Machinery and horsepower prices. 1850 - 1913[*]

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Abstract

The debate on industrial revolution (IR) has been focused on the incentives behind investment decisions and how the preliminary conditions to allow this phenomena were situated in England. One of the most famous and original theories to explain IR is the developed by (Allen, 2012, 2009b,a), who taking into account a vast literature on organic fuels and the transition to fossil fuels (WRIGLEY, 1962; Wrigley, 2013), argues that the reason why IR was British is the unique combination of expensive labour and cheap energy. This combination produces the incentives to invest in labour saving machinery. Several works have proved the existence of cheap fossil fuels during the XIX century, determined by the introduction of coal. Figures and indicators on wages and energy are broadly accepted, however, machinery price indexes are at least discussed and the elaboration of the most used index is based almost completely in the iron price (Feinstein (1972, 1988). To prove the Allen hypothesis we require a better index on machinery, measuring horsepower prices, relative costs and changes in their international trade. Using novel data based on merchants catalogues, several international trade statistics plus all the price indexes available, this article presents a improved machinery price index for UK in the period 1850 - 1913; given the influence of British Machinery & Equipment in the world market until 1913, this price index could be useful to understand relative costs transformation in several regions.

JEL Codes: N13, N63, N70, O13, O14, O33.

Keywords: Machinery prices, Industrial Revolution, Technological change.

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1 Introduction

Computers prices has been decreasing without interruption since 1990's. If we count the services given by these machines, the classic accountability become useless. Microchips' capacity has been increasing year by year, converting the extremely expensive PC of the 1980's in a quite common consumer good in our days. This, and other contemporaneous examples compels us to review and question our capital stock measures, base of modern Total factor productivity (TFP) figures and some of the wealth components that are key to understand income differences between countries.

A similar problem arises when we try to measure machinery prices in the long run. In this article we will test the feasibility of our current price indexes on machinery & equipment and how its revision could affect estimations about the industrial revolution pace and diffusion. Therefore, machinery and equipment is one of the main components of the technological change and probably, the "easiest" way to measure structural changes in the economy. The current debate on robotization and jobless derived from automatization is an inheritor from the luddism phenomena, unemployment lead by technological changes and labour saving technology. Even the actual importance of this phenomena, the newest theories on industrial revolution and several attempts to measure energy prices and its relation with economic growth Kander and Stern (2014); Rubio and Folchi (2012); Allen (2015), our current knowledge on machinery prices during the crucial period of 1850- 1913 is limited. Currently, for UK, the main index was elaborated by Feinstein (1972). As we are going to see later in the text, this index is strongly correlated with iron and steel prices, dismissing the complexity and quality changes of M&E. One of the main problems to estimate a reliable price index for machinery are the quality changes through the years, because uses, functions and models are changing constantly and the services displayed by machinery and equipment were not the same in 1870 than 1913. In order to solve these problems, we propose a relative price index with more elements, taking into account the most important indicator of machinery and equipment in the first and second industrial revolution: horsepower prices. Focusing our attention in the relative price instead an isolated machinery price, we could improve our knowledge of price incentives in a crucial time of modern economic history.

This article is organized as follows: in the second section, we do a critical review of the main literature on machinery prices indexes and how important have been these figures to understand industrial revolution diffusion. In the third section we describe the main sources used to improve the current machinery price index. In the fourth section, methodology is described and explained. Fifth section contents the preliminary results with a comparison with previous indexes and sixth, concludes with the discussion and further research

2   Literature review

There has been several studies dealing with machinery and equipment in UK highlighting the dissertation by Floud (1976). In the case of Sweden, there are works worth to mention, such as "Priser och marknadskrafter i Sverige 1885-1969: en prishistorisk studie" (Ljungberg, 1990). The figures presented in these books are relevant for our research, but do not resolve the main questions that we have proposed.

