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Adam Smith, Watch Prices, and the Industrial Revolution

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Adam Smith, Watch Prices, and the Industrial Revolution.

Morgan Kelly and Cormac Ó Gráda*

Abstract

Although largely absent from modern accounts of the Industrial Revolution, watches were the first mass produced consumer durable, and were Adam Smith's pre-eminent example of technological progress. In fact, Smith makes the notable claim that watch prices may have fallen by up to 95 per cent over the preceding century; a claim that this paper attempts to evaluate. We look at changes in the reported value of over 3,200 stolen watches from records of criminal trials in the Old Bailey court in London from 1685 to 1810. Before allowing for quality improvements we find that the real price of watches in nearly all categories falls steadily by 1.3 per cent per year, equivalent to a fall of 75 per cent over a century, a rate considerably above the growth rate of average labour productivity in British industry in the early nineteenth century.
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The diminution of price has . . . been most remarkable in those manufactures of which the materials are the coarse metals. A better movement of a watch, that about the middle of the last century could have been bought for twenty pounds, may now perhaps be had for twenty shillings.[a]

[a] *Wealth of Nations*, Bk 1 Ch 11 Pt 3 "Effect of the Progress of Improvements on the Real Price of Manufactures."

Adam Smith

1 Introduction.

Most recent studies of the Industrial Revolution focus on the sustained innovations in the three sectors of textile spinning, iron making, and steam power that began in Britain between 1750 and 1850. However, to one usually well informed, contemporary observer, things appeared quite different. Discussing technological progress in *The Wealth of Nations* Adam Smith (1976, 270) ignores most of the famous inventions in these three sectors, and instead chooses as his paradigm of technical progress one good that is entirely absent from most current histories of the Industrial Revolution: watches. In fact, Smith makes the notable claim that, over the preceding century, the price of watches may have fallen by up to 95 per cent, a claim that we attempt here to evaluate.

To test whether watch prices had been falling steadily and steeply since the late seventeenth century we use the records of over 3,200 criminal trials at the Old Bailey court in London from 1685 to 1810.[1] Owners of stolen goods gave the value of the items they had lost, and, because watches were frequently stolen, we can reliably track how their value changed through time.

Contemporaries divided watches into two categories, utilitarian silver or metal watches; and more expensive gold ones. Adjusting for inflation, the price of each type of watch falls steadily by 1.3 per cent per year, equivalent to a fall of 75 per

[1] Tim Hitchcock, Robert Shoemaker, Clive Emsley, Sharon Howard and Jamie McLaughlin, et al., The Old Bailey Proceedings Online, 1674-1913 (www.oldbaileyonline.org, version 7.0, 24 March 2012).

cent over a century. If we assume modest rises in the quality in silver watches, so that a watch at the 75th percentile in the 1710s was equivalent to one of median quality in the 1770s, we find an annual fall in real prices of 2 per cent or 87 per cent over a century, not far from what Adam Smith suggests.[2]

Most of the cost of a silver watch was the labour involved in cutting, filing and assembling the parts, so we can gauge the rise of labour productivity in watch making by comparing how the price of a watch fell relative to nominal wages. During the period 1680–1810 real wages were roughly constant so this rise in labour productivity is similar to the fall in real prices of watches.

To put this productivity growth in eighteenth century watchmaking in perspective, Crafts and Harley (1992) estimate that average labour productivity in British industry grew by 0.26 per cent per year in the period 1759–1801, and 0.21 per cent from 1801–1831, while the corresponding estimates from Broadberry, Campbell and van Leeuwen (2013) are 0.63 and 0.68: see Crafts (2014, Table 3).

This rapid productivity growth by contemporary standards stemmed from continuous improvements in tools and techniques—most notably mechanical cutting of gearwheels and crucible steel for springs—and growing intensification of the division of labour, with watch-making showing strong spatial concentration and individual artisans specializing in the production of a single interchangeable component, or more precisely a component that could be interchanged with another after a judicious amount of filing. As well as being a major sector in its own right, watch making may have produced important spillovers to other sectors, with contemporaries highlighting the central role of watch and clock makers in designing and building the textile machinery of the early Industrial Revolution.

In terms of their wider implications, our results highlight that the process of sustained technological progress which is nowadays seen to define the Industrial Revolution dates back in England to at least the late seventeenth century, rather than the accepted date of the mid eighteenth century, and also the importance of mechanical but not powered innovation during this time.[3] The evolution of the English watch industry also supports the view of Kelly, Mokyr and Ó Gráda (2014) on the importance of the interaction between elite inventors and skilled artisans in generating the Industrial Revolution. The decisive innovation in making portable watches

[2]Because watches fulfilled a variety of purposes, being status symbols and stores of value as well as ways to tell the time accurately, we cannot come up with some simple quality adjusted measure of cost such as the price per lumen-hour of lighting derived by Nordhaus (2008).

