of the economy, making it even harder to estimate technical coefficients. What we need, therefore, is a new benchmark based on detailed input-output relationships for a large share of the manufacturing industry, the further from 1913 the better. That would impose stern discipline on our conjectures, although the construction of an input-output table is admittedly a questionable exercise in the absence of any comprehensive public investigation or any form of census with information on cost shares.[113] Until then, the volume of value added in year *t* amounts to nothing but the product of the value added share of our benchmark of 1912 and gross output in constant prices year *t*. It implies that the movement of value added in constant prices equals the movement of gross output in constant prices for industry specific series, while the aggregate series for manufacturing is constructed by weighting these series by constant value added shares for 1913.

5.5.1. Net output in current prices

Although a double deflation of value added to establish the volume of value added is unattainable, there is still scope for improving our measure of value added in current prices. Now, the movement of relative prices, in the form of the ratio of prices for intermediate consumption goods to prices of final goods, enters the picture. Among intermediate consumption goods materials of different kinds matter a great deal more than fuels; the cost share of materials in gross output relative to fuel is in most cases very large, around 97 per cent. The share of intermediate consumption in gross output varies widely by industry, from being 5 to 15 per cent in extractive industries such as iron ore and stone quarrying to between 80 and 90 per cent in sugar industries and flour mills, which are very intensive in their use of raw materials. Movements of relative prices are a great deal more important for material-intensive industries than extractive ones. For most industries the share of intermediate consumption in gross output ranges from 40 to 50 per cent. The weighted share is closer to 40 while the median and the arithmetic mean are closer to 50.

Two requirements must be met to make our measure of value added in current prices reflect changing relative prices. First, we need prices for the whole gamut of final products and intermediate consumption in manufacturing. This

[113] Interestingly, the British series of volume output in the nineteenth century suffers from the same flaw, as it is based on only the value added weights in 1907, coinciding with the publication of the first British Census of Production. The late Charles Feinstein's last project was to establish a new benchmark in 1851 in order to resolve some of the issues previously discussed. The project has been carried to an end by Mark Thomas and will be published posthumously by Cambridge University Press (Lyons *et al*. 2008 p. 287).

condition is partly met, at least after 1885, thanks mostly to Ljungberg's (1990) detailed compilation. [114] Second, we need information on cost shares of materials in gross output and input-output relationships between different industries, preferably through a detailed input-output table at some point in time (not too far off). The point of departure is a public investigation, conducted on behalf of a committee appointed to investigate the consequences of the protectionist turn in Swedish trade policy in 1888, which presented a detailed study of the cost shares of material and fuel for no less than around 180 industries in 1913 (SOU 1923). It did not give any information on the kinds of material inputs each industry purchased, so the usefulness of this source is limited to information on the cost share of fuel relative to that of material and the share of net output relative to gross output. Net output is defined as gross output less costs of materials and fuels. This is not equivalent to value added, each industry's contribution to GDP, because net output still contains costs for maintenance and repair work. It is, however, additive over all industries within the manufacturing sector without any appreciable duplication. Supplementary public investigations and in-depth studies of particular industries have provided additional information on input-output relationships, and Bohlin (2007) made use of these sources to construct an input-output table for the manufacturing sector at a level of aggregation fairly close to the present one.[115] Proper matching between prices of intermediate consumption and final goods is intuitive in some cases, for instance flour mills (grain in and flour out) while for others it is trickier (e.g. shipyards), requiring additional information from special investigations; for some it is simply impossible (e.g. chemicals). If we assume that the amount of material per unit of output is time invariant, the computation of net output in current prices becomes straightforward. Material inputs divided by gross output in 1912 gives the share of material for a benchmark year from which we make a backward extrapolation using the relative movement of the prices of intermediate consumption, p_M, and the prices of final goods, p_Q, as in formula (5.10).[116] One minus that cost share times gross output derives value added in current prices.

[114] The number of price series is far from enough to allow the estimation of value added shares for all industries, which means that for some of the industries current gross output multiplied by a constant value added share in 1912 expresses the movement of current value added.

[115] The details behind the input-output table do not appear in Bohlin (2007) but the sources are numerated in his Appendix 1b pp. 31–2. My calculations are based on his unpublished material. Appendix 5.3 details the weights given to the different material inputs and lists the sources of the price series used to compute net output in current prices.

[116] Backward extrapolation from a large number, let us say a cost share of material of 0.8, results in much greater volatility (in absolute numbers) than if it is done from a smaller number. The combination of a large cost share of materials and a volatile relative price ratio yield negative value added in some instances. Although negative value added is thinkable for a very limited time period, it is probably due more to measurement errors. When negative value added occurs as a result of backward projection from a benchmark it is in all likelihood the result of errors in

GRAPH 5.4. Value added shares in the Swedish manufacturing industry, 1868–1912

Note: To render Schön's series of value added shares comparable to mine I have subtracted the value of handicraft production from his final series of gross output and value added in current prices.
Sources: The series titled *new*: The series of value added and gross output are set out in Appendix 5.1, and Appendix 5.3 details the sources; the series titled *Schön*: gross output for manufacturing and handicraft in Schön (1988 table I1) minus gross output for handicraft workers (table 15). For his series of value added for manufacturing and handicraft (table I2) minus value added for handicraft workers (shares of value added on pp. 101–5).

$$\frac{M_{1912}}{Q_{1912}} * \frac{p_{M,t}}{p_{Q,t}} = \text{cost share year t} \qquad (5.10)$$

$$(1 - \text{cost share year t}) * Q_t p_{Q,t} = \text{value added in current prices year t} \qquad (5.11)$$

Schön (1988 pp. 123–51) used this method to compute value added in current prices for five of the most important industries, textile, iron and steel, mechanical engineering and sawmills for the pre-1913 period. For the rest he used the shares of value added in 1913, which were presented in the public investigation on cost shares, assuming that they remained constant over time. Therefore, movements of value added shares reflect the evolution of relative prices in the above mentioned five industries accounting for around 50 per cent

the measurement of prices for either intermediate consumption or final products, or both. Another reason might be changed technical coefficients.

of gross output in 1870, with a tendency to diminish somewhat towards the end of the period. My new estimate of value added in current prices, using (5.10) and (5.11), encompasses a larger share of the manufacturing industry, accounting for 75 per cent in 1870 and close to 90 per cent in 1912. The inclusion of more dynamic industries, such as paper pulp and paper, causes the share to expand over time. The new net output shares differ from Schön's value added shares in some aspects, as graph 5.4 visualises. The two series are not straightforwardly comparable, though. In addition to the difference between net output and value added, I need to assume that the value added share in 1913, as estimated by the public investigation into cost shares (SOU 1923), was the same in 1912. Schön does not have to invoke this assumption since his series spans and continues after 1913. Still, these incompatibilities cannot alone account for the different behaviours of the two series. First, the new measure has a more volatile nature. Second, the level of my series is on average 16 per cent higher. Third, my series turns downwards after the mid 1890s while Schön's series tends to increase from at least the turn of the century.[117]

5.6. Productivity measures

Any productivity measure seeks to estimate the efficiency with which different inputs are used to produce final goods. Labour productivity, i.e. output per unit of labour input, either on a rate-of-change or level basis, serves frequently as a measure of productivity in historical studies. In its rate-of-change version as in formula (5.12) labour productivity is defined as the growth of the volume of value added, V_d, less the growth of labour input, L.

$$\text{Labour productivity growth rate} = \frac{\dot{V}_d}{V_d} - \frac{\dot{L}}{L} \qquad (5.12)$$

As has become clear in the discussion above, difficulties often arise in the measurement of output, but problems may also arise when measuring labour inputs. If the number of hours has moved in one or another direction, the number of workers gives a misleading impression of labour inputs. In addition, a quality-adjusted measure of labour input, allowing for factors such as, for instance, the level of education and training of the labour force, might be preferable. The most important objection to the use of labour productivity is that it does not reveal whether or not improvements have been achieved by substituting capital for

[117] The difference in 1912 is, as we would expect, small, only 6 per cent. I have replicated Schön's (1988 pp. 133–5, 142) adjustments of value added shares to take account of the differences in the way gross output was recorded before and after 1913 in the Swedish Industrial Statistics.

labour. A higher capital to labour ratio normally raises labour productivity. Labour productivity growth is thus a partial and insufficient measure of the efficiency with which both labour and capital are used. When data permit, economists and economic historians therefore prefer to look at the growth in total factor productivity (TFP), which subtracts from the growth of output the growth of total factor inputs (TFI); a weighted average of the growth of capital, K, and labour, L. The weights used to combine capital, α, and labour, $1-\alpha$ into TFI are their income shares of value added. A different representation of TFP, as in formula (5.14), shows that it also equals the sum of labour productivity and capital productivity, with each productivity component weighted by its share of income.

$$\text{Total factor productivity growth rate} = \frac{\dot{V}_d}{V_d} - \frac{\dot{TFI}}{TFI} = \frac{\dot{V}_d}{V_d} - \alpha\frac{\dot{L}}{L} - (1-\alpha)\frac{\dot{K}}{K} \qquad (5.13)$$

$$\text{Total factor productivity growth rate} = \alpha\left(\frac{\dot{V}_d}{V_d} - \frac{\dot{L}}{L}\right) + (1-\alpha)\left(\frac{\dot{V}_d}{V_d} - \frac{\dot{K}}{K}\right) \qquad (5.14)$$

Two dimensions of this simple formula merit further treatment: first, how should we interpret TFP growth rates; and second, how to compute them in the absence of information on capital inputs. There has been a large number of different interpretations of what in fact TFP growth embodies. Earlier generations of economists – those who stumbled across a contribution of TFP to output growth which exceeded 50 per cent – tended to view TFP growth as technological change, if in very broad terms (Abramovitz 1956; Solow 1957;). The large weight given to TFP in the first growth accounting exercises pointed to an unknown dimension of economic growth, in Moses Abramovitz' evocative words 'a measure of our ignorance'. The hunt for an explanation of TFP has since been centred on either human capital or technical change. To view TFP as an expression of technical change suffers, however, from the fact that the capital stock is an intrinsic carrier of new technology. New technology is embodied in the capital stock. Without technical change, capital accumulation would just amount to piling capital goods of already existing technology, and diminishing returns would thwart further efforts to raise output. The pioneers of growth accounting were challenged by two articles by Zvi Griliches and Dale Jorgenson (Griliches and Jorgenson 1966; Jorgenson and Griliches 1967). They claimed that the large share attributed to TFP in raising output was in fact the result of a failure to account for improvements in the growth of input quality. Thus TFP was nothing but a measure of our measurement errors. Quality adjusted indices of labour and capital made the residual go away. Disembodied technical change as identified by the residual was non-existent. Most technical change now became embodied, hidden in the indices of capital and labour, or as Gordon (2004 p. 92) put it: 'Griliches and Jorgenson have thrown the baby out with the error-ridden bathwater'. To find a pathway out of the quagmire of attempts to interpret TFP growth, this study instead appeals to Harberger's (1998 p. 3) 'paean in praise of real cost reduction as a standard label'. Real cost reduction is an apt description of TFP in the sense that it distils the essence of what economic agents try to achieve, namely to reduce costs by saving on the factors of production, be they personnel, buildings, tools or fuels. But before delving into that matter we need to tackle another measurement issue.

An important limitation of TFP as computed in formula (5.13) or (5.14) is the requirement of information on volumes of output, capital stock and number of workers/working hours. As the discussion above has made clear, information on labour inputs is far from satisfactory, at least not pre-1896, and we have had to substitute growth of gross output in constant prices for our preferred measure, growth of value added by double deflation. An even severer problem is the capital stock, evidence of which is harder to come across, especially at industry and sector levels. Seemingly there is an urgent need for a different solution. We may have recourse to the accounting identity in formula (5.15), where Q, M, K and L are volumes of gross output, material, capital and labour and p_Q, p_M, p_K, r, and w are their respective prices. It illustrates how current gross output, $p_q Q$, can be dissolved into remuneration to labour, capital and costs of purchase of materials.

$$p_Q Q = wL + rp_K K + p_M M \tag{5.15}$$

Taking logs and differentiation of (5.15) gives formula (5.16), where α, β and $1\text{-}\alpha\text{-}\beta$ are cost shares of labour, capital and intermediate consumption. By rearranging formula (5.16) we obtain formula (5.17) which shows a measure of total factor productivity advance on both sides. On the left hand side the percentage change in total factor productivity is computed by the difference between the percentage change in volume gross output and the percentage change in quantities of labour, capital and material (primal way); and on the right hand side total factor productivity is the sum of the percentage change in wages, rent and prices of capital goods, and prices of material inputs less the percentage change in final products (dual way).

$$\frac{\dot{p}_Q}{p_Q} + \frac{\dot{Q}}{Q} = \alpha\left(\frac{\dot{w}}{w} + \frac{\dot{L}}{L}\right) + \beta\left(\frac{\dot{r}}{r} + \frac{\dot{p}_K}{p_K} + \frac{\dot{K}}{K}\right) + (1-\alpha-\beta)\left(\frac{\dot{p}_M}{p_M} + \frac{\dot{M}}{M}\right) \tag{5.16}$$

$$\frac{\dot{Q}}{Q} - \alpha\frac{\dot{L}}{L} - \beta\frac{\dot{K}}{K} - (1-\alpha-\beta)\frac{\dot{M}}{M} = \alpha\frac{\dot{w}}{w} + \beta\left(\frac{\dot{r}}{r} + \frac{\dot{p}_K}{p_K}\right) + (1-\alpha-\beta)\frac{\dot{p}_M}{p_M} - \frac{\dot{p}_Q}{p_Q} \tag{5.17}$$

As economic historians often have much better information on prices than on quantities, this accounting identity delivers the promising message that TFP in fact can be computed despite lack of information on capital investments and number of workers/working hours.[118] To complete the computation of TFP the dual way takes as prerequisites the following components: price data for final goods, intermediate consumption goods, industry-specific wage series, estimates of cost shares and a measure of the returns to capital. Prices of final products were dealt with in a previous section (5.5) and Bagge *et al*. provide industry-specific wage series. As to cost shares, in section 5.6 an attempt is made to estimate net output in current prices, which makes it possible to compute labour and capital's shares of income by drawing on Jungenfelt's (1966) annual wages and my new series of employment. The wage bill in 1913 is known thanks to the public investigation on cost shares (SOU 1923) and backward extrapolation from that benchmark gives annual industry-specific wage bills between 1868 and 1912.[119] Dividing net output in current prices by the wage bill derives labour's share of income; the other part accrued to capital. In sum, reasonably reliable estimates of all but the last component, returns to capital, are at our disposal. How to establish a measure of the returns to capital thus warrants special attention in what forms the subject of the coming section.

5.6.1. Returns to capital

To complete the computations of TFP the dual way requires information on the cost of capital, r. In fact, if it is not possible to come across information on the growth rate of r, TFP will not be more accessible through the dual than the primal approach, as will become clear below. In attempts to come up with a measure of the growth of r in aggregate series most authors have tended to conceive of it as a rental cost of capital. It follows therefore that the measures they have constructed involve the use of the interest rate, the nominal price firms pay for an additional unit of capital. The use of the interest rate is premised on the assumption that the relation between the profit rate and the interest rate is in a state of equilibrium. The equilibrium is reached when the profit rate equals the real interest rate. It is, however, easy to come by historical evidence of the profit rate and the interest rate following different pathways for long stretches of time. Still, from the perspective of this undertaking the foremost objections to using the interest rate are twofold: first, it introduces a foreign element into a system

[118] For application of the dual approach to TFP in manufacturing, see for instance McCloskey (1973) and Voth and Antras (2003).

[119] Jungenfelt's (1966) annual wage series cover only groups of industries. The group-specific wage series are used to indicate the movement of annual wages for all industries in a particular group. The employment series do not contain any salary employee as they were not reported in the Swedish Industrial Statistics. If salary-employee were included labour's share of income would be larger, and the share of capital, accordingly, lowered. The exclusion of salary employee – provided that their share of the entire labour force was fairly constant – does not affect the estimated growth rate of labour productivity.

whose usefulness rests on a simple accounting identity.[120] Secondly, the interest rate is quite time invariant over long stretches of time, while the wage rate, perforce, tends to grow at the same rate as average labour productivity (Kaldor 1957). If r hardly changes over time it has a small impact on the estimate of TFP. Over the long-run a time invariant measure of r works quite well for the manufacturing industry as a whole, be our conception of it the rental cost of capital, the profit rate or otherwise. But, as we shift our attention from the aggregate into separate industries and from the long to the short run, the idea of equilibrium between the rate of interest and profit rates makes no sense. The capital owners in a firm are rewarded by their own profit rate, not by the general rate of interest. Through direct and indirect evidence we know the profit rate exhibits marked upswings and downswings depending on the business cycle, for instance. The share of wages in value added provides indirect evidence. Obviously, if the wage share goes up and down – and it does – so does the share of capital. Those swings are caused by changed magnitudes of the capital to output ratio and/or the profit rate. Direct evidence is rare. Gårdlund's (1947) investigation into the profit rate for a number firms points to wide swings in the course of time. The only way to circumvent the dearth of independent information on the rate of profit for separate industries is to derive it endogenously from formula (5.17) which shows the accounting identity in rate-of-change form. The result of this exercise appears in formula (5.18), where I utilise the assumption that gross output and the volume of intermediate consumption, and consequently value added, grow at the same rate (see section 5.5.) The same assumption is also used in formula (5.19) below.

$$\frac{\dot{r}}{r}=\frac{1}{\beta}\frac{\dot{p}_Q}{p_Q}-\left(\frac{1-\alpha-\beta}{\beta}\right)\frac{\dot{p}_M}{p_M}+\frac{\alpha}{\beta}\left(\frac{\dot{V}_d}{V_d}-\frac{\dot{L}}{L}-\frac{\dot{w}}{w}\right)+\frac{\dot{V}_d}{V_d}-\frac{\dot{K}}{K}-\frac{\dot{p}_K}{p_K} \tag{5.18}$$

Formula (5.18) shows – somewhat discouragingly, perhaps – that the paucity of independent information on the rate of profit makes the computation of TFP still depend on the capital stock and the number of workers. The result also illustrates how the rate of change of a large number of components influences the evolution of the profit rate. It rises with prices of final output, p_Q, and falls with prices of intermediate consumption, p_M, and prices of capital goods, p_K. It furthermore rises with the share of profit (growth of labour productivity less growth of wages) and capital productivity (growth of output less growth of capital stock). After inserting the growth of r so defined into formula (5.17) we arrive at formula (5.19):

[120] Voth and Antràs (2003 p. 60) seem to be aware of that problem but ignore it.

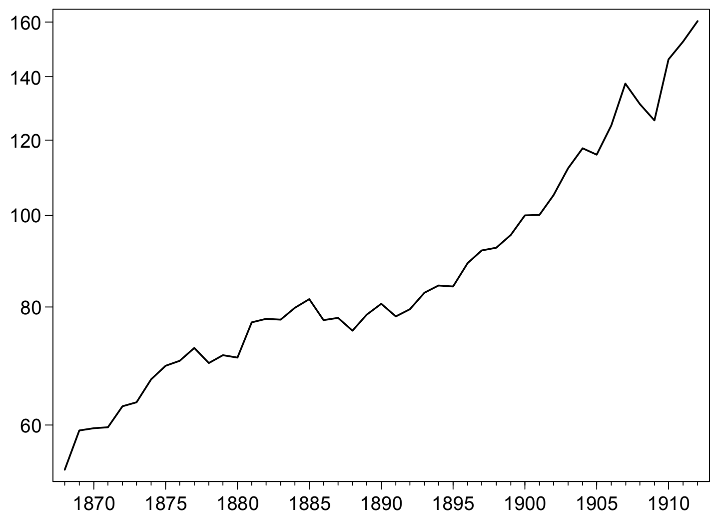
$$\frac{\dot{V}_d}{V_d} - a\frac{\dot{L}}{L} - b\frac{\dot{K}}{K} = a\left(\frac{\dot{V}_d}{V_d} - \frac{\dot{L}}{L}\right) + b\left(\frac{\dot{V}_d}{V_d} - \frac{\dot{K}}{K}\right), \tag{5.19}$$

where $a = \dfrac{\alpha}{\alpha + \beta}$ and $b = \dfrac{\beta}{\alpha + \beta}$.