Therefore, machinery prices have been analysed from tangential perspectives, and not as playing a key role; the technological changes that occurred in the past centuries (XIX and XX) are so huge that we have to continue re-estimating relative prices of capital goods. This problem is even bigger if we want to elaborate long run series and to compare the prices of a good in the 1870's with that of a "similar" item in the 1930's. Current debates in computers and software prices are dealing with similar problems. Several attempts have been made to understand the role of technology and relative prices changes in historical perspective (Collins and Williamson, 2001), but the majority of these works are estimations based on proxies of capital prices such as interest rates or import/export figures. In Collins and Williamson (2001), as example, M&E price indexes are proxies of investment figures, which do not take into account the enormous differences within the several Non-residential investment items.

Technological changes in the machinery & tool industry have been so incredible in the last two hundred years that the use of almost same indexes for the period 1850 - 1913 could be considered a noticeable mistake. However, as we will see in this section, the construction of M&E indexes taking into account quality changes are absent. If we observe the last developments in economic history research, it could be possible to sort the literature on M&E prices among Technological change studies, historical national accounts and industrial revolution debate.

Allen (2012); Albers (2002) observed in a comparative framework and analysing a national experience respectively, the influence of machinery in economic growth and how the available horsepower in the economy could impulse productivity and the transition from organic to mineral fuels.

If the studies of such people as Abramovitz and Solow are even approximately correct with respect to orders of magnitude, then the contribution of technological change to rising per capita incomes absolutely dwarfs the contribution from a rising but qualitatively unchanging stock of capital

"Several studies have collected data on prices paid bybuyers, butfew of these series refer to capital goods. While a seller can provide price information on a given model of a complicated piece of machinery over a period of time, most buyers purchase capital goods only occasionally and thus cannot provide a continuous price series

Collins and Williamson (2001)

The relative price of capital goods, an important component of the user cost of capital, has rarely been incorporated into comparative studies of long-run capital accumulation. This article constructs and explores a data set for capital-goods and equipment prices covering the 1870–1950 period for 11 OECD countries. We document substantial differences across countries in the relative prices of capital goods, but also find convergence in those prices over time. Finally, we show that relative capital- goods prices are strongly negatively correlated with investment rates.

Figure 1: Price indexes for Machinery and Equipment and Iron. 1850 - 1913

Feinstein, Plant and Machinery

ClevelandIron
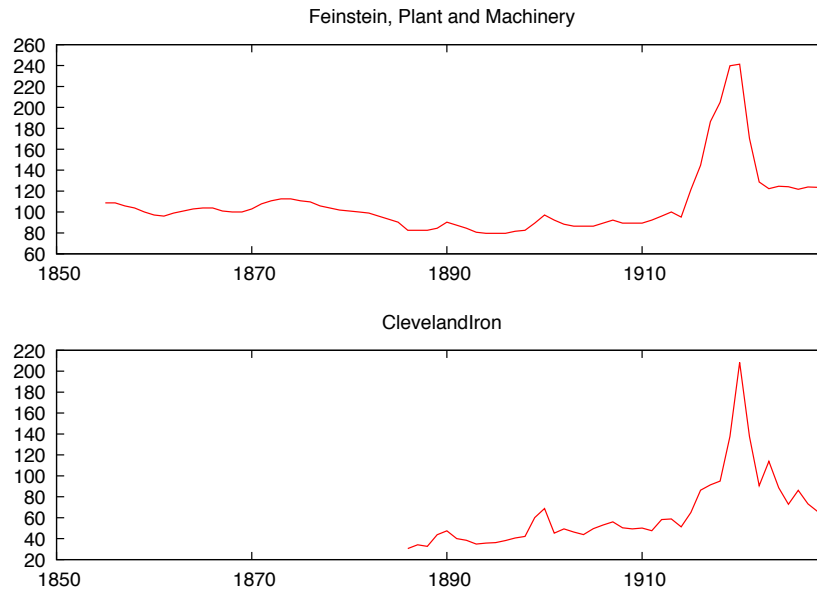
Ignoring tax implications, the user cost of capital can be written as $(P_K/P)(r + \gamma)$ where r is the real interest rate, P_K is the price of capital goods, P is the price of output, and γ is the depreciation rate. For a given rate of depreciation, the cost is determined by the interest rate and the capital goods prices.