[3]The beginnings of growth in the seventeenth century are consistent with the findings of Broadberry et al. (2015) and Clark (2005), while the importance of small scale capitalism is emphasised by Berg (1993).

reasonably accurate and therefore feasible was the balance spring originated by two of the greatest scientists of the late seventeenth century: the idea of replacing a pendulum with a spring probably originated with Thomas Hooke in 1658, while the first working spring watch was made by Christian Huygens in 1675 (Landes, 1983, 124–128). Once this conceptual breakthrough occurred, England's extensive tradition of metal working and the absence of restrictions on hiring apprentices allowed its watch industry to expand rapidly.

By the late eighteenth century, the English watch industry was producing around 200,000 watches per year, about half of European output (Landes, 1983, 231) while watch ownership was high, even among labourers, as we will see below. However, the British watch industry was precocious not only in its rise, but in its fall. By the 1820s, the English watch industry had reached the limits technical and organizational ability and was starting to face severe competition from cheap Continental imports, leading to considerable hardship in traditional watchmaking areas and petitions for import controls.

While there is an extensive literature on the history of time keeping (for instance Britten 1934 and Landes 1983) its emphasis is on expensive watches and chronometers rather than the mass produced watches that are our concern here. The rise of the English watch industry is described by Cippola (1970, 141–147), Thompson (1967, 64–70), and Landes (1983, 231–235) while the widespread ownership of watches by the end of the eighteenth century is demonstrated by de Vries (2008, 2–3) and Styles (2007, 98–107). The Old Bailey records we employ have not been used before to track prices, but were used in the pioneering study of Voth (2001) to estimate changes in people's time use (based on witnesses reports of what they were doing, working or at leisure, at the time a crime was committed, which requires the widespread ownership of watches to establish time of day reliably). More recently Horrell, Humphries and Sneath (2015) have used Old Bailey records to look at changing patterns of ownership of consumer goods.

The rest of the paper is as follows. In Section 2 we outline our data on watch prices from the Old Bailey, while Sections 3 and 4 analyse the evolution of watch prices between the late seventeenth and mid nineteenth centuries. Section 5 briefly outlines the organization and functioning of the English watch industry.

2 Watch Prices in the Records of the Old Bailey.

We use the record of criminal trials in the Old Bailey court in London to track the path of watch prices from the late seventeenth until the mid-nineteenth century. Because watches were valuable and easily resold, organized theft of watches was

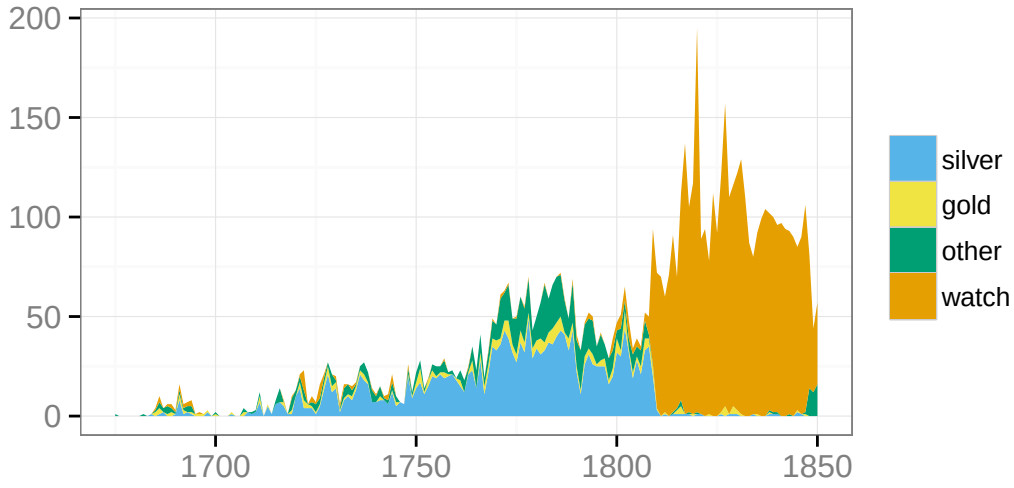

Figure 1: Annual number of watches in Old Bailey records by type.

widespread (Thompson, 1967). Court records give the reported value of 7273 stolen watches running from 1675 to 1850 but early observations are sparse, with only 92 records before 1710. Contemporaries divided watches into two types: utilitarian metal or silver watches, and more expensive gold ones: for instance, 1797–98, the British government imposed a tax on watch ownership, with a rate of 2.5 shillings for a silver watch, and 10 shillings for a gold one (Thompson, 1967, 67).