What remains is a neat expression which tells us that TFP computed the dual way (right hand side) is the weighted sum of the growths of labour productivity and capital productivity, where each component is weighted by its share of income. Hence we have reverted to the same expression as in formula (5.14) and the effort that was made to escape our reliance on the capital stock is belittled. Nevertheless, if we take just a final assumption on board, there are really grounds for closing this section in a more hopeful mood. If we assume that the output to capital ratio remains constant over time, the capital productivity component will just go away and we are left with the notion that TFP is nothing but the growth of labour productivity times the wage share. This underscores the need to attain series of employment to compute labour productivity, which is one of the stated objectives of this investigation. It furthermore renders unnecessary the series of industry-specific wage series and all the price series, all of which were necessary ingredients in the dual approach to TFP. Instead, the crucial issue now becomes whether assuming constant output to capital ratio is warranted. In the very long-run this assumption is rather uncontested; it remains a stylised fact of economic growth since Kaldor (1961). For more narrow time spans the ratio may exhibit changes in one or another direction – certainly the ratio expands and contrasts in association with the business cycle and the rate of utilisation – but in the long-run it probably remains quite stable. At the very least, in relation to labour productivity the output to capital ratio is less liable to significant and sustainable movements in either direction, and will therefore exercise a considerably smaller influence on the estimate of TFP. As will become clear below, evidence of the Swedish capital stock in the manufacturing industry seems to buttress the assumed constancy in the long-run trend of the output to capital ratio for the study period in its entirety.

5.7. Evidence of productivity in the manufacturing industry

Despite the seemingly endless flow of articles dealing with one or another of the various aspects of TFP there are a mere handful of instances where authors have addressed its very long-run evolution or pondered on the role it might have played in the historical narrative (Field 2003). Before looking closer at the evolution of TFP and the light it may cast on Swedish economic development in a wider perspective, let us focus first on labour productivity. The measure of



GRAPH 5.5. Labour productivity in the Swedish manufacturing industry, 1868–1912 (1900=100)

Note: The series of output consists of industry-specific series of volume of gross output weighted by net output shares from 1913. The series of labour input is derived by multiplication of the series of number of workers and the series of total annual working hours. Sources: The series of output and number of workers are set out in Appendix 5.1, and Appendix 5.3 details the sources; working hours: see chapter 4, table 4.7. Net output shares from SOU (1923).

labour inputs should reflect working hours. Information on pre-World War I working hours is in short supply but an attempt is made in chapter 4 to add our fragmentary pieces of evidence together to make a reasonable assessment. That series of working hours is used to compute the series of labour productivity plotted in graph 5.5. Three productivity regimes are discernible. First a short-lived acceleration until 1877; then one of moderate increases until the mid-1890s; and finally a shift to a more upward track which was followed until 1912, with the exception of the setbacks during the turmoil preceding and spanning the labour conflict in 1909. Table 5.4 breaks down the investigated era in its entirety into 11 consecutive five-year time spans and confirms the visual impression; acceleration, deceleration and acceleration again, now stronger than ever before. Pre-1900 labour productivity growth never exceeded 3.5 per cent annually while in 1900–1904 and 1908–1912 it grew by an annual rate of 4.5 and 6.1 per cent respectively. Table 5.4 also shows labour's share of value added and the product of it and labour productivity which equals TFP, providing the output to capital ratio did not change. It puts further emphasis on the acceleration after the turn of the century as a consequence of the rise in labour's share of income.

Previous studies for Sweden have shown that TFP in manufacturing progressed moderately, if at an accelerating rate, in the decades before World

War I. Schön (2004a) computes TFP by subtracting the growth of labour inputs and capital inputs weighted by income shares from the growth of value added in constant prices between 1870 and 2000. Here it suffices to compare his result for the two sub-periods, 1870–1890 and 1890–1910. He finds that the annual growth of TFP was virtually zero in the first sub-period, while it was 0.7 per cent in the second. Before him Holmquist (2003) established a similar rate for the latter sub-period. Table 5.4 shows my results for the same sub-periods: 0.57 in the first and 1.45 in the second. Thus Schön's and my new results uncover an upturn in TFP growth rate after 1890. The issue that begs an answer is how the estimates of TFP attained by my approach will change in the event of a systematic change in the output to capital ratio. An increase in the true output to capital ratio will bias my estimate of TFP downwards, whereas a decrease will bias it upwards. The simulation in table 5.5 shows how the estimate of TFP would change in the event of a change in the output to capital ratio of 0.5 per cent annually, a rate of change of capital productivity which is, I think, on the upper side. If the direction of change in the output to capital ratio is reversed halfway through the 1870–1910 era, first increasing, and then decreasing, the difference between the two sub-periods is almost wiped out. TFP would have increased by 0.88 in 1870–1890 and by 1.18 in 1890–1910. If it moved the other way around, the difference would, it hardly needs saying, escalate; from 0.27 in the first sub-period to 1.72 in the other. A change in the capital to output ratio of the order of magnitude suggested here counts.

TABLE 5.4. Labour productivity, labour's share of value added and TFP in the Swedish manufacturing industry, 1868–1912

	Annual percentage growth rates of labour productivity	Labour's share of income	Annual percentage growth rates of TFP
1868–1912	2.01	0.43	0.86
1870–1890	1.46	0.39	0.57
1890–1910	3.14	0.46	1.45
1868–1872	3.19	0.36	1.14
1872–1876	3.18	0.34	1.09
1876–1880	-0.02	0.39	-0.01
1880–1884	2.53	0.40	1.00
1884–1888	-1.54	0.44	-0.68
1888–1892	0.99	0.45	0.44
1892–1896	2.43	0.45	1.09
1896–1900	2.75	0.45	1.24
1900–1904	4.49	0.46	2.06
1904–1908	3.95	0.49	1.93
1908–1912	6.13	0.50	3.06

Note: TFP is a product of labour productivity and labour's share of income. To some extent TFP is underestimated because labour's share of income does not include salary employee.

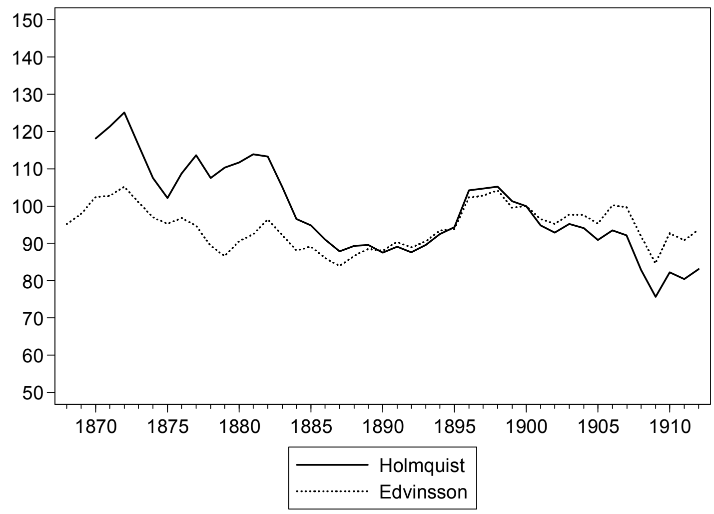
TABLE 5.5. Simulation of the impact of changed capital productivity on the estimate of TFP

	TFP estimated assuming constant capital to output ratio	Impact on the estimate of TFP if the output to capital ratio changes by:	
		+0.5 % annually	-0.5% annually
1868–1912	0.86	1.15	0.58
1870–1890	0.57	0.88	0.27
1890–1910	1.45	1.72	1.18

Note: adding to or subtracting from the TFP estimate in table 5.4 0.5 times capital's share of value added (see formula 5.19).

However, attaining a reliable measure of the net stock of tangible assets is fraught with great difficulties, as the uncertainty surrounding the available measures testifies. Holmquist (2003) is a recent attempt to construct a capital stock, for manufacturing as a whole and for groups of industries. Instead of using the Perpetual Inventory Method (PIM), which calculates the stock of produced assets indirectly from investment in preceding accounting periods, he takes as his points of departure the three benchmark years of 1879, 1913 and 1926 for which there exist values of fire insurances. They give an indirect measure of the stock of fixed assets at three points in time. He then uses horsepower per worker from the Swedish Industrial Statistics to interpolate between these benchmarks and shows in a growth accounting exercise that TFP took on a modest role in raising output, just 7 per cent. The rapid decline in the output to capital ratio explains why TFP was found to have contributed so little. To support his evidence Holmquist argues that the era of rapid investments in factory buildings and new technology, ushered in by the industrial revolution, entailed rapid enlargement of the capital stock in many industries. That, combined with more than average growth rates for capital intensive industries, may well have lowered the output to capital ratio in the manufacturing industry. Labour productivity was raised through the substitution of physical equipment for artisan workers. As this initial phase of the industrial revolution was ebbing out the growth of output (and labour productivity) owed more to forces we usually fail to identify properly but often label technical progress.

Edvinsson (2005 p. 108) has expounded criticism against Holmquist's evidence, in particular the levels of net stock of machinery and equipment in 1913 and 1926. They are too high, he claims, making the series of capital stock grow unreasonably fast from the earlier benchmark of 1879 to the benchmarks of 1913 and 1926. What Homquist identifies as a drop in capital productivity in the wake of industrialisation, Edvinsson instead attributes to measurement errors. It is surprising though to find controversy in the estimated levels of net stock of machinery and equipment for the benchmarks of 1913 and 1926, as in all likelihood they rest on more firm evidence than the earlier benchmark of



GRAPH 5.6. Estimates of the output to capital ratio (in fixed prices) for the manufacturing industry, 1868–1912 (1900=100)

Sources: Value added in constant prices: Schön (1988 table I14); Capital stock: Edvinsson (2005 www.historia.se); Holmquist (2003 Appendix table 1)

1879; the public investigations in 1913 and 1926 captured a larger share of industries than did the investigation in 1879.

Graph 5.6 compares two output to capital ratios, where the denominator is either Holmquist or Edvinsson's (based on the PIM) real net stock of capital, and the nominator is the series of value added in constant prices in manufacturing and handicraft from Schön (1988).[121] The difference between the two lies at the beginning and the end; Holmquist output to capital ratio declines while Edvinsson's remains quite stable. If the truth hovers somewhere in between the two measures, we can safely conclude that the assessed rate of TFP change for the manufacturing industry for the period as a whole, assuming zero change in capital productivity, is at least not too low. The estimates of TFP within my accounting framework, for instance those in the 11 consecutive time spans in table 5.4, fail to accommodate the short-term movements (if taken at face value) in the capital productivity in graph 5.6, but for assessing the long-term evolution of TFP the assumption of constancy in capital productivity is plausible.

Finally some remarks on how the Swedish evidence relates to some previous discussions about TFP growth in the nineteenth and twentieth century. Abramovitz and David (1973, 2000) have championed the idea that economic

[121] Schön's (2004a) capital stock is also based on the Perpetual Inventory Method but since he does not report the figures his output to capital ratio could not be reproduced here.

growth in the nineteenth century was achieved mainly through greater capital intensity. That means workers were aided by an increasing stock of capital at their disposal, which contributed to making their efforts more productive. Physical capital goods were piled up at a faster rate than the growth of output, which entailed negative capital productivity growth rates; as a result, in the growth accounting exercise TFP bears little weight in relation to the capital to labour ratio (capital intensity), or in relation to capital and labour inputs, depending on how one prefers to carry out the computation of TFP. Only in the late nineteenth and early twentieth century did the growth experience turn out to be a story more centred on the marked rise in TFP. Output outgrew the accumulation of capital goods, and the role played by TFP in boosting real output was augmented. With this evidence of TFP growth in mind, Abramovitz and David place their interpretative emphasis on the difference between tangible and intangible capital formation. The former we associate with investments in physical equipment, those that enter our measure of the capital stock. The latter comprises investments in education and training and research and development, the evidence of which is more indirect, embodied in the capital stock or affecting output otherwise, mainly through the residual. They notice a marked shift in 1890, when a previous growth regime based on increased capital intensity was broken, paving the way for another regime which relied more on intangible capital formation. In the period 1855–1890 the residual accounted for 35 per cent of the recorded labour productivity growth, a share that increased to 69 per cent in the period 1890–1927. What Abramovitz and David identify as a raise in the significance of TFP after 1890 corresponds to the subsequent gradual increase in the output to capital ratio, which was documented in a seminal contribution by Gallman (1966). He showed that the output to capital ratio declined in the US during most of the nineteenth century and much effort has been made to identify the capital-augmenting factors responsible for that decline (Gallman 2000). It remained stable after around 1890 and increased in the interwar period. An intriguing issue is whether the Abramovitz/David story, however firmly rooted in the (North) American context, is a parallel to the Swedish growth experience.

Since total factor productivity, as defined here, is nothing but labour productivity multiplied by labour's remunerative share of value added, it is not possible to attribute to TFP and capital intensity their contributions to augmenting labour productivity. Yet, by merely looking at the evidence of capital productivity in graph 5.6 we can conclude that the answer can only be in the negative, the Swedish TFP experience is certainly not a replica of the Abramovitz/David American story. A prerequisite for a shift in growth regime such as Abramovitz and David depicted, from capital to knowledge intensive, is that the capital to output ratio was subjected to a sustainable increase. The available evidence of the Swedish output to capital ratio fails to reflect such an upturn; it fluctuated considerably but if anything it drifted somewhat downwards. What the evidence does show is that the growth of labour productivity accelerated after the 1890s, and chapter 4 also documented that the Swedish labour productivity outgrew the American from 1900 to World War I. The shares attributable to TFP in the US (increasing) and Sweden (stable) may indicate that the Swedish convergence, measured in terms of labour productivity, has been somewhat overestimated. The significant upward drift of labour productivity in Sweden was due to investments in tangible assets to a greater extent than in the US. However, if the capital goods that were piled up at a rate paralleling the growth of output hosted all the knowledge, technology and productivity potential for increasing growth rates of output, we cannot put much faith in our measure of TFP. Furthermore, to draw implications for the historical narrative on evidence of output to capital ratios in each country's manufacturing sector is risky. What are required are more thorough investigations into separate industries as the physical capital requirements at the aggregate level depend on the combined effects of the trends in the output to capital ratios within industries as well as changes in the relative importance of industries with different output to capital ratios. Although high value added industries grew vigorously at the end of the nineteenth and beginning of the twentieth century Sweden was still dependent on large raw material-based industries whose output to capital ratios were larger than the average. Their relative importance overshadowed the progress made in more dynamic industries. Perhaps the awaited increase in the output to capital ratio in the manufacturing industry, the analogy of the American experience, occurred in the interwar period when the dynamic industries encroached sufficiently on the older raw-material based industries' share of output.

5.8. Evidence of productivity growth patterns

The path of the growth of productivity in the manufacturing industry is governed by the combined effects of separate industries' trajectories (within) and the shifting weights attributable to each industry (between). This section focuses on the former effect, evidence of productivity broken down into annual growth rates by industry in five subsequent sub-periods. The account does not intend to detail the myriad of possible explanations, with respect to, for instance, new technologies, political and institutional settings and conditions in the world markets, for the observed pattern of growth rates. Useful such descriptions exist elsewhere.[122] Instead, a few words about some of the key findings serve our need to make the empirical investigation form a suitable background for the last

[122] If we restrict attention to overviews the best example is Gårdlund's (1942) colourful portraits of nearly all the different manufacturing industries. Other overviews can be found in, for instance, Montgomery (1947), Jörberg (1961), Magnusson (1996), Schön (2000b).

section, which discusses the extent to which our evidence squares with different visions of the growth process.

The investigated era needs to be divided into sub-periods, short enough to catch the dynamics in the differences across industries and long enough to mitigate the influence of short-term swings and the fragile nature of our data. If the stated purpose of this investigation had been to estimate with accuracy the rate at which the different industries' productivity grew, the choice of time periods would have had to incorporate due considerations of the business cycle; estimates of exponential trend coefficients are highly sensitive to starting and end points. However, the actual aim of the study, to identify the pattern of growth rates across industries with respect to two different views on the growth process, eases the otherwise firm constraints imposed on the choice of starting and end points of the time periods. My choice of time periods reflects, instead, the access to additional information on, for instance, firm size which is confined to five benchmark years, namely 1872, 1880, 1889, 1897, 1903 and 1912, thanks to Jörberg's (1961) painstaking research into the primary sources underlying the publication of the Swedish Industrial Statistics for these years.[123] That additional information will be employed in a future endeavour to explore the determinants of the observed pattern of growth rates, so the benchmarks constitute the five overlapping time periods used below.

Whereas we could buttress the assumption of constancy in the trend of the output to capital ratio in the manufacturing industry as a whole with a series of capital stock and output, the mass of productivity evidence by industry represents a more blurred image with respect to the impact capital productivity may have exercised on our estimates of TFP. We cannot exclude the fact that the output to capital ratio was subjected to episodes of sharp acceleration and deceleration in some or all of the industries during at least one of the investigated sub-periods. Henceforth the TFP expression will therefore, when it refers computed figures, be accompanied by an asterisk to signal the slender foundation on which its estimated dimension rests. Since a particular industry's growth rate should be interpreted with caution, the primary objective of what follows must therefore be merely a commitment to uncover the underlying pattern of productivity growth rates.

The mosaic of different growth records calls for a useful tool that can bring order to the complexities and puzzles we all associate with economic growth. We need an expression able to capture the essence of a wide variety of growth experiences. Harberger's dichotomy, yeast versus mushroom, provides an instrument to set apart two possible images with respect to the pattern productivity growth rates over time and across industries brought forth in the

[123] Jörberg (1961 p. 218) proposed a different division of the 1869-1912 period. He explored various aspects of the Swedish manufacturing industry in five time spans based on the 6 troughs in the business cycles, namely 1869, 1879, 1887, 1893, 1901 and 1909.

five overlapping time periods.[124] A yeast-like process is one in which growth rates are quite uniformly distributed; there is communality in TFP experiences across a majority of industries in a particular time period. Furthermore, the rank of industries in TFP growth rates remains similar over time, which means that there is persistence from time to time of the leaders and those lagging behind. In contrast, mushroom-like patterns are characterised by large distances between those industries that achieve high rates of TFP growth rates and those that underachieve. The large variability in rates of TFP growth rates attributes a significant importance to the impact of underachievers on the average growth rate of the economy. There are also frequent shifts in the ranks of industries according to their achieved growth rate; leading industries in one time period may slip into decay in the other and vice versa, time and again as we shift from one period to another. The methodology used to uncover the pattern of growth experiences draws inspiration from Harberger's view that TFP embodies real cost reductions, achieved by each production unit to reduce the required amount of labour, capital or material per unit of final produce. The following section expounds on the foundation of real cost reduction.