Nevertheless, after employing similar national accounts price series al- most forty years ago, Robert Gordon observed that "To deny the existence of these differential price trends is to deny the validity of the deflated estimates of the components of GNP on which we all so heavily rely."15 It is no surprise that historical national accounts data are quite imperfect, and so it is clear that we must proceed with caution. At the same time, it seems foolish to postpone the exploration of potentially important determinants of long-term economic growth simply because the data are not ideal. Until the next round of revision of historical national accounts (and their underlying price series) and the appearance of comprehensive cross-country capital- goods price data for the nineteenth century, the comparisons we make here rely on the best evidence we could assemble.

Over the 80 years as a whole, Australia, Canada, Denmark, Italy, Japan, Sweden, and the United King-dom all appear to have had relatively expensive capital goods, implying a relatively disadvantageous price structure for capital accumulation. Japan, Sweden, and the United Kingdom carried the heaviest burdens. Finland, Germany, Norway, and the United States all appear to have had relatively cheap capital goods, im-plying a favorable price structure for capital accumulation. The impact of these differences in price structure on rates of capital accumulation will be explored later, but this is a good time to remind the reader that it is the relative price of capital goods we are describing; consequently, differences in consumption-goods prices may matter as much as differences in capital-goods prices in explaining cross-country differences in the ratio.

Jones, for example, uses data underlying the PWT to argue that "an increase in the relative price of

machinery reduces capital accumulation and therefore reduces the growth rate of the economy.

Cain, P. J., & Hopkins, A. G. (1980). The Political Economy of British Expansion Overseas, 1750-1914. The Economic History Review, 33(4), 463. http://doi.org/10.2307/2594798

Accounts and papers, Fifty-Three Volumes. Wholesale and retail prices Session 17 February 1903 - 14 August 1903

2.1 Feinstein

Feinstein (1972) elaborated an impressive amount of data to estimate the main macroeconomic variables of UK during the period 1855-1965. To estimate the capital stock during these years, he utilized the Perpetual Inventory Method (PIM), developed by Goldsmith few years before. In the case of "Plant and Machinery", the decision to estimate the prices in the long run could be criticize with our contemporary point of view, but absolutely understandable with the main objective of his work (the broad picture of the British economy). His work took the principal raw material to build machinery during the second half of the XIXth century and the first half of the XX: iron. Using iron prices plus an arbitrary "quality index", correspondent to the eight per cent of the aforementioned price, he calculated machinery price index until 1913. To test this estimation, we can see the graph 1 and the table 2.1 and extremely high correlation between both variables, measured as indexes and growth rates. Using a simple OLS model, we could estimate the correlation between the iron and the machinery price near to 0.84.

Model 2: OLS, using observations 1886–1933 ($T = 48$)

Dependent variable: l_PlantMchFeinstein

	Coefficient	Std. Error	t-ratio	p-value
const	2.05186	0.169255	12.12	0.0000
l_ClevelandIron	0.640738	0.0414515	15.46	0.0000

Mean dependent var	4.655194	S.D. dependent var	0.286761
Sum squared resid	0.623949	S.E. of regression	0.116465
R^2	0.838559	Adjusted R^2	0.835050
$F(1, 46)$	238.9346	P-value(F)	7.74e–20
Log-likelihood	36.12025	Akaike criterion	−68.24049
Schwarz criterion	−64.49809	Hannan–Quinn	−66.82623
$\hat{\rho}$	0.640256	Durbin–Watson	0.675412

One of the main reasons to have a reasonable doubt on the current machinery price indexes are the international trade figures. If we consider the literature on the "British decline" and how the UK begun to be replaced in the main international markets, could be unexplainable a noticeable growth in the machinery exports (Broadberry and Burhop, 2007; Ljungberg, 2012). Nevertheless, a reconstruction of the UK exports share on M&E has shown how steadily this sector was gaining weight in the exports basket. Moreover, several works on Latin American M&E markets have discovered a slower decline of the British share in

the market Tafunell and Ducoing (2016); Ducoing and Tafunell (2013). The critics on these figures are not new. Some years after Nicholas (1980) pointed out that the indexes developed by Feinstein (1972) were not totally reliable.