After 1809, all but 103 of the 4027 watches are described only as "watch". Before this, however, more detail is provided. For the 3246 stolen watches before 1810, 61 per cent are described simply as "silver watch" and 9 per cent as "gold watch". The distribution of watches by type is shown in Figure 1.

The fact that our data come from criminal trials may bias our sample towards more expensive watches. Before 1829, London did not have a regular metropolitan police force, so that most prosecutions for theft were privately initiated: useful descriptions of the evolution of London's criminal justice system during this period are given by McLynn (1991, 17–35) and Voth (2001). This may bias our data towards wealthier victims with more expensive watches, at least in later periods.

During the 1720s, the normal daily wage for a building labourer in London was 3 shillings, equivalent to £0.9 for a six day week.[4] Looking at the silver watches in our records from the 1720s, the median value was £4, the first quartile is £2.5, and the cheapest watch was £1: in other words, watches were expensive relative to wages, so that it is likely that most thefts would have been prosecuted. By the 1790s however, nominal wages had risen to 3.5 shillings per day, or £0.95 per week, while the median and bottom quartile of watch values have halved to £2 and £1.25 respectively. There is therefore a likelihood that in later periods, thefts of cheap watches may not have been worth the effort of prosecution. To the extent that these cheap watches are omitted, our estimated fall in average watch prices will be an under-estimate.

With the expansion of London, an increasing number of minor crimes were tried at Local Sessions, with only the most serious crimes going to the Old Bailey. This can be seen in Figure 5 where declared watch values rise steadily after 1810. Old Bailey records cease to be a reliable guide to average watch prices and our analysis therefore focuses on the period before 1810.

2.1 Occupations of Victims.

A sense of who owned watches on the eve of the Industrial Revolution may be obtained from a profile of the 233 Old Bailey victims whose watches were stolen between 1780 and 1783. Of the 137 whose status might be guessed at, 76 were relatively well off (gentlemen, traders, clerks, travellers by coach or on horseback, homeowners, and so on), while 61 were described as artisans, workers, servants, or lodgers. In addition, most of the 41 who had their watches stolen in a tavern or were pickpocketed by a prostitute were also probably of lower socioeconomic status (5 fall into both the last two categories). The extensive watch ownership among working men is also found by Styles (2007, 98–107).

Difference in social status is apparent in the value of stolen watches. Among the affluent group the mean value is £5.7 while among workers or victims of prostitutes the values are identical at £2.3.

By contrast, at the start of the century, only a small proportion of victims between 1700 and 1730 with identifiable status (16 out of 202) are described as workers, lodgers, servants, or artisans; while another 62 had their watch stolen while drinking or with a prostitute.

[4]This is based on Hunt (1986, Table 5) who gives a wage of 3 shillings per day for the 1760s, and Clark (2005) who shows that nominal wages hardly changed between the 1720s and 1760s. Clark's data are available at http://gpih.ucdavis.edu/files/England_1209-1914_(Clark).xls