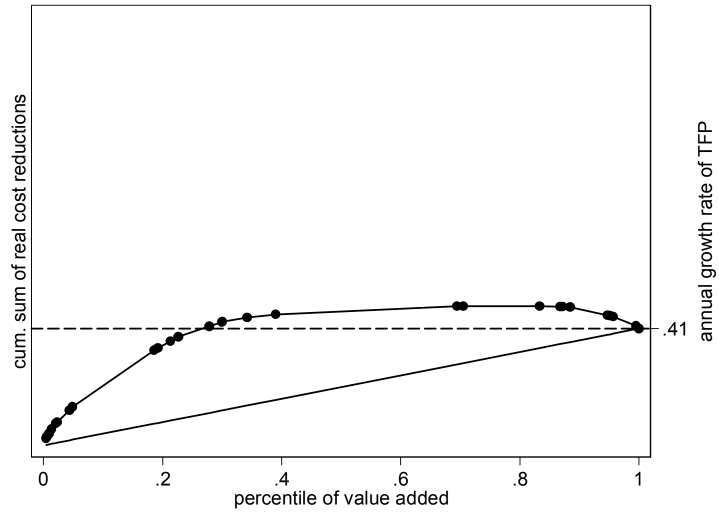
5.8.1. Real cost reductions in 1872-1880

The cost reductions (or increases) undertaken by each firm or industry are additive. Table 5.6, showing the full sample of 26 industry experiences in the first sub-period, 1872–1880, makes it possible to appreciate the notion behind treating real cost reductions as additive. Column (1) shows annual growth rates of TFP* by industry in descending order, while column (2) reports their initial value added in 1872.[125] The first step is to compute the magnitude of each industry's real cost reduction expressed in initial (1872) prices (column 3).[126] It illustrates how much output would have increased between 1872 and 1880 had the industry operated with the same quantity of inputs as in 1872. Columns (4) and (6) are the cumulative sums of initial value added and real cost reductions. In column (5) the cumulative sums of column (4) are scaled to percentages. Thus 100*0.5/7.94 gives 6.29, the percentage share of the paper pulp industry's cumulative sum of real cost reductions. Column (7) similarly shows the

[124] As this investigation only covers the experiences of entire industries, it is not possible to say anything about the performance of separate firms. We do not know if a commonality of TFP experiences was more prevalent than diverse ones within industries.

[125] All estimates of annual productivity growth rates are derived by running a regression of the log of productivity on time. Then (Exp(b)–1)*100 gives the annual percentage growth rate of productivity.

[126] Colum (1) reports annual growth rates. For instance the paper pulp industry grew 6.02 per cent annually in 1872–1880 and its value added in 1872 was 0.83 million kronor. Then, $0.83*1.0605^8–0.83$ yields 0.50, the amount of cost reduction the paper pulp industry achieved in the same period.



GRAPH 5.7. Pattern of real cost reductions, 1872–1880

percentage shares of the cumulative sums of value added in column (6). Columns (5) and (7) give us immediate insights into the distribution of real cost reductions. We may, for instance, infer from them that the 16 first industries in the table, accounting for 36.04 per cent of total value added in 1872, together contributed 100.8 per cent of the total real cost reduction. Even if another four industries also achieved real cost reductions, their contributions were offset by the remaining ones suffering from real cost increases.

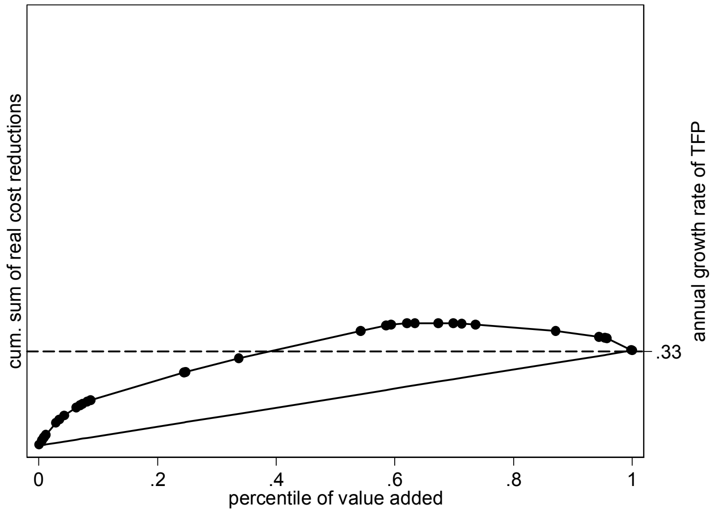
The implicit growth pattern in table 5.6 can be comprehended more easily through a graphical visualisation (graphs 5.7–5.11). Plotting the cumulative sums of real cost reductions from table 5.6 (column 4 and 6) along a straight line would make the graph bear a close resemblance to the Lorenz curve. It is also illustrative to include a measure of the average growth rate of TFP* in the graph. This is done by computing the weighted TFP* growth rate (initial value added as weights) for each period; then creating a right vertical axis labelled with this annual growth rate; and finally scaling the cumulative real cost reductions so as to comply with the same annual growth rate. The vertical axes are furthermore scaled identically in all sub-periods, rendering the shapes of the different graphs comparable. The straight line represents the hypothetical situation in which all industries achieve the same rate of TFP* growth. The area between the curve and the straight line is the combined effect of variations in size of the industry and the TFP* growth rate. The slope of the straight line visually assesses how fast aggregate TFP* grew annually: the steeper the slope of the line the faster was TFP* progress. A downward sloping line would signal negative annual

TABLE 5.6. Real cost reductions by industry, 1872–1880

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Industry	Annual TFP* growth rates (%)	Value added 1872, mil. kr	Real cost red.	Cum. sum of real cost red.	Cum. %-age of real cost red.	Cum. sum of initial value added	Cum. %- age of initial value added
2	Pulp	6.05	0.83	0.50	0.50	6.29	0.83	0.42
3	Prod. of leather, fur	4.80	0.18	0.08	0.58	7.30	1.01	0.51
4	Coal	3.15	0.76	0.21	0.79	10.00	1.77	0.89
5	Refined wood prod.	3.05	1.04	0.28	1.08	13.57	2.81	1.42
6	Clothing	2.67	1.47	0.35	1.42	17.92	4.28	2.16
7	Chemicals and fert.	2.40	0.49	0.10	1.53	19.21	4.77	2.41
8	Paper	2.05	4.25	0.75	2.27	28.64	9.02	4.55
9	Bricks	2.00	1.19	0.21	2.48	31.22	10.21	5.16
10	Sawmills*	1.47	28.49	3.53	6.01	75.71	38.71	19.54
11	Dairy*	1.22	1.25	0.13	6.14	77.31	39.95	20.17
12	Iron mines	1.16	4.52	0.44	6.58	82.78	44.47	22.45
13	Matches	1.12	2.82	0.26	6.84	86.09	47.29	23.87
14	Textile	0.75	10.77	0.66	7.50	94.44	58.07	29.31
15	Tobacco	0.68	4.51	0.25	7.75	97.60	62.58	31.59
16	Paint	0.39	0.12	0.00	7.76	97.65	62.70	31.65
17	Sugar	0.36	8.68	0.25	8.01	100.80	71.39	36.04
18	Charcoal*	0.25	10.11	0.20	8.21	103.33	81.49	41.14
19	Iron and steel work	0.10	63.49	0.50	8.71	109.63	144.98	73.19
20	Breweries	0.04	2.32	0.01	8.72	109.73	147.30	74.36
21	Flour mills*	0.00	26.68	0.00	8.72	109.72	173.98	87.82
22	Spirit*	-0.06	7.13	-0.03	8.68	109.29	181.11	91.42
23	Soap and detergent	-0.09	0.88	-0.01	8.67	109.21	181.99	91.87
24	Mech. eng. ironware	-0.48	13.03	-0.49	8.18	102.99	195.02	98.45
25	Tannery	-0.48	0.93	-0.04	8.15	102.54	195.96	98.92
26	Glass	-0.50	1.15	-0.05	8.10	101.97	197.11	99.50
27	Chinaware and tile	-2.12	0.99	-0.16	7.94	100.00	198.10	100.00

Note: Unless otherwise stated output and employment are taken from Bidrag till Sveriges officiella statistik. D. Fabriker och manufakturer. (*) implies that output from other sources is combined with my estimates of employment (see section 5.3), thus entailing a higher degree of uncertainty. TFP is defined as the growth of labour productivity times labour's share of value added, where labour productivity is defined as the growth of volume of gross output divided by number of workers. The straight lines in column (5) indicates when 100 percent of cumulative sum of real cost reduction has been achieved and the straight line in column (7) the corresponding percentage of the cumulative sum of value added in initial prices.

growth rates. The left vertical axis represents percentiles of cumulative real cost reductions while the x-axis shows the percentiles of initial value added. The dashed line crosses the left vertical axis when 100 per cent of cumulative real cost reductions have been achieved. A large area between the dashed line and the curve gives life to the idea of a strikingly uneven distribution across industries according to the extent to which they achieved significant real cost reductions. It would probably make most of us inclined to gravitate towards the mushroom side of Harberger's dichotomy. It also indicates that significant real cost reductions were highly concentrated to relatively few industries, implying



GRAPH 5.8. Pattern of real cost reductions, 1880–1889

that the majority did not enjoy any significant real cost gains, and that some may even have suffered from real cost increases. If, on the other hand, the area between the curve and the dashed line is small, the growth pattern is more even, characterised by a commonality in TFP* growth experiences.

The 1870s marked the beginning of a growth process characterised by advances across a broader frontier of the economy.[127] Still, most industries, including those that would become high-flyers in the decades to come, were small and relied mostly on handicraft-like production technologies. That circumscribed their potential to gather a sustainable acceleration in the rate of output and hence productivity growth. Additionally, the moderate size of many industries makes the assessment of their TFP* growth rates more prone to errors. That said, the average growth rate looks somewhat bleak, 0.46 per cent annually. The growth pattern which asserts itself between 1872 and 1880 is quite uneven. The paper pulp industry grew vigorously but the breakthrough of new chemical (sulphite) pulp was still in its infancy. As number two in rank comes, perhaps as a surprise, products of leather and fur, a small scale and consumer based

[127] The following sections, 5.8.1–5.8.5, discuss briefly some quite well-known features of the Swedish economic development without references being made to the literature. They also contain some descriptions, based on Gårdlund (1942) unless otherwise stated, of technological developments within some of the most important industries.

TABLE 5.7. Real cost reductions by industry, 1880–1889

	Industry	(1) Annual TFP* growth rates (%)	(2) Value added 1880, mil. kr	(3) Real cost red.	(4) Cum. sum of real cost red.	(5) Cum. %-age of real cost red.	(6) Cum. sum of initial value added	(7) Cum. %-ages of initial value added
1	Paint	4.68	0.14	0.07	0.07	0.99	0.14	0.06
2	Coal	3.49	1.13	0.41	0.48	6.72	1.27	0.58
3	Metal	3.09	0.70	0.22	0.70	9.81	1.97	0.91
4	Prod. of leather, fur	3.03	0.27	0.08	0.78	10.98	2.24	1.03
5	Quarrying	2.45	0.60	0.14	0.93	13.01	2.83	1.31
6	Clothing	2.26	1.26	0.28	1.21	16.96	4.10	1.89
7	Dairy*	1.75	1.93	0.33	1.54	21.54	6.03	2.78
8	Paper	1.35	5.00	0.64	2.18	30.57	11.03	5.08
9	Glass	1.31	1.46	0.18	2.36	33.11	12.49	5.76
10	Chemicals and fert.	1.13	1.17	0.12	2.48	34.86	13.66	6.30
11	Bricks	1.10	1.74	0.18	2.66	37.39	15.40	7.10
12	Pulp	0.71	1.38	0.09	2.75	38.65	16.77	7.73
13	Sawmills*	0.63	37.51	2.17	4.93	69.13	54.28	25.02
14	Tannery	0.61	0.80	0.04	4.97	69.76	55.08	25.39
15	Mech. eng. ironware	0.53	21.20	1.04	6.01	84.37	76.29	35.16
16	Iron and steel work	0.47	48.92	2.13	8.14	114.26	125.20	57.71
17	Textile	0.45	10.23	0.42	8.57	120.16	135.43	62.42
18	Chinaware and tile	0.35	2.09	0.07	8.63	121.10	137.52	63.38
19	Tobacco	0.19	6.45	0.11	8.74	122.65	143.96	66.35
20	Iron mines	0.02	3.24	0.01	8.75	122.74	147.20	67.85
21	Sugar	0.01	9.17	0.01	8.75	122.81	156.37	72.07
22	Spirit*	-0.03	6.05	-0.02	8.74	122.56	162.42	74.86
23	Refined wood prod.	-0.08	3.45	-0.03	8.71	122.20	165.87	76.45
24	Matches	-0.15	5.60	-0.07	8.64	121.15	171.47	79.03
25	Flour mills*	-0.17	32.25	-0.48	8.16	114.47	203.72	93.90
26	Breweries	-0.34	2.36	-0.07	8.09	113.47	206.08	94.98
27	Soap and detergent	-0.38	0.78	-0.03	8.06	113.10	206.86	95.35
28	Charcoal*	-1.06	9.72	-0.89	7.17	100.59	216.59	99.83
29	Cement	-1.31	0.37	-0.04	7.13	100.00	216.96	100.00

industry. The industries achieving high productivity growth rates were all modest in size; the first eight industries accounted for merely 10 per cent of initial value added. The value added of the 16 industries responsible for 100 per cent of cumulative real cost reductions amounted to merely 36.04 per cent of total initial value added, hence the curve symbolizing the cumulative sum of real cost reductions crosses the dashed vertical line early. In contrast, the large industries, which in descending order were iron and steel works, sawmills and flour mills, alone accounted for 60 per cent of initial value added. None of them grew particularly fast, but the ground on which our knowledge about their developments rests is quite thin. Most surprising is perhaps the negative productivity growth of mechanical engineering and iron industry, at least with the rapid expansion of railways in the 1870s in mind. It would, however, aspire to become one of the forerunners around the turn of the century.

5.8.2. 1880–1889

For the period between 1880 and 1889, the growth pattern looks quite similar to the previous period, which may partly be explained by the similar weak growth rate of the whole; it decelerated from 0.41 to 0.33. The sample of industries is expanded to comprise the cement industry, the metal industry and the stone quarrying industry. Once again 16 industries accounted for 100 per cent of real cost reductions. These 16 industries constituted 57.71 per cent of initial value added. Once again the overachievers were all small industries. Eleven of the 12 highest ranked industries – the paper industry aside – had a value added below 2 million kronor. Together these twelve industries' share of the total sum of initial value added was no more than 7.7 per cent. The impressive growth of the pulp industry was brought to a halt despite the advance of the sulphite method, and the paint industry took over its role as front-runner. The leather product industry, the coal industry and the clothing industry enjoyed productivity growth rates above two per cent annually in the first sub-period as well as in this one. Two of the six industries which suffered from real cost increases in the first period joined another six industries whose TFP* growth rates turned negative in this period. The mechanical engineering and iron ware industry climbed the table somewhat. The larger degree of overshooting above the 100 per cent real cost reductions can be explained by the productivity performance of the iron and steel work industry. Its large size and improved growth rate enlarges the area between the curve and the dashed line.

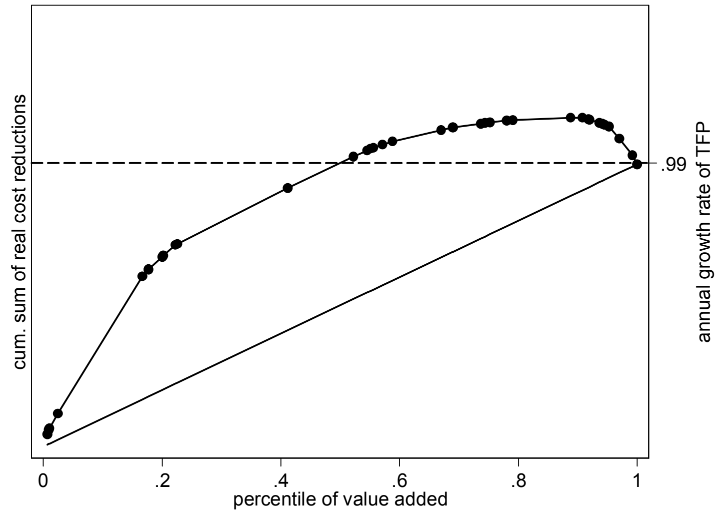
5.8.3. 1889–1897

In the third sub-period, from 1889 to 1897, the growth of productivity reached 1 per cent annually, thus accelerating in relation to the previous decades. This sub-period spans part of the important 1890s and precedes the years around the turn of the century when Swedish industrialisation gathered momentum. The sample of industries is extended by six new industries: the electro mechanical industry, the shoe industry, the explosives industry, the chocolate and candy industry, the slaughter house industry, the printing industry and the shipyard industry. It required the collected effort of only 13 of the 36 industries, representing 55.8 per cent of initial value added, to exceed the 100 per cent of cumulative real cost reductions. The reason a smaller number of industries was needed to surpass the 100 per cent cumulative reduction was the modest improvement in productivity of the iron and steel work industry; its sheer size influenced the distribution of the cumulative sum of real cost reductions.