Figure 2: Share of M&E exports on total UK exports. 1850 - 1913
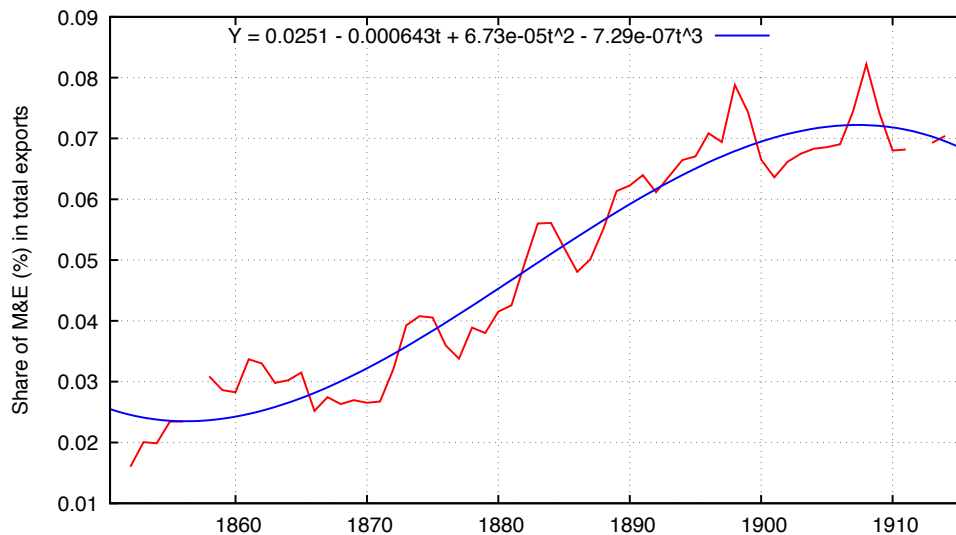
Source: Annual Stament of the trade, several years

As we can appreciate in the figure 2, the share of machinery was growing constantly since 1860, increasing its participation in the exports basket from 2% until 7% circa 1910.

Beside the price explanation, there are others factor underrated by the literature, such as international business networks, branding and path dependence. For example *Engineering*, a magazine specialized in Machinery and Tools industries, reported during the boom of the 1890's that quickly delivery was becoming more important than price in determining engineering orders Nicholas (1980). For example, there is little evidence of price competition for agricultural implements in the Victorian market, remarked that non price factors such as differences in size, accessories, style and draft were heavily emphasized. To include these factors is necessary a different kind of approach, beyond the scope of this research.

3   Methodology

As we have been noticed, one of the biggest problems of the current machinery price indexes are the lack of "quality" embodied in these figures. A machinery price index should include some proxy of efficiency or at least a related indicator. To improve our knowledge on this matter, we have developed a new index which includes information from several sources and considers the relative price of M&E.

3.1 Sources

The grounds for contention in discriminating between the models which emphasize supply, particularly Floud's revised model, as opposed to demand, centers in the first instance on the movement of American and British machinery prices. Unfortunately no definitive answer is possible since the price indexes for American and British machinery are unreliable....

Nicholas (1980)

Appleby's Catalogue   During the period 1863 - 1905, Appleby Brothers was one of the main machinery retailers in UK, having a noticeable presence in the market. In these years, to promote their products, the company published with random frequency the famous *Illustrated Handbook and price of current of Machinery and Iron Work*, a detailed sample or their products, sorted by kind of machinery.[1] The image 3 shows a typical advert by Appleby's circa 1878. At the top of the page there is a detailed draw of the machine, in this case, a compound beam engine. Below this image, there is a description of the machine in terms of efficiency and fuel consumption, and finally, the most important information for our research the features of this engine: nominal horsepower (in its several models), price, coal consumption, etc. There has had a debate on the adequate method to account for capital prices among researchers on the topic. Which is the right price? effective sell or offered price? Probably an effective sell price is the closer to a real machinery price, however, to get this kind of information is beyond the scope of this paper (Gordon, 1971).