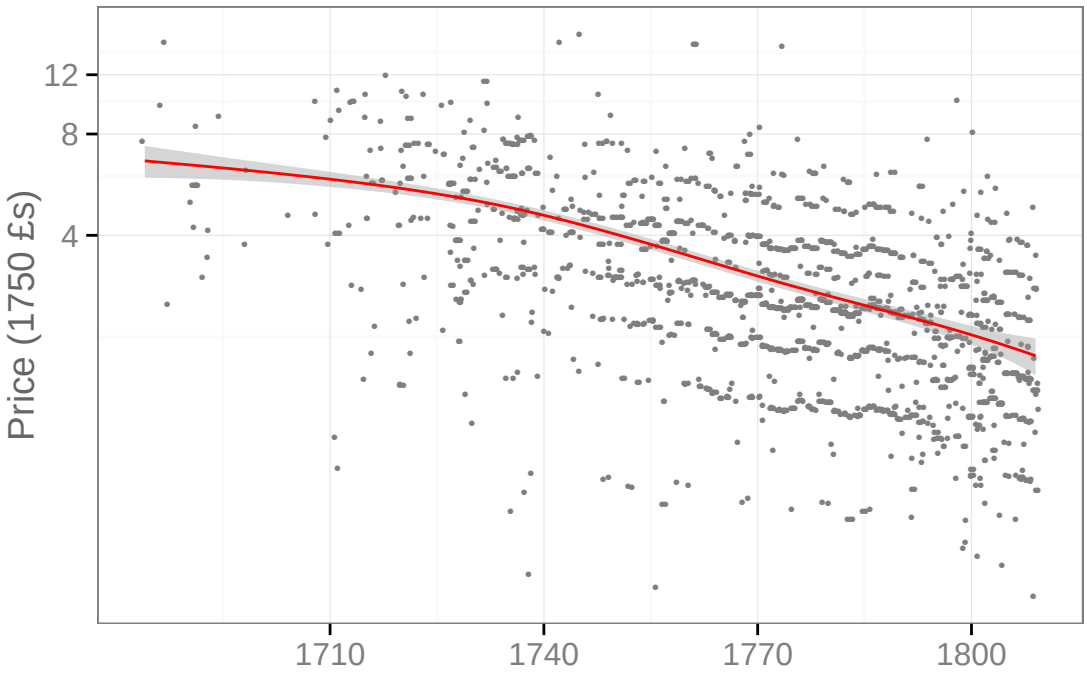

Figure 2: Reported value of silver watches (in 1750 pounds, logarithmic axis) in Old Bailey trials, 1680–1809.

3 Watch prices, 1710–1809.

As Figure 1 indicates, the generic watch in the Old Bailey records before 1810 is a silver watch. In Figure 2 we plot the reported value of silver watches in 1750 prices (deflated using Clark's (2005) retail price index). Points are jittered to separate overlapping values, and the figure includes a locally weighted sum of squares (loess) line to indicate trends. Three outliers are omitted to make the plot more legible: two watches valued at £20, and one valued at £0.10. It can be seen that the average price of a silver watch falls from around £6 in 1710 to around £2 by 1809.[5]

Table 3 gives the results of a regression of the log of silver watch prices (again deflated to 1750 prices) on year from 1710 to 1809. It can be seen that the price of silver watches falls at 1.3 per cent per year. For comparison, we also include

[5]This is somewhat less than the fall estimated by Elmers (1992), who suggests that the price of good quality London pair-case silver watches fell from about £8.5 to £2.5 in the period 1710–1810.

the reported value of the 280 gold watches in the court records.[6] The price of gold watches falls at the same rate as silver ones.

As noted in the introduction, the production cost of a basic watch was largely labour so the growth of productivity can be assessed by comparing watch prices with wages. From 1710 to 1810 real wages, measured by Clark's (2005) series were roughly constant which means that shifts in demand for watches associated with rising incomes can be ignored. We find an annual fall of watch prices relative to nominal wages of 1.4 per cent compared with 1.3 per cent relative to prices. However, national wage series disguise a lot of regional variation: much of the production of watch parts was concentrated in Lancashire which, because of the rise of the cotton industry, went from one of the lowest wage areas in England in the 1760s to one of the highest by 1833 (Hunt, 1986) with nominal wages increasing 40 per cent relative to national prices. It follows that our estimates of productivity growth in the late eighteenth century may be underestimates.

There were two parts to a watch: the mechanism, which was mostly brass with a steel spring, and the case. It would be expected that most of the fall in the cost of a watch would be in the mechanism, and this will be understated if the case is included. However, this turns out not to make much difference.

A cheap double cased watch of this period contained roughly two ounces of silver, with more expensive watches perhaps 2.5 ounces.[7] During our period England operated on a *de facto* silver standard, with a pound sterling worth close to 3.8 ounces of silver, so that the silver content of a watch case would have been around 5 shillings. Subtracting this amount from the declared value of watches causes the real price of mechanisms to fall at 1.5 per cent per year, compared with 1.3 per cent for complete watches.

How did the prices of more expensive silver watches fall compared with cheaper ones? Figure 2 suggests that the price fall was fairly uniform across all price ranges, and this can be confirmed with a quantile regression (Koenker, 2005) carried out in the R package quantreg. Figure 4 gives the slope regression coefficients and 2 standard error confidence interval for each decile of the data (where standard errors are computed using the wild bootstrap of Bilias, Chen and Ying (2000): using other bootstrap procedures gave similar results), where the horizontal lines denote the

[6] We exclude one gold repeater watch with a reported value in 1764 of £630: for comparison, at the time the building cost of a Royal Navy sloop, before fitting with guns, was around £1,800 Winfield (2007, 310–311). The next most expensive watches in our sample are two worth £100.

[7] *Monthly Magazine*, 47, 1819. There may also have been a long-term decline in the thickness and therefore the silver value of cases as a consequence of the introduction of roller flattening in the production of silver sheet from the 1720s (Clifford, 1999) so earlier watch cases may contain yet more silver. We are grateful to John Styles for this information.

	Silver	*Gold*
Intercept	24.427	25.424
	(0.933)	(2.822)
Year	−0.013	−0.013
	(0.001)	(0.002)
R^2	0.280	0.196
Adj. R^2	0.280	0.193
Num. obs.	1953	281

Heteroskedastic consistent standard errors in parentheses.