TABLE 5.8. Real cost reductions by industry, 1889–1897

	Industry	(1) Annual TFP* growth rates (%)	(2) Value added 1889, mil. kr	(3) Real cost red.	(4) Cum. Sum of real cost red.	(5) Cum. %-ages of real cost red.	(6) Cum. sum of initial value added	(7) Cum. %-ages of initial value added
1	Metal	6.26	2.07	1.29	1.29	5.06	2.07	0.73
2	Cement	6.00	0.76	0.45	1.75	6.83	2.83	1.01
3	Electro mechanical	5.12	0.26	0.13	1.88	7.34	3.10	1.10
4	Shoes	4.23	0.09	0.03	1.91	7.47	3.18	1.13
5	Pulp	3.53	4.51	1.44	3.35	13.10	7.69	2.73
6	Iron and steel work	3.37	44.80	13.62	16.97	66.32	52.49	18.62
7	Iron mines	2.31	3.18	0.64	17.61	68.81	55.67	19.75
8	Paint	2.03	0.21	0.04	17.65	68.95	55.88	19.82
9	Prod. of leather, fur	1.87	0.62	0.10	17.75	69.34	56.51	20.04
10	Paper	1.86	6.39	1.02	18.76	73.32	62.90	22.31
11	Tannery	1.17	1.02	0.10	18.86	73.70	63.92	22.67
12	Sawmills*	1.09	58.57	5.30	24.16	94.41	122.48	43.44
13	Mech. eng. ironware	1.02	34.92	2.96	27.12	105.97	157.40	55.83
14	Charcoal*	0.97	7.14	0.58	27.69	108.22	164.54	58.36
15	Glass	0.96	1.81	0.14	27.84	108.78	166.35	59.01
16	Quarrying	0.85	1.64	0.11	27.95	109.23	168.00	59.59
17	Breweries	0.79	4.76	0.31	28.26	110.44	172.76	61.28
18	Dairy*	0.60	5.25	0.26	28.52	111.45	178.01	63.14
19	Matches	0.46	6.11	0.23	28.75	112.34	184.12	65.31
20	Explosives	0.42	0.28	0.01	28.76	112.38	184.41	65.41
21	Sugar	0.31	14.72	0.37	29.13	113.83	199.13	70.63
22	Bricks	0.30	2.11	0.05	29.18	114.03	201.24	71.38
23	Clothing	0.25	2.58	0.05	29.23	114.24	203.82	72.29
24	Textile	0.21	9.04	0.15	29.39	114.83	212.85	75.50
25	Chemicals and fert.	0.19	3.37	0.05	29.44	115.02	216.22	76.69
26	Flour mills*	0.09	30.61	0.22	29.65	115.88	246.83	87.55
27	Tobacco	0.01	6.14	0.01	29.66	115.91	252.97	89.73
28	Chinaware and tile	-0.52	3.17	-0.13	29.53	115.40	256.14	90.85
29	Chocolate and candy	-0.60	0.40	-0.02	29.51	115.32	256.54	90.99
30	Spirit	-0.72	5.38	-0.30	29.21	114.14	261.92	92.90
31	Pork butcheries	-0.81	1.80	-0.11	29.10	113.70	263.72	93.54
32	Soap and detergent	-0.87	1.00	-0.07	29.03	113.44	264.72	93.90
33	Shipyard	-0.93	2.25	-0.16	28.87	112.81	266.97	94.69
34	Book printing	-2.63	5.67	-1.09	27.78	108.56	272.64	96.70
35	Refined wood prod.	-2.86	6.86	-1.42	26.36	103.00	279.50	99.14
36	Coal	-4.62	2.43	-0.77	25.59	100.00	281.93	100.00

At the top of table 5.8 we find the metal industry, followed by four relatively recently established industries: the cement industry, the electro mechanical industry, the shoe industry and the pulp industry. These industries' different characteristics underpin the difficulties in explaining the observed growth pattern. The electro mechanical industry is the epitome of the Swedish triumph of engineering in an era often referred to as the *Second Industrial Revolution*

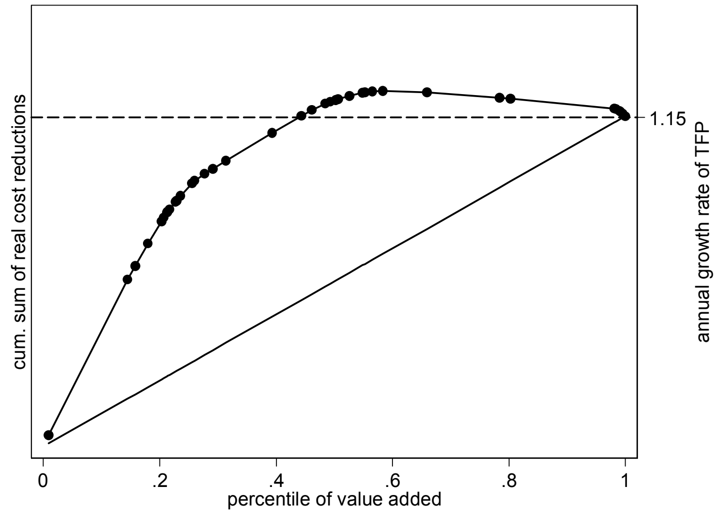


GRAPH 5.9. Pattern of real cost reductions, 1889–1897

(Landes 1969) in economic history literature. Just recently founded, it began to grow swiftly during the 1890s, accompanied by successive improvements in productivity and an unending flow of product innovations. It would become one of the most important export industries in the twentieth century. The premise of expansion of the paper pulp industry was, needless to add, the previously ample but at the time rapidly declining Swedish forest supply, but the breakthrough cannot be understood without taking into reckoning its close connection to the chemical industry. During the 1990s the chemical methods, sulphite and sulphate, encroached on the output share of the mechanical method. The shoe industry represented a domestic consumer goods industry whose production was safeguarded against foreign competition by tariffs of a fair size. This former handicraft-based industry belonged to the group of industries whose performance stands out in the last three sub-periods. The tariffs may have been conducive to development and improvements of productivity followed vigorous growth of output. The first cement industry was established in 1873 but another five industries came into being at the end of the 1880s and during the 1890s. Cement came to an increasing extent to be used in all kinds of construction works, not the least in social overhead construction. At the other end of the scale nine industries experienced real cost increases, four of which did so in at least one of the previous sub-periods, namely the chinaware and tile industry, the spirit industry, the soap and detergent industry and the refined wood products industry. Apart from the coal industry there is no previous evidence of the remaining laggards. Needless to add, we cannot exclude the fact that their weak and even negative productivity records may in fact reflect measurement errors. It is not entirely likely that an industry suffers from recurrent real cost increases. It is not probable either that they belong to the club of industries enjoying considerable progress.

TABLE 5.9. Real cost reductions by industry, 1897–1903

	Industry	(1) Annual TFP* growth rates (%)	(2) Value added 1897, mil. kr	(3) Real cost red.	(4) Cum. sum of real cost red.	(5) Cum. %-ages of real cost red.	(6) Cum. sum of initial value added	(7) Cum. %-ages of initial value added
1	Electro mechanical	4.17	4.19	1.16	1.16	3.41	4.19	0.92
2	Mech. eng. ironware	3.95	61.21	16.04	17.20	50.46	65.40	14.43
3	Matches	3.60	6.09	1.44	18.64	54.69	71.49	15.77
4	Pulp	3.53	9.83	2.27	20.92	61.35	81.32	17.94
5	Paper	3.33	10.78	2.34	23.26	68.22	92.10	20.32
6	Cement	3.27	1.74	0.37	23.63	69.30	93.84	20.71
7	Shoes	3.17	2.52	0.52	24.15	70.83	96.37	21.26
8	Paint	2.74	0.39	0.07	24.22	71.03	96.76	21.35
9	Tannery	2.66	1.57	0.27	24.48	71.82	98.33	21.70
10	Shipyard	2.65	4.60	0.78	25.27	74.11	102.93	22.71
11	Margarine	2.43	0.67	0.10	25.37	74.42	103.60	22.86
12	Chemicals and fert.	2.38	3.41	0.52	25.89	75.93	107.00	23.61
13	Book printing	2.29	8.78	1.28	27.16	79.67	115.78	25.55
14	Prod. of leather, fur	2.01	2.02	0.26	27.42	80.43	117.80	25.99
15	Clothing	1.41	7.95	0.70	28.12	82.47	125.75	27.75
16	Bricks	1.38	6.16	0.53	28.64	84.02	131.91	29.11
17	Quarrying	1.35	10.44	0.87	29.51	86.58	142.34	31.41
18	Flour mills	1.28	35.94	2.86	32.38	94.97	178.29	39.34
19	Textile	1.25	22.48	1.74	34.11	100.06	200.77	44.30
20	Iron mines	1.17	8.38	0.61	34.72	101.84	209.15	46.15
21	Charcoal	1.04	10.30	0.66	35.38	103.78	219.45	48.42
22	Glass	0.80	4.05	0.20	35.58	104.36	223.50	49.32
23	Chinaware and tile	0.79	4.30	0.21	35.79	104.97	227.80	50.27
24	Soap and detergent	0.72	1.72	0.08	35.86	105.19	229.52	50.65
25	Tobacco	0.56	8.85	0.30	36.16	106.08	238.36	52.60
26	Refined wood prod.	0.55	10.28	0.34	36.50	107.08	248.65	54.87
27	Chocolate and candy	0.33	1.74	0.03	36.54	107.18	250.38	55.25
28	Breweries	0.33	6.03	0.12	36.66	107.54	256.42	56.58
29	Dairy*	0.06	8.04	0.03	36.69	107.61	264.46	58.36
30	Sugar	-0.07	34.12	-0.14	36.55	107.21	298.58	65.89
31	Iron and steelworks	-0.17	56.77	-0.57	35.98	105.55	355.35	78.41
32	Spirit	-0.18	8.52	-0.09	35.89	105.28	363.88	80.29
33	Sawmills*	-0.21	80.75	-1.00	34.89	102.34	444.63	98.11
34	Explosives	-0.51	1.51	-0.05	34.84	102.21	446.13	98.44
35	Pork butcheries	-1.42	2.31	-0.19	34.65	101.65	448.44	98.95
36	Rubber	-1.46	1.29	-0.11	34.54	101.33	449.73	99.24
37	Bakery	-2.17	1.75	-0.22	34.33	100.70	451.48	99.62
38	Coal	-2.47	1.70	-0.24	34.09	100.00	453.19	100.00



GRAPH 5.10. Pattern of real cost reductions, 1897–1903

5.8.4. 1897–1903

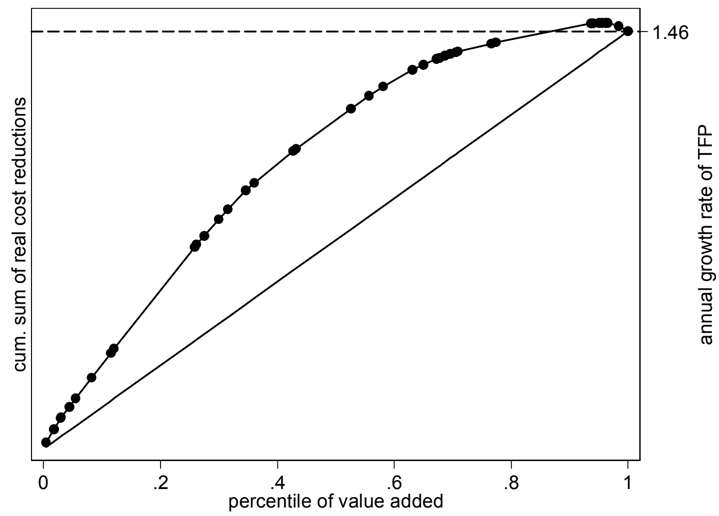
The 1897–1903 sub-period coincides with the sharp bend of the series of average rate of productivity growth in the manufacturing industry in 1899, which shifts the ensuing course upwards (graph 5.5). The progress of a wide array of industries around the turn of the century makes the period crucial in Swedish economic history literature. Sweden was leaving the premature stage of development in which raw material based industries governed the direction output and productivity growth would take; instead, it was entering a phase signified by transformation and refinement. As was shown in chapter 4, Sweden rapidly reduced the thitherto wide labour productivity gap vis-à-vis the UK and the US. The sample now captures two further industries: the bakery industry and the rubber industry. Compared to the previous period the average growth rate of TFP* increased slightly, from 0.99 to 1.15 per cent annually. The average growth rate of the whole would have been a great deal more impressive without the signs of faltering in the sawmill industry and the iron and steelworks industry. Their substantial weight in the sample drags down the average growth rate. 100 per cent of real cost reductions was the joint effort of 19 industries, or fifty per cent of all industries in the sample. Fourteen of the industries, or one third, achieved TFP* growth rates above two per cent. Among these top scoring industries there were those that we have already become acquainted with, such as the paper pulp industry, the cement industry and the electro mechanic industry, but there were also newcomers such the paper industry and matches industry as well as a rare example of a food industry (margarine) growing by more than two per cent annually. The production of matches underwent a spectacular upswing in terms of output and the number of firms after the turn of the century. The earlier strike-anywhere matches containing phosphorus in the head faded into the background, while paving the way for the safety matches, which had to be struck on a specially prepared surface to ignite. Mass production techniques, which boosted output significantly, were developed in the 1890s. It was a very old industry where innovation in product design and new standardised production methods caused a sudden upsurge in output, productivity and exports.

Most important, though, was the progressing mechanical engineering and ironware industry, whose importance now was becoming unrivalled; it alone accounted for 47 per cent of the cumulative sum of real cost reductions. The significant jump that stands out in the graph stems from the large weight it bears; the magnitude of its real cost reduction dwarfs the rest in comparison. This industry's asserted dominance over the rest of the industries expands the area between the curve and the straight line. It has not been possible to separate the mechanical engineering industry from the ironware and foundry industry for reasons that are further explicated in Appendix 5.3. The ironware and foundry industry delivered iron and steel products, either in the quite crude form of manufacturing plates, rails, tubes, wires and nails, or further processed into various machine-made products. Mechanical engineering had roots back in the 1830s, grew steadily in latter half of the nineteenth century, and blossomed in the 1890s into being an industry highly competitive in the word market and yet able to supply the domestic industries until World War I with an almost infinite variety of manufacturing machines, some of which were based on Swedish inventions.

Two of the largest industries, the sawmill industry and the iron and steel industry, had to bear a cessation of productivity growth. Their contribution to the shape of the productivity pattern is almost zero. Seven further industries endured real cost increases; three of them did so anew, the slaughter house industry, the spirit industry and the coal industry; four of them did so for the first time, while for the remaining two there is no prior evidence.

5.8.5. 1903–1912

The last sub-period, 1903–1912, extended and reinforced the rapid growth track established in the previous period. The swift development of TFP* covered a vaster swath of industries than ever before. The overall TFP* growth of the manufacturing industry which had been on a course of steady rise since 1880, achieved an annual rate of 1.46, a rate which would have been higher had not the sawmill industry burdened it by its sheer size and sedate pace. The pattern is extremely even when judged by the number of industries that furnished at least a bit of real cost reductions; no less than 32 industries, or 82 per cent of all



GRAPH 5.11. Pattern of real cost reductions, 1903–1912

industries in the sample, took part in the accumulation of 100 per cent real cost reduction. Their value added accounted for 93.63 per cent of the total sum of value added. If ever the metaphor 'a yeasty growth process' has been an apt description of the pre-World War I productivity record in the Swedish manufacturing industry, it is here. The area between the curve and the dashed lined disappears almost altogether.

The picture of wide-spread progress by industry painted in table 5.10 is colourful. Among the 15 industries whose growth rate of productivity exceeded 2 per cent per annum we find the – by now well-known – cement industry, the electro mechanic industry, the matches industry, the shoe industry, mechanical engineering and iron industry and the paper industry. But something in the environment fostered rapid improvements of productivity for a host of other industries too. Unexpected achievements by small players such as the tannery industry, the book printing industry and refined wood product industry adds colour to the growth picture. If we take just a further step down the ladder we also find the first food industry, the slaughter industry; it ranked 17 but recorded a respectable annual growth rate of productivity of 1.7 per cent amid booming growth rates in general. Only four industries were burden by real cost increases: the charcoal industry for which there is no earlier evidence at hand, the spirit industry, a notorious underachiever, and the margarine industry, a former fast growing industry now descending into lower ranks. A quick scan of the lower half of table 5.10 discloses that the majority of industries which failed to

TABLE 5.10. Real cost reductions by industry, 1903–1912

	Industry	(1) Annual TFP* growth rates (%)	(2) Value added 1903, mil. kr	(3) Real cost red.	(4) Cum. sum of real cost red.	(5) Cum. %-ages of real cost red.	(6) Cum. sum of initial value added	(7) Cum. %-ages of initial value added
1	Cement	4.51	2.50	1.22	1.22	1.52	2.50	0.45
2	Matches	3.28	7.49	2.53	3.74	4.66	10.00	1.79
3	Electro mechanical	3.22	6.42	2.12	5.87	7.31	16.42	2.93
4	Paint	2.78	0.54	0.15	6.02	7.50	16.95	3.03
5	Shipyard	2.69	7.51	2.03	8.04	10.02	24.46	4.37
6	Shoes	2.65	6.21	1.65	9.69	12.07	30.68	5.48
7	Book printing	2.60	15.32	3.98	13.67	17.03	46.00	8.22
8	Paper	2.59	18.16	4.71	18.38	22.89	64.16	11.47
9	Tannery	2.57	3.37	0.87	19.24	23.97	67.53	12.07
10	Mech. eng. ironware	2.54	77.03	19.52	38.76	48.29	144.56	25.83
11	Explosives	2.51	2.02	0.50	39.27	48.92	146.58	26.19
12	Chemicals and fert.	2.39	7.00	1.66	40.92	50.98	153.58	27.45
13	Iron mines	2.28	14.03	3.16	44.08	54.92	167.62	29.95
14	Metal	2.24	8.67	1.92	46.00	57.30	176.28	31.50
15	Refined wood prod.	2.17	17.17	3.65	49.65	61.85	193.45	34.57
16	Bricks	1.73	8.43	1.41	51.06	63.61	201.88	36.08
17	Textile	1.72	36.96	6.13	57.19	71.25	238.84	42.68
18	Pork butcheries	1.70	2.99	0.49	57.68	71.86	241.83	43.22
19	Iron and steel work	1.52	52.36	7.62	65.30	81.35	294.19	52.57
20	Quarrying	1.50	17.58	2.53	67.83	84.50	311.77	55.71
21	Pulp	1.38	13.51	1.77	69.61	86.71	325.28	58.13
22	Sugar	1.22	27.95	3.22	72.82	90.72	353.22	63.12
23	Tobacco	1.01	10.26	0.97	73.79	91.92	363.49	64.96
24	Clothing	0.98	12.74	1.17	74.96	93.38	376.22	67.23
25	Rubber	0.82	2.46	0.19	75.14	93.61	378.68	67.67
26	Dairy	0.79	5.32	0.39	75.54	94.10	384.01	68.62
27	Bakery	0.74	5.50	0.38	75.91	94.57	389.51	69.61
28	Glass	0.64	5.22	0.31	76.22	94.95	394.73	70.54
29	Prod. of leather, fur	0.58	2.09	0.11	76.33	95.09	396.82	70.91
30	Flour mills	0.53	31.60	1.53	77.86	97.00	428.42	76.56
31	Chinaware and tile	0.50	4.71	0.22	78.08	97.27	433.13	77.40
32	Sawmills*	0.44	90.83	3.67	81.75	101.84	523.96	93.63
33	Soap and detergent	0.24	2.34	0.05	81.80	101.91	526.30	94.05
34	Breweries	0.17	5.74	0.09	81.89	102.02	532.04	95.08
35	Coal	0.04	2.72	0.01	81.90	102.03	534.76	95.56
36	Margarine	-0.04	3.26	-0.01	81.89	102.01	538.02	96.15
37	Chocolate and candy	-0.12	2.06	-0.02	81.87	101.98	540.08	96.51
38	Spirit	-0.64	10.80	-0.61	81.26	101.23	550.88	98.44
39	Charcoal	-1.33	8.71	-0.99	80.27	100.00	559.59	100.00

participate in the upswing belonged to the food industry or consumer goods industries in general, an exception being the coal and sawmill industry, although the reader has by now become accustomed to coming across these industries at the bottom of the table. The other two large and natural resource based industries, iron mines and iron and metalworks, did better in the last sub-period than in the previous ones. In iron mining, magnetic prospecting, machine boring with steel-drills, blasting with nitroglycerine, electrical rails and elevators were some of the most important contrivances. They contributed a competitive edge to the iron ore mining that enjoyed increasing export rates thanks to growing demand from Germany above all. The large-scale concentration of ironworks which took place in the latter half of the nineteenth century probably raised the average productivity of each production unit. After the turn of the century the new ingot-steel production, based on the methods of Bessemer, Martin and Thomas, surpassed the production of bar iron which was based on the Lancashire method. Sweden was ahead of many of its competitors in the application of the new methods within steel making.

5.8.6. Summing up the evidence

The empirical investigation serves to disclose whether there is a recognisable pattern of TFP* growth rates formed by the manufacturing industries included in the sample. Does the observed pattern make us inclined to gravitate towards the mushroom-side of Harberger's dichotomy; or does the evenness with which yeast expands fit better as a portrayal of the Swedish growth process in the manufacturing industry. If we start by considering what the shapes of the different graphs disclose, it is clear that there is nowhere near any overshooting of the same magnitude as in Harberger's evidence of American industries and Mexican firms in the latter half of the twentieth century, when overshooting of 50–100 per cent sometimes occurred. That overshooting did not amount to more than 20 per cent owes much to the relatively narrow span within which growth rates ranged. Yet, overshooting is a salient feature in all but the last sub-period in the sense that less than fifty per cent of the industries, measured in initial value added, were sufficient to accumulate the 100 per cent of real cost reductions. Seen through the lens of the measurement tool that Harberger proposes, the overall impression that the growth pattern was quite uneven predominates.

Evidence which would furthermore tilt the interpretative emphasis towards the mushroom side is a lack of persistence in leadership over time. It is straightforward to let Spearman's rank correlation coefficients test whether the rank of industries shifts predominantly as we move from one time span to another. None of the correlation coefficients set out in table 5.11 are particularly large and none are statistically significant; the test thus fails to single out a sustainable rank order among the included industries. This sets into sharp relief the disparate pattern of high and low rates of TFP* growth rates across industries; the shifts in rank outweigh any tendency towards persistence.