There are eight Appleby catalogues available: 1863, 1869, 1873, 1878, 1879, 1885, 1895 and 1897. The last one was re-edited several times, with a new price estimation in the first page. In the 1904's re edition, the text said: "NOTICE. Owing to the increased cost of labour and materials since the publication of this book (1897), the printed prices are no longer reliable, and about ten per cent. should be added to cover this increase" Every year is going to be used as benchmark to interpolate it with the rest of variables. Let's see an example of these benchmarks: taking the year 1895, we search for a similar engine from the items gathered from previous handbooks. In this case an interesting product are the "compound condensing engines", because the information presented in the catalogue allows to estimate the average fuel consumption.

Table 1: Prices of Tandem Compound Condensing Engines

Indicated horse power	100	150	200	250	300	350
Price of engine	525 £	£650	£780	£910	£1000	£1130

Source: Appleby's Handbook, 1895, pag. 9

Taking into account all the elements presented previously, the new relative price index is constructed as follows
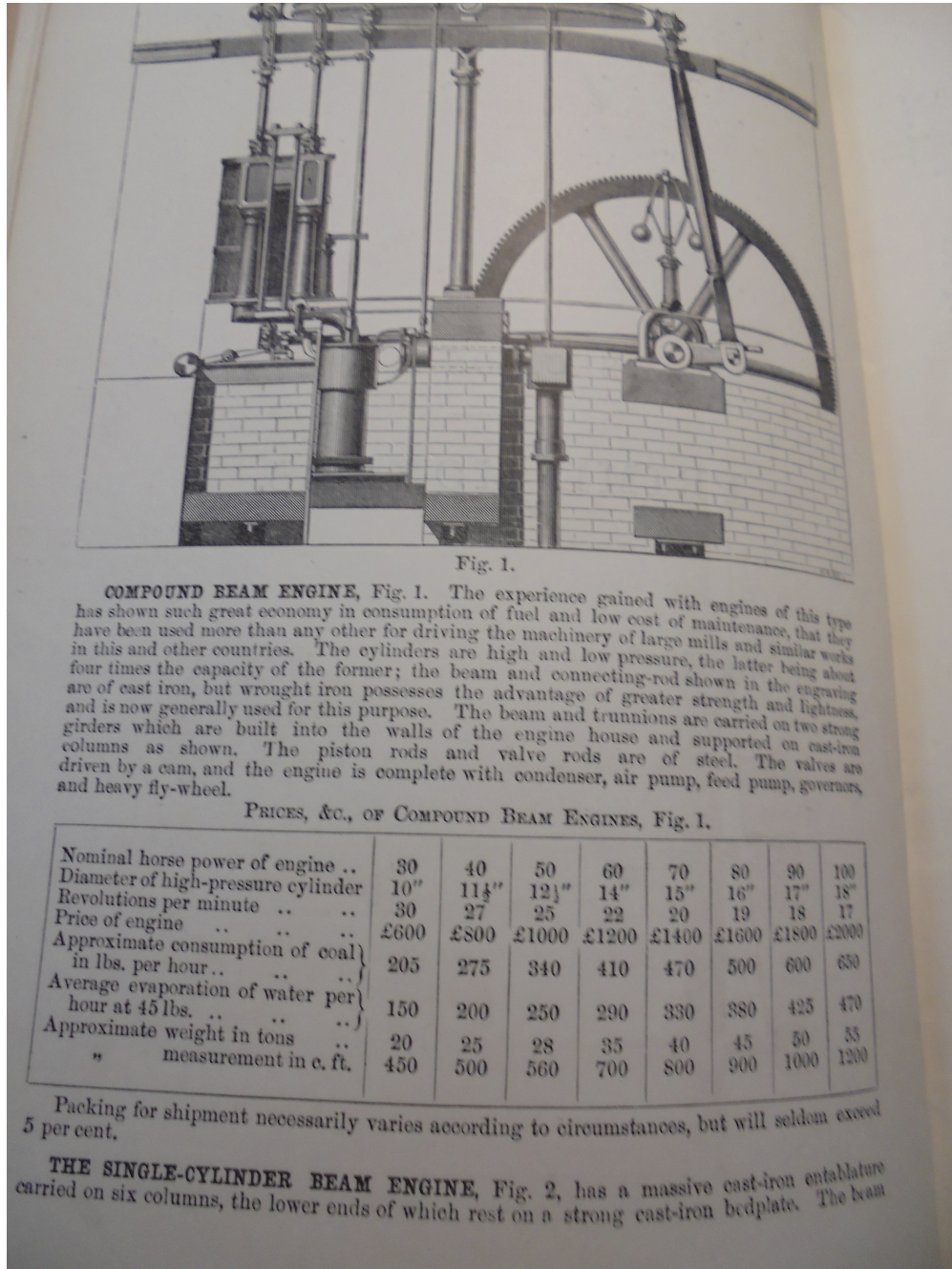
- 1850 - 1913