Figure 3: Regressions of log watch prices on year, 1710–1809.

coefficient and confidence interval for the entire sample. It can be seen that, although low-price watches show a slightly larger fall of 1.4 per cent, there is little variation around the 1.3 per cent annual fall.

These estimates of real price falls of around 1.3 per cent per year will underestimate technological progress in watch making if, as seems likely, the quality of watches rose through time. It is to be expected that more accurately shaped parts made from harder metals would increase both the durability and accuracy of watches. As well as telling the time and acting as visible status symbols, de Vries (2008, 3) and George (1966, 363) suggest that an important role for watches for ordinary people in an era before mass banking was as convenient stores of value: a windfall could be used to buy a watch which could later be sold or used as collateral to borrow from a pawn broker.

To claim, as Adam Smith does, that nominal watch prices had fallen by 95 per cent in the previous century is clearly an exaggeration—the implied fall of 3 per cent per year is higher than the 2.6 per cent rise in real productivity that McCloskey (1981) estimates for the most dynamic industrial sector, cotton, from 1780–1860—but not necessarily an enormous one. For Smith's claim of a 3 per cent fall to be true, a watch that cost £1 in the 1770s would have had to cost £6 sixty years earlier in the 1710s. Looking at our sample of silver watches, this would imply that a watch at the 80th percentile of quality and price in the 1710s would be equivalent to one at the tenth percentile in the 1770s, which seems implausible. However, if we suppose conservatively that a watch at the third quartile of quality in the 1710s was equivalent to one at the median by the 1770s, this gives us an annual fall in real price of 2 per cent, or 87 per cent over a century.

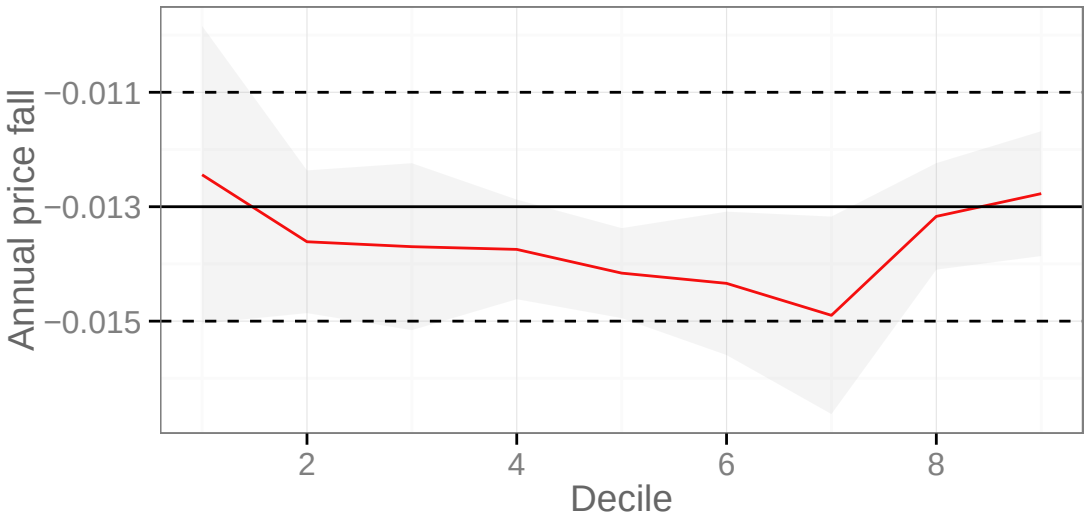

Figure 4: Annual price fall from quantile regression of silver watch prices, 1710–1809.

4 Watch Prices, 1810–1850.

After 1810, as Figure 1 shows, most watches in the Old Bailey records are described simply as "watch". Figure 5 shows the declared value of all 7192 watches (excluding the £630 watch) in the Old Bailey records from 1700 to 1850. It can be seen that the average price of all watches before 1810 shows the same behaviour as the subsets of silver and gold watches looked at above, but with a slightly higher rate of fall, decreasing by around four fifths in real terms between 1700 to 1810. However, prices reach a minimum in the 1810s and then start rising steadily until 1850.