However, even if the presence of growth experiences of all kinds is an indisputable characteristic of Swedish pre-World War industrialisation, we must not let that evidence mask salient and recognisable features of the growth record.

TABLE 5.11. Spearman's rank correlation coefficients for the consecutive time spans

	Spearman's rank coefficient	Number of industries
1872–1880/1880–1889	-0.315	28
1880–1889/1889–1897	-0.132	31
1889–1897/1897–1903	0.073	38
1897–1903/1903–1912	0.115	41

Note: Spearman's rank coefficient measures the stability of rank orders of achieved TFP growth rates between two different time spans.

The 1903–1912 period marks a tendency towards forming a more even pattern of productivity growth. The coefficient of variations for TFP growth rates and real cost reductions were roughly halved in the last period, as table 5.12 shows. Additional evidence is provided by graph 5.11 in which the area between the dashed line and the curve almost disappear, which highlights that an overwhelmingly large share of the industries (measured by the share of initial value added) added to the 100 per cent of the cumulative sum of real cost reductions. Few industries experienced real cost increases and those who did so were either insignificantly small in size or suffered from insignificantly low rate of real cost increases. The evidence of a marked upturn in average growth rate after the turn of the century fits well with the rapid Swedish catch up in labour productivity vis-à-vis the UK and the US found in chapter 4 for the same period. In addition, even if the Spearman rank correlation coefficients fail to single out any sustained rank among the industries, there are at least two reasons why further considerations should not come to a halt here. First, even small shifts in rank affect the size of the Spearman rank correlation coefficient. The quality of the data does not permit firm conclusions about minor changes in rank. Second, our focus should be set on whether an industry appears in the upper one fourth of the table, is anchored in the middle or if it notoriously underachieves.

When we shift our attention to the broader pattern discernable in tables 5.6–5.10 a quite clear picture begins to emerge. The 18 industries, whose growth rate of TFP* falls below one per cent per annum in at least 50 per cent of the sub-periods in which they appeared, are found in the first column in table 5.13. Half of them belong to the food industry, which is equivalent to saying that, apart from the margarine industry, all food industries joined the group of underachievers. The preponderance of industries suffering from sluggish productivity growth belonged to the consumer goods sector. The second column of table 5.13 shows in the same manner the industries which performed systematically better than average, with a growth rate exceeding two per cent annually.[128] With the exception of book printing and the two consumer goods

[128] It is very likely that the mechanical engineering industry would have joined the club of fast growing industries had it been possible to separate it from the iron ware and foundry industry.

TABLE 5.12. Coefficient of variations for TFP* and real cost reduction

	1872–1880	1880–1889	1889–1897	1897–1903	1903–1912
TFP*	1.5	1.5	2.5	1.4	0.8
Real cost reductions	2.3	2.5	3.4	2.9	1.6

industries, the shoe industry and the leather and fur industry, all of the overachievers belonged to the 'capital goods sector' as classified by Jörberg (1961 pp. 42–3). The fast growing industries were furthermore quite small; apart from the paper, pulp and book printing, all had value added below 10 million kronor in 1903 (table 5.10, column 2). Some of them were recently established, which explains why their output levels were moderate (cement, shoes, electro mechanical), but for most of them the transformation from small scale and handicraft-like production methods into mechanisation and mass production provides a more generic explanation. That resulted in manifest growth of output from very low levels, which encouraged rapid productivity growth rates. It is, however, only a small and incomplete menu of possible explanations as a more exhaustive coverage of the determinants of our observations is beyond the scope of the present investigation. A more encompassing study requires that we attribute to each industry a number of qualities and explore causalities within an econometric framework. Yet, the elementary classification into overachievers and underachievers deployed here brings compelling evidence of a sharp divide between the domestic consumer goods industries lagging behind the industries which relied on more dynamic properties.

5.8.7. Searching for common stimuli

The search for underlying causes motivated the effort to illustrate the prevalence of either yeast- or mushroom-like growth patterns. Observations of productivity across industries or firms that refuse to obey any easily recognisable order may challenge the very idea of modelling, at least those models which pose a strong link of the TFP growth rates to one or just a few parameters. In Harberger's (1998 p. 16) own words: 'it really is a jungle out there'. If we recognise that the actual growth record is of a very multifaceted nature, it becomes more far-fetched to think of simple models predicting a particular outcome as a result of externalities flowing from new technologies. The number of restrictions necessarily imposed on such a model would make it alien in relation to the historical narrative. Whereas economists manifest an unquenchable appetite for neat models, economic historians are more reluctant. The belief that the nature of economic growth eludes our attempt to capture it may indeed translate into an appeal for more history. The concept of General Purpose Technology (GPT)

The mechanical engineering industry's output grew appreciably faster than the ironware and foundry industry's output.

reflects one of numerous efforts to forward our understanding of the growth process. It unites to some degree the idea of a yeasty growth process on the one hand and new technology that has great scope for improvement, broad externalities and many technological complementarities on the other (Lipsey *et al*. 1998). If the positive externalities which stem from a new technology boost TFP growth rates economy-wide, it should result in a quite even growth pattern, indicating that a wide spectra of economic activities benefit from this technology. In contrast, a situation in which a mere handful of industries reach high levels of TFP growth rates is difficult to reconcile with the essence of GPT. However, historical studies of important technological breakthroughs, such as the steam engine, electricity and information and communication technologies, have persuasively shown that their initial impact on the economy is inconsequential. Several decades may have to elapse before the full potential of a new technology can be realised. One reason for the delayed impact is the dependence on investments in technologies that are complementary to the GPT.[129] By implication, it is risky to attempt to match evidence of a productivity pattern at the industry or firm level with a GPT. What we perhaps can expect to find is a linkage between a uniform yeasty growth pattern and a GPT which is about to, or has eventually, realised its complete potential. The challenging task of tracking the origin, application, diffusion and eventual realisation of a GPT's ability to generate positive externalities with fare-reaching implications for real

TABLE 5.13. Overachievers and underachievers with respect to annual growth rate of TFP*

Growth rate of annual TFP* > 2 per cent	Growth rate of annual TFP* < 1 per cent
Cement	Charcoal
Electro mechanical	Glass
Paint	Breweries
Shipyard	Dairy
Shoes	Explosives
Book printing	Sugar
Paper	Textile
Chemicals and fertilizers	Flour mills
Metal	Tobacco
Pulp	Chinaware and tile
Products of leather and fur	Chocolate and candy
	Spirit
	Pork butcheries
	Soap and detergent
	Coal
	Sawmills and planning mills
	Rubber
	Bakery

Note: The industries are classified as overachievers if their recorded growth rates of TFP exceeded 2 per cent annually in at least half of the sub-periods in which they appeared. In the same manner, the industries classified as underachievers achieved annual growth rates below 1 per cent.

cost reductions is preferably assigned to economic historians.

In the last sub-period, 1903–1912, there was commonality of significant real cost reductions among a majority of industries, suggesting a possible link between this yeast-like expansion and a new technology with great scope for externalities. Although the attributes given to a GPT are numerous, arguably only the steam engine and electricity could possibly have qualified as GPTs in the late nineteenth and early twentieth century (Edquist and Henrekson 2006). Mechanisation, measured as the increase in horse power per worker, increased steadily in the 1870s onwards (Jörberg 1961). It is unknown, though, how large a share of the motive power installed came from the steam engine. It affected the sawmill industry most, but several other industries also made headway with the application of steam. The irregular pattern of productivity progress until the turn of the century questions the existence of a GPT, be it steam power or otherwise. The role of electricity is more delicate. Contemporaries and most economic historians have concurred with each other in the view that the electric unit drive, running each machine with individual electric motors, was a lever in production; not so much because of the energy and direct cost savings it entailed, but because of its great scope for increased flow of production, improved working environment, improved machine control and ease of plant expansion (Devine 1983). It is uncertain though if these effects of indirect savings were also sufficiently pervasive in the years preceding World War I to argue that there was a link between electrification and the uniform productivity pattern. David (1990) and David and Wright (2003) have argued that it would take yet another decade or so before electricity possibly could have taken on the role as primus motor in manufacturing because the electric group drive, one electric motor running a group of machines, which dominated before World War I, did not bring all the great cost saving potential of electricity generating motive power. Schön (2000a) nevertheless argues that electricity was the new technology on which a new development block was created in the 1890s. Electrification of Swedish industry proceeded rapidly owing to scarcity of domestic supply of fossil fuel, abundance of hydropower and energy-intensive industries. Initially the mechanised processes driven by motive power were electrified while the electrification of thermal processes in the iron, steel, pulp and paper lagged behind. Around the turn of the century roughly 10 per cent of all motive power was electrified and by the outbreak of World War I that share had increased to 50 per cent. Norgren (1992), for instance, has shown that 80 per cent of the large establishments in the mechanical engineering industry had installed electric motors with the explicit intention of raising productivity, either in the form of unit drive or group drive. In particular, plants producing quite few and homogenous goods adopted electricity to enhance efficiency, which underscores the potential electricity had to foster mass-production technology.

The evenness with which a multitude of industries advanced in 1903–1912, along with rapid electrification, represents a possible nexus.[130] We know that the US and the UK experienced a marked upturn in TFP growth rates in the interwar years at the same time as a quite uniform pattern of growth rates among industries began to assert itself (Kendirck 1961; Matthews *et al.* 1982). David and Wright (2003) argue that electricity was one of the most important determinants of this upsurge and convergence in TFP growth rates. If Sweden was somewhat ahead in electrification, it remains in fact a tantalizing possibility that the American experience in the interwar years, however celebrated, was in fact heralded in the Swedish manifestation of rapid productivity growth rates and high degree of uniformity among industries after 1900. It remains to be seen in future work whether this bold conjecture withstands scrutiny.

5.9. Conclusions

For economic historians it is common knowledge that country experiences of industrialisation rest on foundations which are highly localised and idiosyncratic to particular trajectories and cultures. Yet the quest for similar patterns and generic explanations continues with relentless zeal. Arnold Harberger has presented two clear visions of the growth process: growth across firms and industries is either uneven and resembles mushrooms or it is even and resembles yeast. Based on the evidence from American manufacturing industries and Mexican firms in the manufacturing sector in the latter half of the nineteenth century, he envisions a nature of the growth process closely resembling the mushroom metaphor. That vision is a challenge to the whole idea of searching for common underlying factors to account for the observed pattern of growth rates. Harberger argues that if the observed cost reductions among industries refuse to form any easily recognisable pattern, it becomes far fetched to think of a single underlying cause impinging on the conditions of progress. The quest for simple models to explain economic growth would therefore be elusive. The mushroom vision of the growth process is partly at odds with another idea that has crept into the language of economists and economic historians recently, namely that of general purpose technology (GPT). A prerequisite for thinking in GPT terms – a technology that initially has scope for improvement, eventually becomes widely used and has broad externalities – is that our evidence of cost reductions among firms or industries forms a quite uniform pattern.

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[130] Edquist and Henreksson 2006 attempted to measure the link between electrification and labour productivity growth by branches in manufacturing between 1913 and 1939. They found no significant link between the growth of electric motor capacity and the growth of labour productivity.

The number of historical investigations into the nature of productivity growth at the firm of industry level is limited, especially in the pre-World War I era. Thanks to the early and regular publication of Industrial Statistics, the Swedish growth record deserves close scrutiny. As previous writers have made clear, the Swedish Industrial Statistics suffers from a number of flaws which makes it an insufficient source of information on output and employment. A great deal of attention has therefore been given to measurement issues. Although some of them remain unresolved, the strength of the arguments adduced and the consistent manner in which evidence has been gathered make me inclined to sum up the major findings with assurance.

Labour productivity in the manufacturing industry progressed reluctantly until the mid-1890s after which it was set onto a more upward track until 1912. Unlike in the US in about 1890, there is nothing in the Swedish evidence to indicate the existence of a shift from one growth regime, where the growth of labour productivity was mostly due to increasing capital intensity, to another, where TFP, through investments in intangible capital assets, played a more dominant role. The absence of a long-term tendency of change in the Swedish output to capital ratio defies the idea that Sweden underwent a similar transition.

The measurement tool which Harberger proposes, based on the cumulative sum of real cost reductions, laid bare the pattern of real cost reductions across industries in five overlapping time periods between 1872 and 1912. Quite dissimilar rates of real cost reductions among industries prevailed until the turn of the century. With less than fifty per cent of the industries (measured as share of initial value added) sufficient to account for one hundred per cent of real cost reductions in all but the last sub-period, the image which comes to mind is inevitably more reminiscent of mushrooms than of yeast. Furthermore, the formal test, stability versus variety in the ranks of TFP performances, favours variety; shifts in ranks were commonplace. The absence of any clear tendency to form a more uniform pattern adds the Swedish case to the list of instances supporting Harberger's vision of the growth process as something very elusive and difficult to model. This then casts doubt on the usefulness of searching for a specific underlying factor, attribute to it a quality that is *sui generis* and has far-reaching consequences for productivity growth rates, and let it succinctly explain the observed pattern of growth rates. To a certain degree the result weakens the probability that a GPT was in operation in the decades which pre-dated the acceleration of productivity and formation of an even pattern of real cost reductions around the turn of the century.

Still, the quest for generic patterns and succinct explanations should not cease because of this. A different approach used to distinguish between those industries that persistently underachieved and overachieved, one that selects those industries that achieved below one and above two per cent annual growth rates of productivity in at least 50 per cent of the sub-periods in which they appeared, illuminates some distinguished aspects of the Swedish industrialisation. Half of the 18 industries, which were burdened repeatedly by moderate real cost reductions or even real cost increases, belonged to the food industry. Of the remaining ones at least half were consumer goods industries. Of the 13 industries that frequented the upper part of the productivity growth rank table, only two were consumer goods industries. Of the remaining ones most were modest in size, some newly established, others subjected to far reaching technological transformations, and in general seem to have been more capital and knowledge intensive. Thus, behind the mushroom-like advance of Swedish industrialisation before the turn of the century a rift was beginning to emerge between the slow growing, mostly, consumer goods industries on the one hand and the fast growing industries with dynamic attributes on the other. In addition, an equally clear finding is that the upsurge in the average growth rate of productivity after 1900 was accompanied by the formation of a strikingly even productivity growth pattern. In the period 1903–1912 no less than 82 per cent of all industries in the sample, their value added accounting for 93.63 per cent of the total sum of value added, took part in the accumulation of the 100 per cent real cost reduction. That may point to positive externalities flowing from investments in new technology affecting broad spectra of different processes. Some authors argue that electricity, at least in Sweden, may have been a lever for productivity improvements in the decade before World War I. The evidence of a yeasty growth process presented here bolsters this argument.

Appendix 5.1. Output, price deflator and employment in manufacturing

TABLE A.5.1. Output, prices and employment in the Swedish manufacturing industry, 1868–1912

	Gross output in current prices ('000 000)	Net output in current prices ('000 000)	Volume of net output, 1868=100	Gross output deflator, 1868=100	Number of workers ('000)
1868	359.0	119.4	100.0	100.0	123.2
1869	397.4	130.8	111.1	94.3	125.1
1870	402.7	131.6	115.3	95.2	129.5
1871	441.3	142.8	121.6	101.1	136.8
1872	561.3	200.2	136.0	117.5	146.0
1873	634.1	235.1	142.6	129.1	152.5
1874	673.2	244.8	156.2	124.9	158.8
1875	650.4	232.9	164.6	114.4	162.7
1876	630.3	225.2	166.3	111.5	163.2
1877	636.5	223.0	170.6	108.1	163.2
1878	514.8	172.4	154.5	96.2	154.0
1879	505.4	175.5	157.4	93.7	154.5
1880	571.3	217.9	161.1	106.1	160.0
1881	636.0	210.3	183.7	99.5	168.1
1882	637.8	229.5	188.9	100.6	172.0
1883	646.8	237.3	189.6	100.1	173.5
1884	629.5	216.2	198.8	93.2	177.3
1885	659.3	222.1	205.5	89.1	180.1
1886	589.2	210.6	192.5	85.0	178.2
1887	590.2	222.0	193.8	84.4	179.1
1888	628.1	242.4	200.3	88.0	191.6
1889	704.6	278.0	221.4	92.0	204.6
1890	764.5	300.2	232.7	93.3	210.3
1891	793.9	292.0	238.2	91.3	223.0
1892	832.7	297.4	242.1	88.5	223.8
1893	817.6	294.4	252.0	84.6	225.1
1894	856.5	334.8	265.1	85.1	233.6
1895	874.3	351.9	276.7	85.7	245.6
1896	996.1	413.1	316.3	88.1	266.7
1897	1115.2	454.7	347.9	88.7	285.8
1898	1213.4	481.2	369.7	91.4	303.4
1899	1287.3	498.6	385.6	96.3	308.2
1900	1413.4	555.0	412.9	99.0	316.2
1901	1360.2	519.5	407.9	94.2	313.5
1902	1383.3	535.4	425.0	91.9	312.7
1903	1437.8	554.4	456.6	90.9	315.5
1904	1510.7	580.4	486.9	90.5	321.8
1905	1530.6	588.7	480.6	92.4	323.8
1906	1763.7	681.2	545.1	96.1	343.5
1907	1903.8	722.8	609.9	97.4	348.4
1908	1804.1	668.2	565.4	97.2	341.0
1909	1720.7	635.1	527.6	96.8	332.3
1910	2009.9	746.7	631.6	95.5	344.2
1911	2053.5	755.5	660.1	94.9	346.1
1912	2212.4	801.6	708.5	96.3	354.8

Appendix 5.2. Margins of error

Many of the components which underlie the final exploration of productivity are evidently subject to errors, because of measurement errors, omission of important variables or other information, or a flawed procedure. These errors may, furthermore, be either randomly or systematically distributed. Random errors have the desirable statistical property of a zero mean and are roughly symmetrical in distribution, thus making it possible to invoke normal statistical conventions regarding the distribution of errors. Systematic errors may cause a lot of harm to the accuracy of our final conclusions. These errors are under the influence of common underlying factors which make them form a particular pattern (Thomas & Feinstein 2002).

The discussion so far has thus unfolded a number of areas in which the margin of error may be considerable. Sometimes tentative estimates of gross output underlie projections of employment as well as attempts to compute value added. In addition, it is not always straightforward to disentangle the truth from the Swedish Industrial Statistics. The margin of error for series of employment and value added can be large, perhaps as much as 25 percent. One way to check the consistency of the series of gross output and value added and employment is to compute the share of wages in value added for the different industries. Since the wage bill in 1913 is known (SOU 1923) we can project the share of wages in value added by drawing on Jungenfeldt's (1959) annual wage series. We would expect labour's share to vary within reasonable boundaries, at the very least the wage share cannot exceed unity (unless for a year or so). There are a handful of mostly small industries where the wage share displays extraordinary fluctuations, and also exceeds unity for a couple of years. Most of these instances occur in the first two decades of the period. The question then remains whether the error lurks behind the series of annual wages, value added or employment.