- Machines using modern energy carriers (steam power, internal combustion, electricity)

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[1]One of the largest catalogue has five volumes, sorted by prime movers, mining, pump machinery, agriculture and tools

Figure 3: Steam engine offered by Appleby's circa 1878

Fig. 1.

COMPOUND BEAM ENGINE, Fig. 1. The experience gained with engines of this type has shown such great economy in consumption of fuel and low cost of maintenance, that they have been used more than any other for driving the machinery of large mills and similar works in this and other countries. The cylinders are high and low pressure, the latter being about four times the capacity of the former; the beam and connecting-rod shown in the engraving are of cast iron, but wrought iron possesses the advantage of greater strength and lightness, and is now generally used for this purpose. The beam and trunnions are carried on two strong girders which are built into the walls of the engine house and supported on cast-iron columns as shown. The piston rods and valve rods are of steel. The valves are driven by a cam, and the engine is complete with condenser, air pump, feed pump, governors, and heavy fly-wheel.

PRICES, &c., OF COMPOUND BEAM ENGINES, Fig. 1.

Nominal horse power of engine ..	30	40	50	60	70	80	90	100
Diameter of high-pressure cylinder	10″	11½″	12½″	14″	15″	16″	17″	18″
Revolutions per minute	30	27	25	22	20	19	18	17
Price of engine	£600	£800	£1000	£1200	£1400	£1600	£1800	£2000
Approximate consumption of coal in lbs. per hour..	205	275	340	410	470	500	600	650
Average evaporation of water per hour at 45 lbs.	150	200	250	290	330	380	425	470
Approximate weight in tons ..	20	25	28	35	40	45	50	55
„ measurement in c. ft.	450	500	560	700	800	900	1000	1200

Packing for shipment necessarily varies according to circumstances, but will seldom exceed 5 per cent.

THE SINGLE-CYLINDER BEAM ENGINE, Fig. 2, has a massive cast-iron entablature carried on six columns, the lower ends of which rest on a strong cast-iron bedplate. The beam

Source: Appleby's catalogue, 1878.

- IWe use the 8 benchmarks from Appleby's catalogues to estimate HP levels:

  - iron prices

  - energy

  - coal

  - wages

  - Previous indexes (Floud, 1976)

- With these inputs, we have the trend between benchmarks, and also, a quite fair approximation to horse power prices.

- Simple econometric model $Mch_t = \alpha + \beta_{t-1} + \gamma_{t-1} + r_t + e$ where β is energy prices in the previous period and r is the interest rate in period t

4   Results

The previous machinery price indexes have mixed conclusions. In the case of Feinstein (1972, 1988), his index doesn't show a clear trend until the First World Ward and an upward trend after 1914. For the period we are interested, the yearly annual growth rate is -0,37%, starting from high prices in the 1850's.