This price rise is driven by three factors. Most importantly, the cases tried at the Old Bailey change radically at this time, with an increasing number of minor thefts being prosecuted in Local Sessions, so the Old Bailey sample is no longer a reliable guide to watch prices. For example, there are frequent contemporary references to cheap imported watches costing 5 shillings but in our sample of over 4,000 watches from this period there are only 16 of these. In addition, as Landes (1983, 274–307) and Davies (1992) demonstrate, the English watch industry was technologically conservative compared with its Swiss and, later, American rivals, and had reached the limits of technological improvement and division of labour under its fragmented organization before 1815. As real wages rose in England (by around 50 per cent

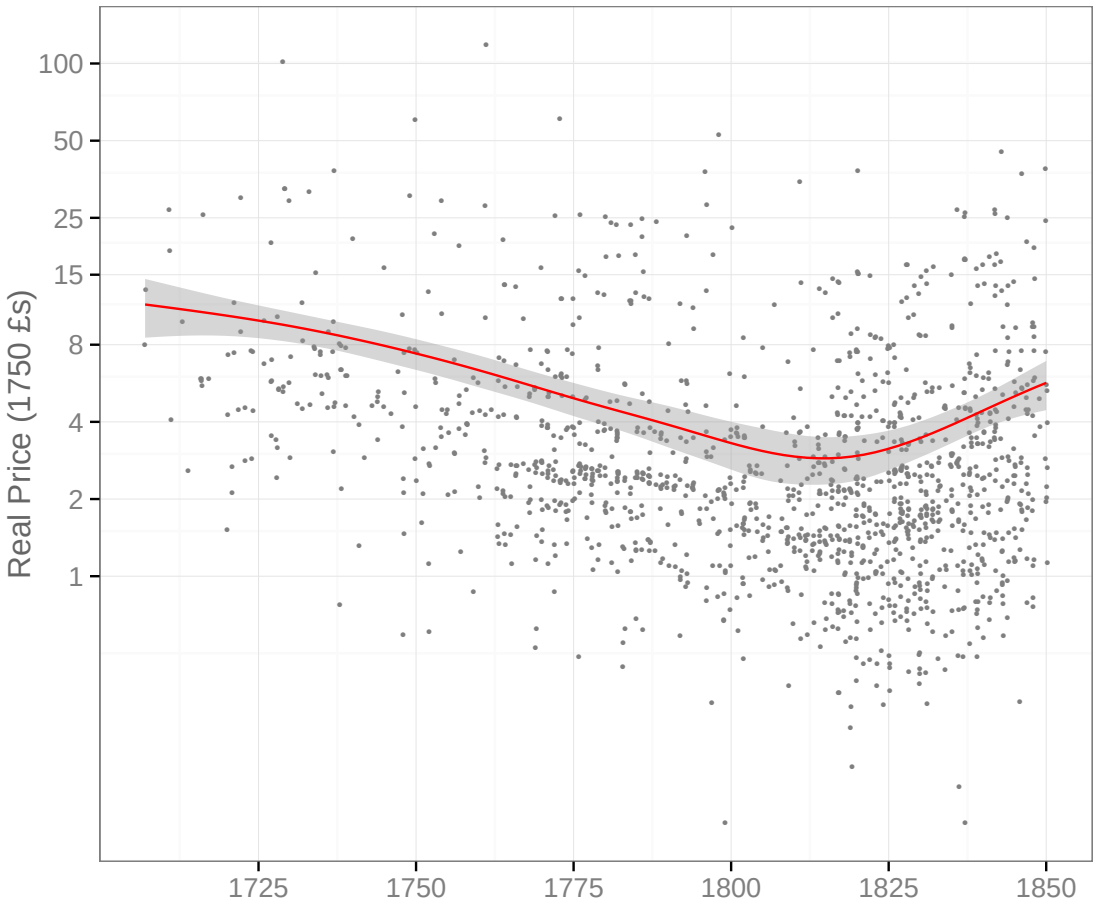

Figure 5: Declared value (in 1750 pounds, logarithmic axis) of all stolen watches in Old Bailey trials, 1700–1850.

in Clark's series from 1810 to 1850), production costs were driven upwards, and consumers probably demanded more expensive watches.

Figure 6 shows the quantile regression coefficients by decile for annual falls in watch prices before and after 1810. It can be seen that before 1810 the annual fall for watches below the top decile is 1.5 per cent per year, and around 2 per cent for the highest group. Between 1810 and 1850, real prices rise for all categories of watch, with the rate of increase rising by cost of watch. The cheapest watches rise by around 1 per cent per year, whereas the most expensive rise at 3 per cent.