Starting with the wage series, there is admittedly a shortage of industry-specific annual wage series, and some of them hinge on a tenuous evidential basis, in fact a mere tiny number of preserved firm records for most industries. Despite the uncertainty surrounding the wage series there are reasons to believe that the source of error rests elsewhere. The pattern formed by the movement of wages for different industries is quite uniform; there are certain boundaries within which wages possibly could have ranged given that labour was a mobile factor. Concerning employment, we are left uninformed whether employment in the Swedish Industrial Statistics pre-1896 refers to the average number of workers or the number of workers engaged at a certain point in time. There are a couple of instances in the Swedish Industrial Statistics where, after actions have been taken to improve the coverage of an industry, the series of employment (and gross output) jump up suddenly. If the increase in the number of workers goes beyond the increase in gross output the firms' liability to render accounts of the number of employed may have changed during the period. Jörberg (1961 p. 379) found a number of smaller firms which refused to submit the requested value of gross output but reported the number of workers. That explains some of the bizarre instances of wage shares exceeding unity. Neither do we know whether or not home workers in the textile industry were included (Jörberg 1961 p. 374). Visual inspection and reasonable judgements as to the reliability of the employment series are the only way to decide whether or not it passes the test. All conspicuous discontinuities have been removed.

Finally, a note on net output. The further back in time the series stretches the smaller is the industry, and the higher is the inclination to come across wage shares that exceed unity. At the beginning of the period small industries, at most a couple of thousand workers or so, conducted many operations by dint of handicraft-like technologies. The gradual substitution of machines for artisans increased the flow of materials, which decreased the value added share. The way value added is computed does not reckon with this shift in technology hence the level of value added is too low at the outset of the period, which in turn makes the wage bill exhaust value added. The first step is therefore to adjust the value added share somewhat upwards, raising the level of value added. That in turn makes the wage share attain more reasonable proportions.

If the usefulness of some of the industry-specific series is overshadowed by doubts concerning their foundations, then what about groups of industries and the manufacturing industry as a whole? In fact, aggregation makes most of these problems go away, provided that errors in different sectors cancel out. Furthermore, larger industries (for which we have better data) dwarf the impact of the smaller industries. Formula (A.5.1) illustrates the issue at stake (Feinstein & Thomas 2002).

$$\sigma_V = \left(\sigma_X^2 + \sigma_Y^2 + 2r_{XY}\sigma_X\sigma_Y\right)^{1/2} \tag{A.5.1}$$

The standard error in any combined measure of two sectors y and x is the square root of the sum of the variances of x and y and the error attained from the measured interdependence of x and y. Thus the size of the overall standard deviation is affected by the assumed correlation between x and y. If the errors in x and y are independent ($r = 0$), the standard error is just the squared root of the sum of the squared variance of x and y. From a researcher's point of view, the perfect case would be if the errors in x and y cancelled each other out completely ($r = -1$), minimising the standard error of the whole. The worst case would be if the error terms were compounded ($r = 1$), maximising the standard error of the whole. Most likely the errors in x and y are related to some degree; the correlation coefficient falls between the endpoints of -1 and $+1$. The margin of error is then derived by multiplying the standard error of the whole by two (95 percent confidence intervals). The message which should get across from this minor digression is that, provided that measurement errors in the various sectors making up the whole are negatively correlated, aggregation goes along with diminishing standard errors of the whole. Although measurement errors plague some of the industry specific series, the reliability of our evidence improves as we add industries together.

Appendix 5.3 Data sources

The following account gives information on gross output, employment, prices of final products and prices of intermediate consumption. Volume C and D of the Swedish Industrial Statistics are hereafter called BiSOS C and BiSOS D (Bidrag till Sveriges officiella statistik). Words in italics mark entries in either of these two volumes.

1. Iron, metal and engineering

The point of departure is the identification of 6 main industries. BiSOS C reports physical output and employment for raw material-based industries like extraction of iron ore and other metals as well as processing of iron ore into pig iron and bar iron. Although BiSOS C also reports figures of ironware until 1891, it is clear that figures for most of the more refined metal products are to be found in BiSOS D. The physical quantities in BiSOS C need to be multiplied by prices to yield series of current gross output. Sometimes there is a perfect match between price series and quantities, as in the case of iron ore. More commonly, though, it has been necessary to combine different series of quantities into a more aggregate series. All series of quantities have then been transformed into series of relatives, with 1896 set to 100. To weight the different series of quantities I have used average gross output shares from 1896–1912. The resulting series is a *de facto* Laspeyres quantity index. Multiplying this quantity index so constructed by price indices gives an index series of gross output in current prices. In 1896 BiSOS C reported both physical quantities and gross output, making it possible, by using the index series of gross output, to extrapolate backwards from the level of gross output in 1896.

BiSOS C reports employment for only three categories: iron ore (*jerngrufvorna*), iron work (*jernverken*) and other metal works and mines (*andra verk med tillhörande grufvor*). Iron ore and iron work are by far the most important industries and appear below as separate groups of industries. The heterogeneity of the third one, other metal works and mines, is a minor problem; most of the output, whose corresponding employment belongs to this category, has been allocated to metal 2.1 because similar, if more refined products, are also reported in BiSOS D. The rest of that output has been added to coal 2.6, paint 8.1 and chemicals 8.7. To raise the number of workers I simply use the gross output to employment ratio in BiSOS D.

A comparison of my level of gross output with Schön's (1988) for group 1 reveals that my level of gross output is markedly larger. In the 1870s and 1880s my level exceeds Schön's by 20 per cent on average. The difference then disappears gradually. The reason for that difference probably goes back to what Lindahl *et al*. (1937) accomplished though it is beyond the scope of this study to further investigate the factors causing this divergence.

1.1 Mechanical engineering, ironware and foundry

The three most important categories are mechanical engineering, ironware, and foundry. Ideally, one would like to have separate series of gross output and employment for all these three categories. The classification of these categories in BiSOS D have, however, changed in ways that make it impossible to match gross output with employment for each of the categories from 1868 to 1912. Mechanical engineering and foundry appear jointly in 1868–1891, although from 1886 to 1891 it is possible to identify each category's gross output (but not employment). Between 1892 and 1895 the three categories appear jointly. Again, it is possible to separate each of the category's gross output but not employment. After 1896 foundry belongs to ironware while mechanical engineering appears as a separate category. Thus, only by lumping the three categories together is it possible to construct consistent series of gross output and employment. A further complication concerns the part of ironware that appears in BiSOS C before 1891. Instead of gross output, BiSOS C gives output in terms of physical quantities, which are multiplied by a proper price index of final products to yield gross output. The number of workers is adjusted by the gross output to employment ratio in BiSOS D.

Gross output and employment from BiSOS D
Mechanical engineering:
1868–1912: *fabriksredskapsfabriker, fiskeredskapsfabriker, gevärsfabriker, aduceringsverk, gjuterier, mekaniska verkstäder, kirurgiska-, matematiska-, musikaliska- och optiska instrumentfabriker, kardfabriker, kulsprutor, sprut-fabrik, symaskinsfabrik, solv- och vävskedsfabrik, urfabriker, åkdonsfabriker, fabriker för tillverkning av muddelverk*.

Ironware:
1868–1912: *bleckslageri, filhuggeri, hästskor, hästskosömn, jerntrådsdragerier, järn- och stålvaror, järn och stålmanufaktur, nålfabriker, träskruv.*

Additional output from BiSOS C
1868–1891: Physical quantities of *järn och stålmanufaktur* that are multiplied by prices of iron and steel products (see below) to give gross output.

Estimates of employment for additional output
1868–1991: Estimated by using the gross output to employment ratio from BiSOS D.

Prices of final products
A division into mechanical engineering, ironware and foundry identifies the three most important statistical categories, and separate price indices are created for each of them. For mechanical engineering, prices of various types of machines are used, while, for ironware, more refined goods made of iron and steel, and, for foundry, prices of castings of iron and steel are used. The final index is constructed by assigning to mechanical engineering the average weight of 0.56, ironware 0.31 and foundry 0.13 based on shares of gross output.

The following sources are used:

Mechanical engineering:
1868–1888: prices of railway carriage (Modig 1971 table 15).
1888–1912: price index of the mechanical engineering industry (Ljungberg 1990 p. 512).

Ironware:
1868–1912: prices of horse shoes, horse-shoes nails and nails (Jörberg 1972 pp. 583, 586–7, 713–4).
1885–1912: same as in 1868–1912 and additionally a variety of nails and screws and shoes (Ljungberg 1990 pp. 291–2).

Foundry:
1885–1912: prices of iron girder, sheet iron, iron tube, castings of iron and steel (Ljungberg 1990 pp. 278–9).

Prices of intermediate consumption
A price index including pig iron and bar iron (Åmark 1921 p. 1275) and the price index of ironware, the weights being 0.71 and 0.29, form the final price index of intermediate material inputs. Fuel is represented by prices of charcoal (0.9) (Jörberg 1972 pp. 698–9) and coal (0.1) (Åmark 1921 p. 1275), accounting for 7 per cent of total costs with a net output share of 0.54 (Schön 1988 p. 134; SOU 1923).

1.2 Metal

Gross output and employment from BiSOS D
1868–1912: *förgyllerier, förnickling, hagel, kapsyler, knappfabriker, stämpelfabriker, galvanisering, guld- och silverarbeten, gulddragerier,*

guldslageri, kopparvarufabriker, metall och bronsfabriker, metallduk och messingtråd, ornamentfabriker, stilhjuteri, skostiftsfabriker, tenngjuteri, skostift.

Additional output from BiSOS C
1868–1896: Physical quantities of *arbeten av guld, silver (hel- och halvprodukt), koppar (inkl halv- och slutbehandlad produkt), messing, kopparsmide, gjutgods av annan produkt än järn, bly (inkl halv- och slutbehandlad produkt), zink (halv- och slutbehandlad produkt)* are multiplied by prices of gold, silver, copper, tin and lead (see below) to give gross output.

1868–1912: Gross output of *arbeten av guld, silver (hel- och halvprodukt), koppar (inkl halv- och slutbehandlad produkt), messing, kopparsmide, gjutgods av annan produkt än järn, bly (inkl halv- och slutbehandlad produkt), zink (halv- och slutbehandlad produkt).*

Estimates of employment for additional output
1868–1912: Estimated by using the gross output to employment ratio from BiSOS D.

Prices of final products
It is not possible to come by prices of the final products. Instead, a price index including the most important input materials is used, assuming the ratio of input to output prices remained quite stable over time.

1868–1912: a weighted price index including gold (0.28), silver (0.07), copper (0.36), tin (0.09) and lead (0.21) where weights are based on shares of gross output in BiSOS C and BiSOS D in 1896. Prices of copper, lead and tin from Åmark (1921 pp. 1275, 1283) and prices of silver from Jörberg (1972 p. 580).

Prices of intermediate consumption
Price index constructed on the assumption that the net to gross output ratio of 0.37 in 1913 (SOU 1923) remained constant in 1868–1912.

1.3. Ship yards

Gross output and employment from BiSOS D
1872–1912: *skeppsvarv.*

Additional output
1868–1871: Schön (1988 p. 76).

Estimates of employment for additional output
1868–1872: The elasticity of output with respect to the output to employment ratio is estimated on the basis of the data from BiSOS D in 1872–1912 (see above). The following regression equation is estimated:
$\Delta\ln(\text{Output/Employment})=\alpha+\beta\Delta\ln\text{Output}$; $\beta=0.904$; $R2=0.5$; T-ratio=4.995.

Prices of final products
1888–1912: A price index of the shipyard industry (Ljungberg 1990 p. 330).

Prices of intermediate consumption
A combined index (weights in parentheses) is constructed using the prices of final products in industry 1.6 (0.12), industry 1.1 (ironware) (0.36), industry 1.1 (mechanical engineering) (0.43), industry 1.4 (0.02), industry 3.1 (0.05) and industry 8.1 (0.02). Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 6 per cent of total costs with a net to gross output ratio of 0.6 (SOU 1923).

1.4. Electro mechanical industry

Gross output and employment from BiSOS D
1885–1912: *elektromekaniska fabriker, elektriska belysningsapparater, elektriska kol- och vattenfilters, elektrisk ledningstråd, lampfabrik (glödlampor).*

Prices of final products
1888–1912: a price index of the electro mechanical industry (Ljungberg 1990 p. 512).

Prices of intermediate consumption
A combined index (weights in parentheses) is constructed using the prices of final products in industry 1.6 (0.56), industry 1.2 (0.22) and industry 1.1 (ironware) (0.22). Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 4 per cent of total costs with a net to gross output ratio of 0.6 (SOU 1923).

1.5. Iron ore

Physical quantities, gross output and employment from BiSOS C
1868–1896: Physical quantities of *järnmalm* and *sjö- och myrmalm* are multiplied by prices of iron ore (see below) to give gross output.

1896–1912: Gross output of *järnmalm, sjö- och myrmalm*.

Prices of final products
1868–1887: prices of iron ore (Jörberg 1972 p. 703).
1887–1912: prices of iron ore (Ljungberg 1990 p. 341).

Prices of intermediate consumption
The cost share of materials is small, mostly in the form of explosives and wood but the cost share of fuel is large. The final price index is an arithmetic mean of prices of final products in industry 3.1 and industry 8.5. Fuel is represented by prices of charcoal (Jörberg 1972 pp. 698–9), accounting in 1913 for 32 per cent of total costs with a net to gross output ratio of 0.86 (SOU 1923).

1.6. Iron and steel works

Physical quantities, gross output and employment from BiSOS C
1868–1896: Physical quantities of *tackjärn, gjutgods från masugn, gjutgods från tackjärns omsmältning, smältstycken, tångjärn, stål, bessermetall, martinmetall, stål av annat slag*. They are transformed into a Laspeyres quantity index by using as weights their average gross output shares in 1896–1912. The quantity index is the price index below to give gross output.

1896–1912: Gross output of *tackjärn, gjutgods från masugn, gjutgods från tackjärns omsmältning, smältstycken, stångjärn, stål, bessermetall, martinmetall, stål av annat slag.*

Prices of final products
1868–1888: The final index is an arithmetic mean of prices of pig iron and bar iron (Åmark (1921 p. 1275).
1888–1912: a price index of steel and ironworks (Ljungberg 1990 p. 512).

Prices of intermediate consumption
The only material input is iron ore (output price in industry 1.5) which combines with fuel to form the final price index. Fuel is represented by prices of charcoal (Jörberg 1972 pp. 698–9), accounting in 1913 for 40 per cent of total costs with a net to gross output ratio of 0.21 (Schön 1988 p. 134; SOU 1923).

2. Stone, clay and glass

BiSOS D provides gross output and employment for five of the six groups of industries in the stone, clay and glass industry. Only coal (2.6) originates from BiSOS C. The output of bricks 1868–1891, adjusted upwards in accordance with Schön's recommendations, represents the only additional output besides what BiSOS gives. By implication, numbers of employment and gross output are quite reliable for the stone, clay and glass industry. For the period as a whole my figures tally closely with Schön's (1988); on average my figures are three per cent larger.

2.1. Glass

Gross output and employment from BiSOS D
1868–1912: *fabriker för glastillverkning, fabriker för tillverkning av glaspulver*.

Prices of final products
1868–1888: arithmetic mean of prices for window glass and bottles (Johansson 1988 pp. 219–20).
1888–1912: price index of the glass industry (Ljungberg 1990 p. 514).

Prices of intermediate consumption
Lack of price information on sand, the most important material input, makes it a shaky project to construct a price index of material inputs. We have to be content with a weighted price index of materials comprising chemical products from industry 8.7 (0.83) and petroleum (0.17) (Åmark 1921 pp. 1274, 1282). However, the share of fuel is large, lending certainty to the final index. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 50 per cent of total costs with a net to gross output ratio of 0.67 (SOU 1923).

2.2. Chinaware and tile

Gross output and employment from BiSOS D
1868–1896: *porslinsfabriker, kakelugns- och stenkärlsfabriker.*

Prices of final products
1868–1896: prices of tiles (Jörberg 1972 p. 561).

Prices of intermediate consumption
As with the glass industry no information on the most important materials exists, but fuel represents the single most important cost item. The price index includes chemical products from industry 8.7 (0.13) and petroleum (0.87) (Åmark 1921 pp. 1274, 1282). Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 37 per cent of total costs with a net to gross output ratio of 0.72 (SOU 1923).

2.3. Quarrying and refined stone products

Gross output and employment from BiSOS D
1868–1912: *torv, stenhuggning, kalk- och kritbruk, sten- och lergods, coke- och asfaltsfabriker.*

Prices of final products
The heterogeneity of this subgroup obstructs the construction of a price index for well defined products. A rather crude combination of prices of final products for cement 2.4, bricks 2.5 and tiles 2.2 is used instead.

Prices of intermediate consumption
Price index constructed on the assumption that the net to gross output ratio of 0.76 in 1913 (SOU 1923) remained constant over time.

2.4. Cement

Gross output and employment from BiSOS D
1874–1912: *cementindustri, cementgjuteri.*

Prices of final products
1874–1888: prices of cement (Åmarks 1921 s. 1273).
1888–1912: arithmetic mean of various kinds of cement (Ljungberg 1990 pp. 353–4).

Prices of intermediate consumption
Price index constructed on the assumption that the net to gross output ratio of 0.54 in 1913 (SOU 1923) remained constant in 1874–1912.

2.5. Bricks

Gross output and employment from BiSOS D
1873–1912: *tegelbruk.*

Additional output
1868–1891: Schön (1988 pp. 35–7).

Estimates of employment for additional output
1868–1873: The elasticity of output with respect to the output to employment ratio is estimated on basis of the data from BiSOS D in 1874–1912 (see above). The following regression equation is estimated:
$\Delta\ln(\text{Output/Employment})=\alpha+\beta\Delta\ln\text{Output}$; $\beta=0.722$; T-ratio=7.409; $R2=0.597$.

1873–1891: Estimated by using the gross output to employment ratio from BiSOS D.

Prices of final products
1868–1888: prices of bricks (Jörberg 1972 pp. 698–9).
1888–1912: a weighted (weights in parentheses) price index of building bricks (0.775), roofing tiles (0.15) and firebricks (0.015) (Ljungberg 1990 pp. 353–4). Weights are gross output shares from the Swedish Industrial Statistics in 1913.

Prices of intermediate consumption
Price index constructed on the assumption that the net to gross output ratio of 0.67 in 1913 (SOU 1923) remained constant in 1868–1912.

2.6. Coal

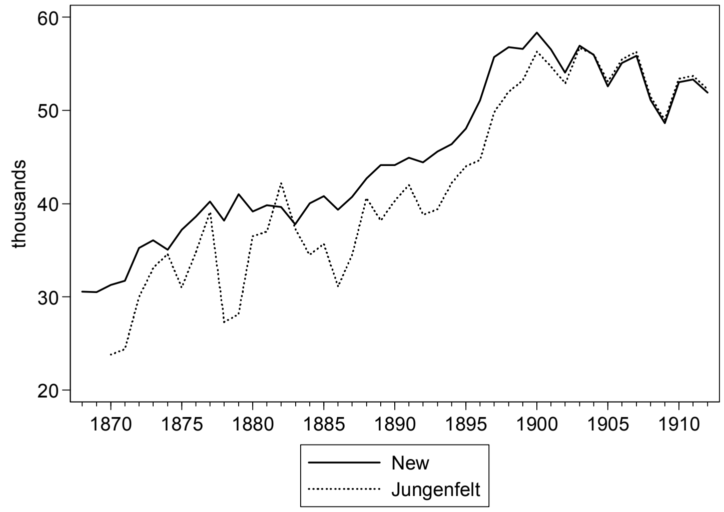
As in the Iron, steel, metal and engineering industry, output of coal reported in BiSOS C has been transformed into gross output by multiplying series of physical quantities with series of coal prices. Employment numbers for coal are hidden behind the heterogeneous label of other metal works and mines (*andra verk med tillhörande grufvor*) where employment is reported by geographical area. However, we know that coal mining only took place in Malmöhus and Kristianstads län and furthermore that no other mining activity occurred there. It means that employment numbers reported for these two geographical areas belong to the output of coal mining.

Physical quantities, gross output and employment from BiSOS C
1868–1896: Physical quantities of *stenkol, eldfast lera, klinkerlera* are multiplied by prices of coal (see below) to give gross output.