4.1   New Price index in Machinery and Equipment

The current price index has been constructed with the methodology described above. The items presented in this preliminary index are mainly steam boilers (prime movers). The upward trend observed in the years before First World War graph 4 in the figures elaborated by Floud (1976) and Feinstein (1972, 1988)

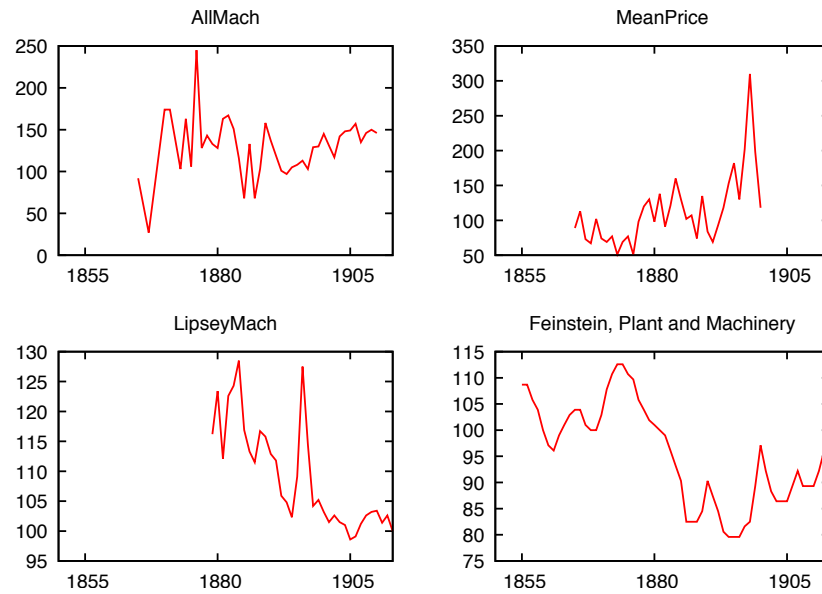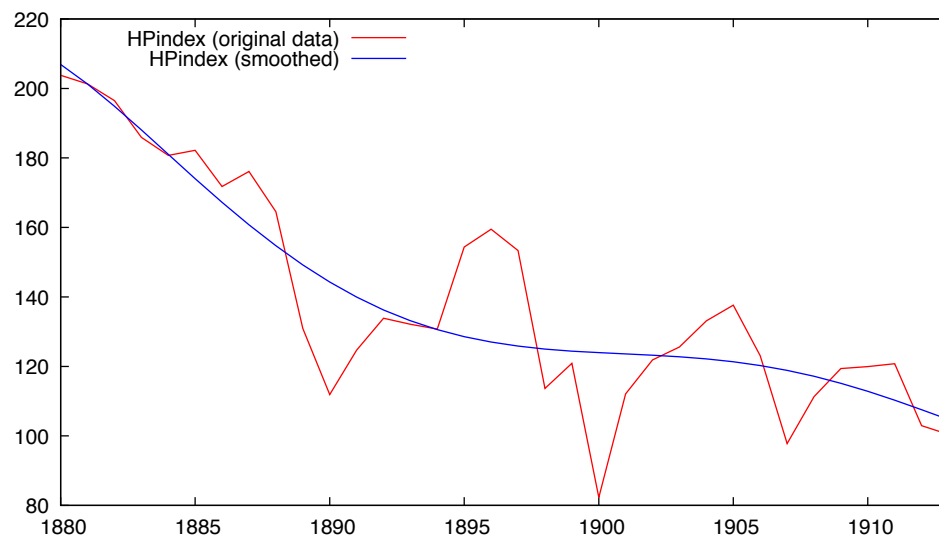Figure 4: Price index for Machinery and Equipment. UK 1850 - 1913. 1900 = 100

Figure 5: HP index, 1880 - 1913 (1913 = 100). Original series and filtered

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