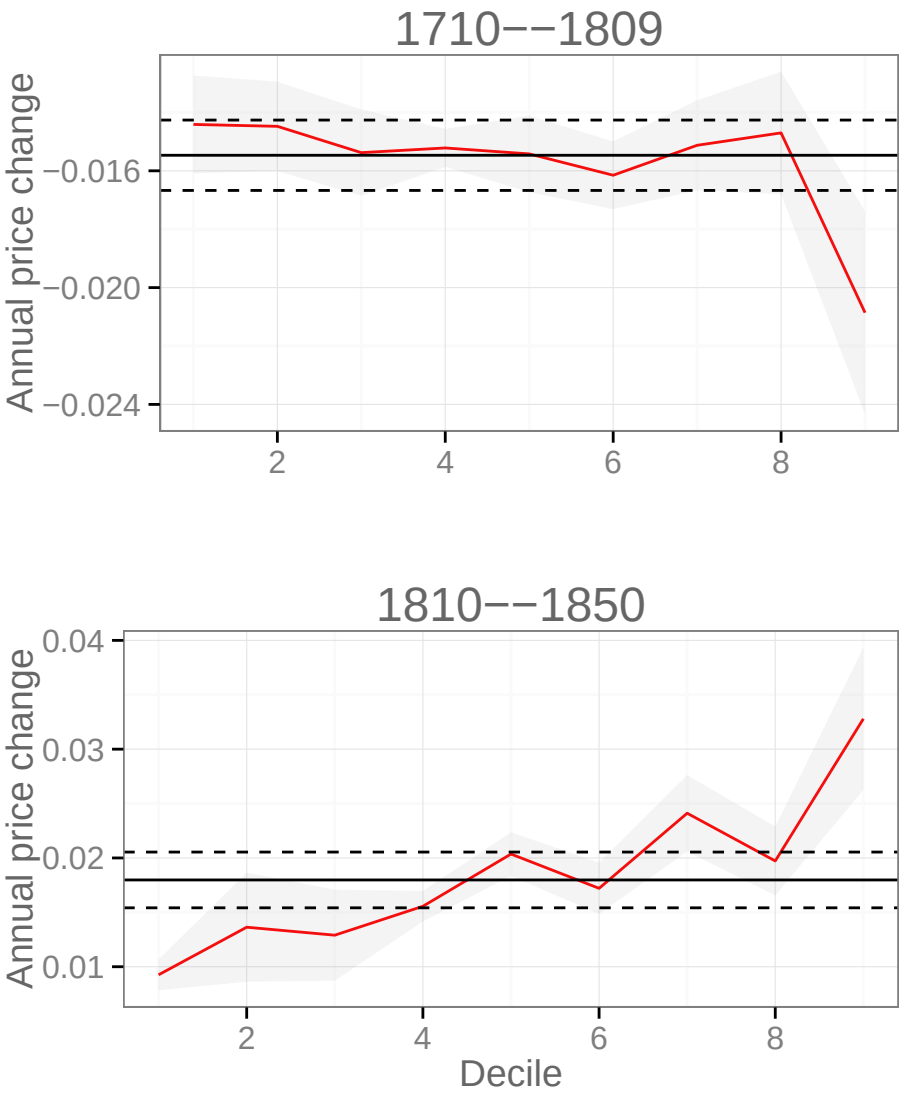

Figure 6: Annual rate of price change from quantile regression of all watch values, before and after 1810.

5 The Evolution of the English Watch Industry.

This continuous fall in watch prices from the late seventeenth century until 1815 reflects the continuous technological innovation and increasingly minute division of

labour of the English watch industry. The first portable, spring driven time pieces—watches in other words—appeared in Germany around 1500 and the first English ones were made by French and German immigrants in London about a century later. However it was not until the invention of the balance spring by Robert Hooke or Christiaan Huygens around 1660 that watches became sufficiently accurate to be of practical use. Cippola (1970, 143) estimates that by 1680, in terms of output and innovation, the English watch industry had become dominant in Europe.

Although largely overlooked by most histories of the industrial revolution, time pieces, and pocket watches in particular, represent the first mass produced consumer durable as de Vries (2008, 2–3) demonstrates. Clocks and watches are mentioned in fewer than 10 per cent of English probate inventories around 1675, but in over a third by the 1720s, and appear in nearly 40 per cent of pauper inventories for the period 1770–1812. Looking at the wills of servants in Paris, 13 per cent already mention watches by 1700, and this rises to 70 per cent by the 1780s; while the corresponding figures for the wills of wage earners are 5 and 32 per cent.

Widespread watch ownership implied large scale production, and by the last quarter of the eighteenth century western Europe was producing about 400,000 watches a year, nearly half of them in England (Landes, 1983, 231). Depending on how long one assumes an average watch lasted, Voth (2001, 51) estimates that there were from 1.4 to 3.1 million watches in England around 1800, equivalent to one watch for every 1.8–4 adults. Based on the expected revenue yield of the 1797–98 watch tax, Thompson (1967, 68) estimates that the government believed there to be 800,000 silver and metal watches, and 400,000 gold ones.