1868–1912: Gross output of *stenkol, eldfast lera, klinkerlera.*

Prices of final products
1868–1912: prices of coal (Åmark 1921 s. 1274; 1282).

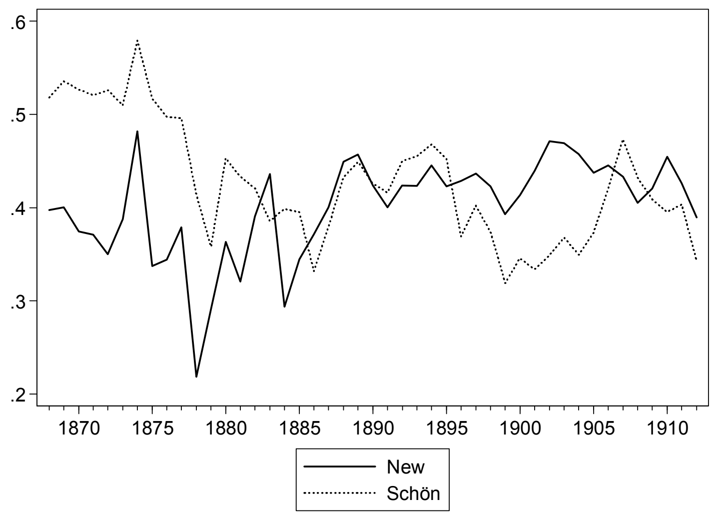
Prices of intermediate consumption
The cost share of raw materials in gross output is moderate. The share of fuel is quite large (0.31) but fuel is the same as the final product, making it impossible to estimate fluctuations in the net to gross output ratio. I have assumed that the net to gross output ratio of 0.93 in 1913 (SOU 1923) remained constant in 1868–1912.



GRAPH A.5.1. Estimated number of workers in sawmills, 1868–1912

3. Wood

The absence of sawmills before 1896 is the most serious lacuna in BiSOS because they accounted for a large share of total output in the manufacturing industry. The first attempt to estimate pre-1896 gross output was made by Lindahl *et al.* (1937). Schön (1988) later on raised the level of gross output further, both before and after 1896. I have incorporated Schön's revisions and my level of gross output tracks Schön's precisely. The importance of sawmills justifies a closer look at the estimated number of workers and the estimated series of net output in current prices. Jungenfelt (1959) tries to make the number of workers correspond with the gross output as estimated by Lindahl *et al.* (1937). He estimates the number of workers by assuming that the cost share of wages in gross output in 1896 remained unchanged back to 1870. The wage sum divided by the average wage gives an estimate of the number of workers. He attains the average annual wage from a wage series in Bagge *et al.* (1933), which starts at a quite high level in 1870 and exhibits almost no growth until the 1890s. The high annual wage level implies a relatively low number of workers at the beginning of the period. The fixed cost share of wages in gross output in current prices makes the level of workers highly susceptible to changes in prices for final products. Instead changes in employment should be related to changes in the volume of gross output. Jungenfelt's estimated number of workers relates to Lindahl *et al.*'s gross output, which is lower than Schön's. My method, based on an estimated relationship between growth in volume output and growth in productivity, gives a series of employment whose level is on average somewhat



GRAPH A.5.2. Estimates of value added shares in current prices for the wood industry, 1868–1912

higher, which it should be, since it relates to Schön's larger gross output. My series furthermore displays smaller fluctuations because it mirrors changes in volume of gross output, not gross output in current prices (graph A.5.1).

As to the estimate of net output in current prices, graph A.5.2 shows Schön's series of value added shares, after it is purged of handicraft production, and my series of net output shares for sawmills and refined wood products. For the period as a whole, Schön's series declines from 0.52 to 0.34 while my series remains without significant trend. There are, however, large fluctuations in both series, which underscores the volatile nature of prices of final products, boards, and the most important intermediate consumption, wood. The two series are not strictly comparable though. Schön has subtracted from gross output the costs of materials and fuel as well as the costs of maintenance and repairs, and, therefore, his series deserves the prefix value added, while my series is not adjusted for maintenance and repair works, and should therefore be called net output (Schön 1988 pp. 146-7). Another reason why the two series are not straightforwardly comparable is that I need to assume that the net output share in 1913, as estimated by the public investigation into cost shares (SOU 1923), was the same in 1912. Schön does not have to invoke this assumption since his series spans and continues after 1913. Yet, these differences cannot account for all the different behaviours of the series. Instead, the choice of price series used to extrapolate the net output share in 1913 may hold the key to understanding the differences. Schön (1988) gives no detailed information on the price series in use.

3.1. Sawmills and planing mills

Gross output and employment from BiSOS D
1896–1912: *sågverk och hyvlerier.*

Additional output
1868–1904: Schön (1988 pp. 43, 79–80).

Estimates of employment for additional output
1868–1896: The elasticity of output with respect to the output to employment ratio is estimated on the basis of the data from BiSOS D in 1896–1912 (see above). The following regression equation is estimated:
ln(Output/Employment)=α+βlnOutput; β=0.622; T-ratio=4.971; R2=0.622.

1896–1904: Estimated by using the gross output to employment ratio from BiSOS D.

Prices of final products
1868–1888: prices of battens (Åmark 1921 pp. 1273, 1282).
1888–1912: price index of the wood industry (Ljungberg 1990 p. 514).

Prices of intermediate consumption
Price index constructed by taking the arithmetic mean of prices of log timber and pine wood (Jörberg 1972 pp. 546–9, 693–4). No information on the cost share of fuel exists. The net to gross output ratio is 0.39 for 1913 (SOU 1923).

3.2. Refined wood products

Gross output and employment from BiSOS D
1872–1912: *korg, kork, käpp, läst, möbel, persienn, skopligg, snickerifabriker.*

Additional output and employment based on extrapolation
1872–1895: Backward extrapolation from 1896 based on movement of the industries recorded in BiSOS D (see above) in order to account for the sharp improvement of coverage in 1896.

Prices of final products
No prices of the most important products are available. Instead, the price index of final products for sawmills and planning mills is used.

Prices of intermediate consumption
Price index constructed on the assumption that the net to gross output ratio of 0.56 in 1913 (SOU 1923) remained constant in 1872–1912.

4. Paper

For paper and paper pulp, BiSOS D provides reliable information on output and employment for the whole period. The coverage of the book printing industry was, however, markedly improved in 1896. Lindahl *et al.* (1937) adjusted the output upwards somewhat between 1896 and 1912, which caused an even larger discontinuity. I accept their adjustment after 1896 but try to smooth the series by backward extrapolations from 1896 to 1868 on the basis of the output and employment for the book printing industries recorded in BiSOS before 1896. That additional output raises output for the paper industry to a level that is on average 36 per cent higher than Schön's (1988) before 1896.

4.1. Paper pulp

Gross output and employment from BiSOS D
1868–1912: *trämassafabriker, pappersmassafabriker.*

Prices of final products
1868–1888: price index of pulp (Schön 1988 p. 205).
1888–1912: a weighted (chained Fisher) index of prices of mechanical and chemical pulp (Ljungberg 1990 pp. 367–8) where weights are annual shares of gross output from BiSOS D.

Prices of intermediate consumption
A weighted index (weights in parentheses) of prices of log timber (0.94) (Jörberg 1972 pp. 546–9) and chemical products in industry 8.7 (0.06) is constructed. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 17 per cent of total costs with a net to gross output ratio of 0.35 (Schön 1988 p. 134; SOU 1923).

4.2. Paper

Gross output and employment from BiSOS D
1868–1896: *pappersbruk och pappfabriker, papperspåsar, kuvertfabriker, tapetfabriker.*

Prices of final products
1868–1885: price index of the paper industry (Schön 1988 p. 205).
1888–1912: arithmetic mean of prices of various kinds of papers (Ljungberg 1990 pp. 371–3).

Prices of intermediate consumption
In the first step three types of price indices are constructed: paper mills producing plain paper where paper pulp in industry 4.2 is the only input material; paper mills producing more refined paper products where a weighted index (weights in parentheses) of paper (see above) (0.73), leather in industry 8.2 (0.24) and rubber in industry 8.4 (0.02) represent prices of material inputs; and finally industries producing wall paper where metal in industry 1.2 (0.16), wood products in industry 3.1 (0.02), and paper (see above) (0.66) and paint in industry 8.1 (0.16) are combined.

In the second step these indices are put together by weights based on average shares of gross output in 1868–1912: paper mills producing paper (0.46), paper mills producing more refined paper products (0.44) and wall paper industries (0.1). Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 11 per cent of total costs with a net to gross output ratio of 0.42 (SOU 1923).

4.3. Book printing

Gross output and employment from BiSOS D
1868–1912: *kortfabriker, litografiska anstalter, bokbinderier.*

Additional output and employment based on extrapolation
1868–1895: Backward extrapolation from 1896 based on movement of the industries recorded in BiSOS D (see above) in order to account for the sharp improvement in returns in 1896.

Additional output
1896–1912: Lindahl (1937 p. 191, table 90).

Estimate of employment for additional output
1896–1912: Estimated by using the gross output to employment ratio from BiSOS D.

Prices of final products
1868–1888: unit values of playing-cards from BiSOS D.
1888–1912: price index of the graphical industry (Ljungberg 1990 p. 516).

Prices of intermediate consumption
A weighted index of prices of paper in industry 4.2 (0.92), paint in industry 8.1 (0.04) and petroleum (0.04) (Åmark 1921 pp. 1274, 1282) is constructed. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 5 per cent of total costs with a net to gross output ratio of 0.66 (SOU 1923).

5. Food and beverages

BiSOS left many gaps in the food industry. The reason is that it excluded many industries closely related to agriculture. For instance the dairy industry did not enter the official industrial statistics until 1913. The small coverage in BiSOS has made the food industry the subject of intensified efforts to estimate output for the industries that were left out. We are now much better equipped with output data for food related industries but we are still short of employment data. Comparing the figures reported in BiSOS with Schön's (1988) revision shows that on average BiSOS failed to report 85 per cent of the total output before 1896. After 1896 the gap decreased gradually to 30 per cent. It testifies to the challenge posed when estimating the corresponding numbers of workers. The very low coverage before 1896 is due mostly to the absence of the flour mills, accounting as it did for fifty per cent of the gap. Before 1896 my level of gross output is on average 13 per cent higher than Schön's (1988). After 1896 the difference vanishes.

5.1. Flour mills

Gross output and employment from BiSOS D
1896–1912: *mjöl och grynkvarnar.*

Additional output
1868–1912: Schön (1988 pp. 83–4).

Estimates of employment for additional output
1868–1895: The elasticity of output with respect to the output to employment ratio is estimated on the basis of the data from BiSOS D in 1896–1912 (see above): The following regression equation is estimated:
$\Delta\ln(\text{Output}/\text{Employment})=\alpha+\beta\Delta\ln\text{Output}$; $\beta=0.827$; T-ratio=10.265; $R2=0.883$.

1895–1912: BiSOS D excluded systematically small production units. Through Jörberg's (1961) conducted investigation into the material underlying the published BiSOS volumes and classification of firms by size, we know that the smallest production units' gross output to employment ratio was only forty per cent of the average production unit. The usual assumption of equal gross output to employment ratio for the industries recorded in BiSOS and the additional output provided by Lindahl *et al*. (1937) and Schön (1988) cannot be justified. I have reckoned with this lower productivity when estimating the number of workers.

Prices of final products
1868–1888: weighted index of prices of rye flour (0.43) wheat flour (0.56) and rolled oats (0.01) (Myrdal 1933).
1888–1912: price index of the flour mill industry (Ljungberg 1990 p. 518).

Prices of intermediate consumption
A weighted index (weights in parentheses) of prices of rye (0.2), wheat (0.5) and oats (0.3) (Jörberg 1972 pp. 635–6, 640–1) is constructed. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 1 per cent of total costs with a net to gross output ratio of 0.17 (SOU 1923).

5.2. Pork butcheries

Gross output and employment from BiSOS D
1891–1912: *slakterier*.

Additional output
1885–1890: Lindahl *et al*. (1937 p. 195).

Estimate of employment for additional output
1885–1890: The elasticity of output with respect to the output to employment ratio is estimated on basis of the data from BiSOS D in 1897–1912 (see above). The following regression equation is estimated:
$\Delta\ln(\text{Output/Employment})=\alpha+\beta\Delta\ln\text{Output}$; $\beta=0.217$; T-ratio=1.573; R2=0.150.

Prices of final products
1885–1888: prices of bacon (Myrdal 1933 pp. 201–3, table B).
1888–1912: price index of slaughterhouses (Ljungberg 1990 p. 516).

Prices of intermediate consumption
Prices of pork (Jörberg 1972 p. 656) are used. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 1 per cent of total costs with a net to gross output ratio of 0.15 (SOU 1923).

5.3. Margarine

Gross output and employment from BiSOS D
1894–1912: *margarinfabriker.*

Prices of final products
1894–1912: price index of the oil and fat industry (Ljungberg 1990 p. 518).

Prices of intermediate consumption
Price index constructed on the assumption that the net to gross output ratio of 0.25 in 1913 (SOU 1923) remained constant in 1894–1912.

5.4. Sugar

Gross output and employment from BiSOS D
1868–1912: *sockerbruk, råsockerbruk, sockerraffinaderier, sockersågning.*

Prices of final products
1868–1888: price index of sugar (Rönnbäck 2007).
1888–1912: price index of the sugar industry (Ljungberg 1990 p. 518).

Prices of intermediate consumption
1885–1912: After the introduction of beet sugar during the middle of the 1880s, imports of unrefined cane sugar gradually ceased. The price index includes only beet sugar (Ljungberg (1990 pp. 250–1). Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 7 per cent of total costs with a net to gross output ratio of 0.21 (Schön 1988 p. 135; SOU 1923).

5.5. Tobacco

Gross output and employment from BiSOS D
1868–1912: *tobaksindustri.*

Prices of final products
1868–1888: price index of tobacco (Schön 1988 p. 205).
1888–1912: price index of the tobacco industry (Ljungberg 1990 p. 520).

Prices of intermediate consumption
1868–1912: prices of raw tobacco (Åmark 1921 pp. 1273, 1282). Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 2 per cent of total costs with a net to gross output ratio of 0.54 (SOU 1923).

5.6 Chocolate and candy

Gross output and employment from BiSOS D
1868–1912: *choklad, karamell och konfektyrindustri.*

Prices of final products
1888–1912: price index of the chocolate and candy industry (Ljungberg 1990 p. 518).

Prices of intermediate consumption
A weighted index (Laspeyres) (weights within parentheses), based on the prices of cacao (0.33) (Ljungberg 1990 pp. 404–5), milk (0.1) (Myrdal 1933) and sugar in industry 5.4 (0.57), is constructed. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 2 per cent of total costs with a net to gross output ratio of 0.44 (SOU 1923).

5.7. Breweries

Schön (1988), in his revision of gross output, found the that gross output level of beer which was reported in BiSOS D was appreciably lower than special investigations in 1880, 1890 and 1897 concluded. He therefore raised the level of gross output for pre-1897 years. The difference between Schön's estimate and BiSOS' given output is added to the output series of breweries. Employment is raised by the assumption that productivity in the added industries did not differ from the ones represented in BiSOS. In 1892, BiSOS started reporting output and employment for punch breweries, and in 1896 also mineral water and soft drinks. The sudden introduction of these activities causes an unwelcome discontinuity. The only solution at hand is a backward extrapolation from the years in which these industries were introduced, assuming that the movement of their output and employment followed the breweries.

Gross output and employment from BiSOS D
1872–1912: *maltbryggeri, mälterier, bärvin, vin och saft, mineralvatten och läsk, punchbryggerier.*

Additional output
Punch:
1868–1871: backward extrapolation from 1872 based on the movement of output for *maltbryggeri* as recorded in Schön (1988 pp. 81–2).

1872–1891: backward extrapolation from 1891 based on the movement of output for *maltbryggeri* as recorded in BiSOS D.

Mineralvatten och läsk:
1868–1871: backward extrapolation from 1872 based on the movement of output for *maltbryggeri* as recorded in Schön (1988 pp. 81–2).

1872–1896: backward extrapolation from 1896 based on the movement of output for *maltbryggeri* as recorded in BiSOS D.

Maltbryggeri:
1868–1897: Schön (1988 pp. 81–2).

Estimates of employment for additional output
Punch:
1872–1891: backward extrapolation from 1891 based on the movement of employment *maltbryggeri* as recorded in BiSOS D.

1868–1871: backward extrapolation from 1872 based on average annual percentage change in employment for *maltbryggeri* in 1872–1890 as recorded in BiSOS D.

Mineralvatten och läsk:
1872–1896: backward extrapolation from 1896 based on the movement of employment for *maltbryggeri* as recorded in BiSOS D.

1868–1871: backward extrapolation from 1872 based on average annual percentage change in employment for *maltbryggeri* in 1872–1890 as recorded in BiSOS D.

Maltgryggeri och mälteri:
1868–1871: The elasticity of output with respect to the output to employment ratio is estimated on the basis of the data from BiSOS D in 1897–1912 (see above): The following regression equation is estimated:
$\Delta \ln(\text{Output/Employment})=\alpha+\beta\Delta\ln\text{Output}$; $\beta=0.525$; T-ratio=4.438; R2=0.585.

1872–1897: Estimated by using the gross output to employment ratio from BiSOS D.

Prices of final products
1868–1888: prices of beer (Jörberg 1972 p. 395).
1888–1912: price index of the brewery industry (Ljungberg 1990 p. 520).

Prices of intermediate consumption
A weighted index of prices of barley (0.58) and hops (0.19) (Jörberg 1972 pp. 635–6, 675–6) and glass bottles (0.23) (Johansson 1988 p. 219) is constructed. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 13 per cent of total costs with a net to gross output ratio of 0.13 (Schön 1988 p. 135; SOU 1923).

5.8. Spirit

From 1896 onwards BiSOS first, then the modern post-1913 version of the Swedish Industrial Statistics, give gross output for unrefined spirit (*brännvinsbrännerier*) and refined spirit (*destilleringsverk*). On average the comparative levels of gross output are similar for these manufacturing processes.

BiSOS included unrefined spirit in 1892 and refined spirit in 1896. Lindahl *et al.* (1937) estimated gross output for the years preceding 1892 but let the problem with refined spirit go unnoticed, which means that the output series of the spirit industry contains an abrupt change in 1896. I presume that the ratio between the unrefined and refined spirit remained stationary before 1896, implying that I accept Lindahl *et al.*'s estimate of unrefined spirit as being a reasonable representation for refined spirit as well.

Gross output and employment from BiSOS D
1892–1912: *brännvinsbrännerier, destilleringsverk.*

Addtitional output
Brännvinsbrännerier:
1868–1891: Lindahl *et al.* (1937 p. 196, table 93).

Destilleringsverk
1868–1891: Lindahl *et al.* (1937 p. 196, table 93).
1892–1895: Adjusted upwards to equal the output of *brännvinsbrännerier*.

Estimates of employment for additional output
Brännvinsbrännerier:
1868–1891: The elasticity of output with respect to the output to employment ratio is estimated on the basis of the data for *brännvinsbrännerier* from BiSOS D in 1897–1912. The following regression equation is estimated:
$\Delta\ln(\text{Output/Employment})=\alpha+\beta\Delta\ln\text{Output}$; $\beta=0.812$; T-ratio=8.722; R2=0.845.

Destilleringsverk:
1868–1891: The elasticity of output with respect to the output to employment ratio is estimated on the basis of the data for *destilleringsverk* from BiSOS D in 1897–1912. The following regression equation is estimated:
$\ln(\text{Output/Employment})=\alpha+\beta\ln\text{Output}$; $\beta=0.3$; T-ratio=1.669; R2=0.166.

1892–1895: Estimated by using the gross output to employment ratio from BiSOS D.

Prices of final products
1868–1888: price of spirit (Lindahl *et al.* 1937 p. 196, table 93).
1888–1912: price index of the spirit industry (Ljungberg 1990 p. 520).

Prices of intermediate consumption
After 1889 it is possible to construct separate indices of material inputs thanks to prices of both refined and unrefined spirit (Ljungberg 1990 pp. 412–3). The index of material inputs for unrefined spirit is an arithmetic mean of prices of

potatoes (Myrdal 1933 pp. 219–20, table C6) and barley (Jörberg 1972 pp. 635–6). Material inputs going into distilleries consist of the price series for unrefined spirit. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 1 per cent of total costs with a net to gross output ratio of 0.12 (SOU 1923).

5.9. Bakery

Gross output and employment from BiSOS D
1890–1912: *bagerier, käksfabriker.*

Additional output and employment based on extrapolation
1890–1895: backward extrapolation from 1896 based on the movement of the industries from BiSOS D (see above) in order to account for the sharp improvement of returns in 1896.

Prices of final products
1890–1912: price index of bakeries (Ljungberg 1990 p. 518).

Prices of intermediate consumption
A weighted index of prices of flour in industry 5.1 (0.91), yeast (0.03) (Ljungberg 1990 p. 407), sugar in industry 5.4 (0.03) and salt (0.03) (Jörberg 1972 p. 619). Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 10 per cent of total costs with a net to gross output ratio of 0.57 (SOU 1923).

5.10. Dairy

The dairy industry never found its way into BiSOS. It appeared for the first time in the modern version of the Swedish Industrial Statistics in 1913.

Gross output
1868–1912: Lindahl *et al*. (1937 p. 194, table 92).

Estimate of employment
1868–1912: The elasticity of output with respect to the output to employment ratio is estimated on basis of the data for *mejeriindustrin* from the Swedish Industrial Statistics between 1913 and 1935. The following regression equation is estimated:
$\Delta\ln(\text{Output}/\text{Employment})=\alpha+\beta\Delta\ln\text{Output}$; $\beta=0.773$; T-ratio=11.322; $R2=0.859$.

Prices of final products
1868–1888: Weighted average of prices of butter (0.8) and cheese (0.2) (Jörberg 1972 pp. 665–6).
1888–1912: price index of the dairy industry (Ljungberg 1990 p. 516).

Prices of intermediate consumption
1868–1885: Arithmetic mean of prices of skimmed and unskimmed milk (Myrdal 1933 pp. 201–3).
1885–1912: Arithmetic mean of various kinds of milk (Ljungberg 1990 pp. 259–60). Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 1 per cent of total costs with a net to gross output ratio of 0.066 (SOU 1923).

5.11. Miscellaneous food industry

Gross output and employment from BiSOS D
1868–1896: *cikoriefabriker, kaffebrännerier, kaffesurrogat, makaroni, senaps-brännerier, konserver, salt, senap, soja, glykos, kryddfabriker, kaffesurrogat, fiskberedning.*

Prices of final products
1868–1888: weighted index of prices of coffee (Myrdal 1933 p. 242) and unit values of compressed yeast from BiSOS D.
1888–1912: price index of the miscellaneous food industry (Ljungberg 1990 p. 518).

Prices of intermediate consumption
Price index constructed on the assumption that the net to gross output ratio of 0.28 in 1913 (SOU 1923) remained constant in 1868–1912.

6. Textile and clothing

This is one of the groups of industries with the most sufficient coverage in BiSOS. On average my numbers of gross output are 99.7 per cent of Schön's (1988) revision.

6.1. Textile

Gross output and employment from BiSOS D
1868–1912: *bomullslistfabriker, färgerier, bomullsspinneri, jutespinneri, hampaspinneri, linspinneri, ullspinneri, impregnering, katttuntryck, kemiska*

blekerier, repslageri, vadmalsstampar, bomullsväveri, kädesväveri, hel och halvylleväveri, linneväveri, juteväveri, sidenväveri, schoddy, trassel.

Prices of final products

Many textile firms are vertically integrated; they produce both yarn and cloth. However, to construct a price index of final products and intermediate material inputs for the entire textile industry it is necessary to treat weaving and spinning separately; as though both sell their final products (yarn and cloth) and purchase their material inputs (yarn or raw material) at the going market rate. In the final price index of final products and intermediate material inputs, spinning is assigned the weight of 0.45 and weaving 0.55.

1868–1885:

Spinning:

At the beginning of the period cotton yarn accounted for the lion's share of gross output, but the significance of woollen yarn grew rapidly. Hemp and flax remained insignificant during the whole period. A chained Fisher index of prices of cotton yarn (Schön 1988 pp. 205–6) and woollen yarn, linen yarn (Jörberg 1972 pp. 680–1) is constructed and the weights are annual shares of gross output from BiSOS D.

Weaving:

A chained Fisher price index, based on the prices of cotton and woollen cloth (Schön 1988 pp. 205–6) and linen fabric (Jörberg 1972 pp. 685–6), is constructed and the weights are annual shares of gross output from BiSOS D.

1885–1912:

Spinning:

A chained Fisher price index, based on prices of cotton yarn (Ljungberg (1990 pp. 428–9), woollen yarn and linen yarn (Jörberg 1972 pp. 680–1), is constructed and the weights are annual shares of gross output from BiSOS D1.

Weaving:

A chained Fisher price index, based on the prices of woollen and cotton cloth (Ljungberg 1990 pp. 435–7) and linen fabric (Jörberg 1972 pp. 685–6), is constructed and the weights are annual shares of gross output from BiSOS D.

Prices of intermediate consumption

Spinning:

A chained Fisher price index, based on the prices of wool (Jörberg 1972 pp. 680–1), cotton (Åmark 1921 pp. 1274, 1282), hemp and flax (Jörberg 1972 pp. 685–6, 675–6), is constructed and the weights are annual shares of gross output from BiSOS D.

Weaving:
Price index of yarn: (see above).

Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 5 per cent of total costs with a net to gross output ratio of 0.37 (Schön 1988 p. 135; SOU 1923).

6.2. Clothing

Gross output and employment from BiSOS D
1868–1912: *filtar, hattar, kardfabriker, lump- och lappull, maskinremmar, bomullsremmar, fisknät, gardin, hängslen, konstgjorda blommor, korsett, kravatt, markis, mössor, paraply, snörmakeri, spets, rullgardin, silkesrederi, sidenappteringsverk, sömnadsfabrik, vadd, band, segel, tältduk, trikå.*

Prices of final products
1868–1879: unit values of socks, underpants and jumpers from BiSOS D.
1879–1888: price index of final products in the textile industry 6.1 (weaving).
1888–1912: price index of the clothing industry (Ljungberg 1990 p. 520).

Prices of intermediate consumption
Price index of final products in the textile industry (weaving) is used. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 2 per cent of total costs with a net to gross output ratio of 0.49 (SOU 1923).

7. Leather hair and rubber

The gross output of this group is very close to Schön's; on average it is merely one per cent higher. No additional estimates are included.

7.1 Tannery

Gross output and employment from BiSOS D
1868–1890: *garverier, läderfabriker, sämskmakerier, pelsvarufabriker*.

Prices of final products
1868–1888: prices of tanned cow hides (Jörberg 1972 p. 630).
1888–1912: price index of tanneries (Ljungberg 1990 p. 522).

Prices of intermediate consumption
A weighted index (Laspeyres) (weights in parentheses), based on the prices of raw hides (0.67) (Åmark 1921 pp. 1275, 1283), Swedish (0.3), imported (0.7), and chemical products in industry 8.7 (0.33), is constructed. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 1 per cent of total costs with a net to gross output ratio of 0.2 (SOU 1923).

7.2. Products of leather and fur

Gross output and employment from BiSOS D
1868–1912: *handskar, portfölj, reseffekter, borstbinderi, nöthårsfiltfabriker, skonåtling, skinntröjfabriker, sadelmakerier.*

Prices of final products
1868–1888: prices of gloves (Schön 1888 p. 206).
1888–1912: unit values of leather gloves from BiSOS D.

Prices of intermediate consumption
A weighted index (Laspeyres) (weights in parentheses), based on of prices raw hides (0.61) (Åmark 1921 p. 1275, 1283) Swedish (0.3), imported (0.7), output prices of tannery in industry 7.1 (0.23), output prices of clothing in industry 6.2 (0.03) and output prices of textile in industry 6.1 (cloth) (0.13), is constructed. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 1 per cent of total costs with a net to gross output ratio of 0.39 (SOU 1923).

7.3. Shoes

Gross output and employment from BiSOS D
1868–1912: *skoindustrier.*

Prices of final products
1888–1912: price index of the shoe industry (Ljungberg 1990 p. 520).

Prices of intermediate consumption
A weighted index (Laspeyres) (weights in parentheses), based on the prices of ironware in industry 1.1 (0.04), prices of paper in industry 6.2 (0.02), textile in industry 6.1 (cloth) (0.02) and hides in industry 7.1 (0.94), is constructed. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 1 per cent of total costs with a net to gross output ratio of 0.27 (SOU 1923).

7.4. Rubber

Gross output and employment from BiSOS D
1871–1912: *gummifabriker.*

Prices of final products
1888–1912: price index of the rubber industry (Ljungberg 1990 p. 522).

Prices of intermediate consumption
A price index constructed on the assumption that the net to gross output ratio of 0.4 in 1913 (SOU 1923) remained constant in 1871–1912.

8. Chemical

Most industries are represented in BiSOS D with sufficient coverage. However, in terms of sheer size the most important industry in this group, the charcoal industry, was not reported in BiSOS until 1898. In 1868 the level of gross output of charcoal was, according to the estimates of Lindahl *et al.* (1937) and Schön (1988), almost three times higher than the rest of the chemical industries. Not until the beginning of the 1880s did gross output of the rest of the chemical industries catch up with the production of charcoal. Then of course the rest surged ahead; yet the share of charcoal never fell below 30 per cent. The close affinity of the charcoal production and iron works explains its weightiness. My level of gross output for the chemical industry as a whole tracks Schön's (1988) revision accurately. The difference is on average less than 1 per cent.

8.1. Paint

The production of red paint (*rödfärg*), which was a by-product of the extraction of copper, is given in physical quantities in BiSOS C until 1896, after which it entered BiSOS D. The quantities have been multiplied by the price index (see below) to give gross output which has been added to the series of gross output from BiSOS D.

Gross output and employment from BiSOS D
1868–1912: *träolja, färg- och fernissfabriker, bresiljeqvarnar.*

Additional output from BiSOS C
1868–1895: Physical quantities of *rödfärg*. They are multiplied by the prices of paint and linseed oil (see below) to give gross output.

Estimate of employment for additional output
1868–1895: Estimated by using the gross output to employment ratio from BiSOS D.

Prices of final products
1868–1885: prices of linseed (Åmark 1921 pp. 1275, 1283).
1885–1888: A weighted index (Laspeyres) (weights in parentheses), based on the prices of paint (0.43) (Ljungberg 1990 p. 470) and linseed oil (0.57), is constructed.
1888–1912: price index of the paint industry (Ljungberg 1990 p. 522).

Prices of intermediate consumption
Price index constructed on the assumption that the net to gross output ratio of 0.26 in 1913 (SOU 1923) remained constant in 1868–1912.

8.2. Soap and detergent

Gross output and employment from BiSOS D
1868–1912: *såpa- och tvålfabriker, stearinljus, parfym.*

Prices of final products
1868–1888: A chained Fisher price index, based on the prices of soap (Schön 1988 p. 206) and candles (Myrdal (1933 pp. 201–3), is constructed. Weights are annual shares of gross output from BiSOS D.
1888–1912: A chained Fisher price index, based on the prices of soap and detergent (Ljungberg 1990 p. 522) and candles (Myrdal 1933 pp. 201–3), is constructed. Weights are annual shares of gross output from BiSOS D.

Prices of intermediate consumption
A weighted price index (Laspeyres) (weights in parentheses), based on the prices of final products in sawmills in industry 3.1 (0.125), paper in industry 4.2 (0.125), oil in industry 8.3 (0.25), soap and detergent in industry 8.2 (0.25) and chemicals in industry 8.7 (0.25), is constructed. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for 2 per cent of total costs with a net to gross output ratio of 0.26 (SOU 1923).

8.3. Oil

This group is very heterogeneous. Most of the industries are small and difficult to classify. Some industries just appear for a short time while others exhibit improbable behaviours. BiSOS improved the coverage sharply in 1896, which caused discontinuity. Backward extrapolation from 1896 irons out the series of output and employment and raises the levels of output and employment. The entire series may enter into the aggregate, but cannot be used to represent growth of productivity, at least not before 1896.

Gross output and employment from BiSOS D
1868–1912: *limkokeri, lackérfabriker, lackfabrik, mineralolja, oljeslagerier, vagnsmörjfabriker, collanolja, dextrin, fiskolja och tran, flott, glycerin, harts, hvalolja, karbolsyra, gelatin, olein och vasselin, oleomargarin, talg, valsmassa*.

Additional output and employment based on extrapolation
1968–1995: Backwards extrapolation from 1896 based on the movement of the industries in BiSOS D (see above) in order to account for the sharp improvement of coverage in 1896.

Prices of final products
1868–1876: Arithmetic mean of petroleum (Åmark 1921 pp. 1274, 1282) and rape oil (Jörberg 1972 p. 689).
1876–1888: Arithmetic mean of petroleum and oilcake (Åmark 1921 pp. 1274, 1282).
1888–1912: price index of the oil industry (Ljungberg 1990 p. 254).

Prices of intermediate consumption
Price index constructed on the assumption that the net to gross output ratio of 0.26 in 1913 (Schön 1988 p. 135; SOU 1923) remained constant in 1868–1912.

8.4. Matches

Gross output and employment from BiSOS D
1868–1912: *tändsticksfabriker, tändsticksämnesfabriker.*

Prices of final products
1868–1885: price index of matches (Schön 1988 p. 206).
1885–1912: price index of matches (Ljungberg 1990 p. 489).

Prices of intermediate consumption
A weighted index (Laspeyres) (weights in parentheses), based on the prices of chemicals in industry 8.7 (0.21), log timber (0.42) (Jörberg (1972 pp. 546–9) and paper in industry 4.2 (0.38), is constructed. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for less than 1 per cent of total costs with a net to gross output ratio of 0.67 (SOU 1923).

8.5. Explosives

Gross output and employment
1868–1912: *tändrör, sprängämnesfabriker, ammunitions- och patronfabriker, krutbruk.*

Prices of final products from BiSOS D
Weighted index (chained Fisher) of unit values from BiSOS D of the following products:
1885–1888: nitroglycerin, dynamite and other explosives.
1888–1896: gunpowder, nitroglycerin, dynamite and other explosives.
1896–1912: black powder, gun cotton and explosives made of nitroglycerin.

Prices of intermediate consumption
A weighted index (Laspeyres) (weights in parentheses), based on the prices of chemicals in industry 8.7 (0.4), Chilesalpeter (0.4), coal (0.1) and cotton (0.1) (Åmark 1921 pp. 1274, 1282), is constructed. Fuel is represented by prices of coal (Åmark 1921 p. 1275), accounting in 1913 for less than 7 per cent of total costs with a net to gross output ratio of 0.41 (Schön 1988 p. 135; SOU 1923).

8.6. Charcoal

Charcoal did not enter BiSOS D until 1898, but even after that the coverage was insufficient because it did not record the charcoal production at iron works. The charcoal production has therefore been subjected to revisions by Lindahl *et al.* (1937) and Schön (1988). Their additional output is added to the present investigation. The output of tar also belongs to the charcoal industry, though in relation to charcoal the magnitude of the tar production is tiny. It appeared in BiSOS in 1896, but with deficient coverage. The additional output estimated by Lindahl *et al*. (1937) and Schön (1988) is incorporated here.

Gross output and employment from BiSOS D
1899–1912: *träkolsverk, beck och- tjärkokerier, terpentin och träsprit.*

Additional output
Träkolsverk:
1868–1885: Schön (1988 pp. 86–7, table 11).
1886–1912: Lindahl *et al*. (1937 p. 200, table 95).

Tjärkokeri:
1868–1871: Schön (1988 p. 88, table 12).
1872–1911: Lindahl *et al*. (1937 p. 202, table 96).

Estimates of employment for additional output
Träkolsverk:
1868–1897: The elasticity of output with respect to the output to employment ratio is estimated on the basis of the data for *träkolsverk* in BiSOS D in 1898–1912. The following regression equation is estimated:
$\ln(Output/Employment)=\alpha+\beta \ln Output$; $\beta=0.709$; T-ratio=3.893; R2=0.538.

1898–1912: Estimated by using the gross output to employment ratio from BiSOS D.

Tjärkokeri:
1868–1895: The elasticity of output with respect to the output to employment ratio is estimated on the basis of the data for *beck- och tjärkokeri* in BiSOS D in 1896–1912. The following regression equation is estimated:
$\Delta \ln(Output/Employment)=\alpha+\beta \Delta \ln Output$; $\beta=0.778$; T-ratio=2.510; R2=0.310.

1896–1912: Estimated by using the gross output to employment ratio from BiSOS D.

Prices of final products
A chained Fisher price index, based on the prices of tar and charcoal (Jörberg 1972 pp. 698–9), is constructed. Weights are shares of gross output (see above).

Prices of intermediate consumption
Price index constructed on the assumption that the net to gross output ratio of 0.48 in 1913 (SOU 1923) remained constant in 1868–1912.

8.7. Chemicals and fertilizers

It is evident that chemicals are notoriously difficult to classify in a consistent manner. The types of industries (*kemisk-tekniska fabriker*) classified as chemicals has not remained constant over time. For instance, it is not possible to distinguish the production of fertilizers from the production of chemicals in general because superphosphate – an important part of compound fertilizers and usually classified as a fertilizer industry – was labelled chemical pre-1896. Furthermore, margarine was also labelled chemical before being separately reported in 1893. Thus, the present series of the chemical and fertilizing industry contains a bit of pre-1893 margarine. A minor part of the output of chemical and fertilizers industry is given in physical quantities in BiSOS C. It concerns copper sulphate and iron sulphate. Multiplying physical quantities by prices gives gross output which has been added to the series of gross output from BiSOS D. Employment has been raised by assuming equal gross output to employment ratio.

Gross output and employment from BiSOS D
1868–1912: *benmjölsfabriker, pudrettfabriker, fiskguano, superfosfat, thomasfosfat, andra gödningsfabriker, kemisk-tekniska fabriker, ammoniak, klorat, kristallsoda, salpetersoda, svafvelsyrad lerjord, svafvelsyra.*

Additional output from BiSOS C
1868–1896: Physical quantities of *svavel, kopparvitriol and järnvitriol* are multiplied by prices of chemical products (see below) to give gross output.

1896–1912: Gross output of *svavel, kopparvitriol and järnvitriol.*

Estimates of employment for additional output
1868–1912: Estimated by using the gross output to employment ratio from BiSOS D.

Prices of final products
1868–1872: prices of Chilesalpeter (Åmark 1921 pp. 1274, 1282).
1872–1888: weighted index (chained Fisher) of unit values of superphosphate and sulphuric.
1888–1912: arithmetic mean of price indices of the chemical industry and the fertilizer industry (Ljungberg 1990 p. 522; 524).

Prices of intermediate consumption
Price index constructed on the assumption that the net to gross output ratio of 0.44 in 1913 (Schön 1988 p. 135; SOU 1923) remained constant in 1868–1912.

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