This output was achieved through an extensive division of labour which, as Landes (1983, 231) observes, better exemplifies the benefits of specialization than does Adam Smith's pin factory.[8] Unlike clock production, which was widely diffused across England, watch production was highly spatially concentrated in London, Coventry, and around the town of Prescot near Liverpool. Production was organized as a cottage industry where parts were made by specialised artisans, and then assembled into mechanisms which were finally assembled into a case with a faceplate that bore the name of the watchmaker who arranged and financed the entire process, and marketed the finished product. The first specialized trade was spring making but division

[8]As Canann observes, Smith (1976, 7) probably got the idea of division of labour from Mandeville's 1729 discussion of watch-making in *The Fable of the Bees*: "... watch-making, which is come to a higher degree of perfection that it would have been arrived at yet, if the whole had always remain'd the Employment of one person; and I am persuaded, that even the Plenty we have of Clocks and Watches, as well as the Exactness and Beauty they may be made of, are chiefly owing to the Division that has been made of that Art into many Branches."

of labour was extensive by the mid-eighteenth century George (1966, 175–177), and by the early nineteenth century it had risen to a degree described by a Coventry watchmaker Great Britain (1817, 77):

> "Movement maker, is divided into frame mounter, brass flatter, pillar maker, crew maker, cock and pittance maker, wheel maker, wheel finisher, barrel maker, barrel arbor maker, pinion maker, balance maker, verge maker, ratch and click maker, and other small steel work; ...and several other branches to the number of 102 in the whole."

Alongside specialized lathes, vices, files, cutting tools, the watch industry was associated with two innovations of sufficient importance to rank as general purpose technologies in the development of British instrument and machine making. The first from the before 1672 was the mechanical cutting of gear wheels, which permitted far more accurate and durable mechanisms in watches, scientific instruments, and machines (Bailey and Barker, 1969). The second, by the clockmaker Benjamin Huntsman around 1740, was crucible steel that produced a homogeneous steel allowing the production of far higher quality springs and files than available elsewhere (the process only spread to continental Europe after 1800).

An important spillover was from watch and clock making to textile machine building as witnesses to the House of Commons from Liverpool and Derby in 1797 maintained Great Britain (1797, 331, 335), a view echoed by Foster and Jones (2011). However, while the Lancashire watch parts industry was located in the same part of England that subsequently developed mechanical cotton spinning, we should be careful of overly simplistic stories of technological spillover. It is certainly the case that the presence of large numbers of artisans accustomed to making and improving mechanisms, and easy access to high quality gears and springs was an aid to the builders of early textile machinery. At the same time, it is clear that machine building rapidly became a separate and specialized activity due to the very different size and forces experienced by a machine compared with a pocket watch and Cookson (1994, 51–77) finds that most of the early machine builders in West Yorkshire had backgrounds in metal working rather than clock making.

The marriage registers of Prescot, the centre of Lancashire watch-making, which happen to list the occupation of the bridegroom, allow us to assess the educational level of watchmakers from their ability to sign their name.[9] Between 1773 and 1845 644 colliers, 654 labourers, and 183 watch and watch-tool makers got married in Prescot's St. Mary the Virgin church. Overall literacy was low, and did not rise much through the period. 83 per cent of colliers and 69 per cent of labourers were

[9] http://www.lan-opc.org.uk/Prescot/

illiterate. In comparison the educational level of watchmakers is much higher, but still 28 per cent could not sign their names.

6 Conclusions

For the last generation, the Industrial Revolution has been viewed as the start of systematic innovation in the British economy that occurred first in modernizing sectors of textiles, iron, and steam power in the middle of the eighteenth century. This paper focused instead on watches, a sector absent from modern discussions of the Industrial Revolution, but for Adam Smith the pre-eminent example of technological progress.

To evaluate Smith's claim that watch prices had fallen sharply over the preceding century we used records of criminal trials at the Old Bailey which give the value of stolen watches. We find steady falls in all categories of watch price of around 1.3 per cent per year. Our results show that the continuous technological improvement and intensification of division of labour usually dated to the mid-eighteenth century goes back in England to at least the late seventeenth century, and highlights the central role of the interaction between elite inventors and anonymous artisans in product innovation.

While our focus here has been on the implications of the rise of the English watch industry for our understanding of the Industrial Revolution, its subsequent decline is also revealing. High English wages made its watch industry vulnerable to cheap continental imports with English wages twice those in Zurich in 1815 (Studer, 2008, Table 2). While a simple Ricardian model would see English workers relocating to other sectors, the decline of the watch industry was associated with considerable unemployment and falling wages in traditional manufacturing areas like Prescot and Coventry, detailed in contemporary Parliamentary reports. At the same time, while the popular Allen (2009) model of the Industrial Revolution would predict a burst of labour saving innovation in British watch-making, the sector in fact remained organisationally and technically conservative and was decisively overtaken by more innovative Swiss and American competitors as the nineteenth century progressed, a process outlined by Landes (1983, 257–320).

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