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HOURS, EMPLOYMENT, AND EARNINGS OF AMERICAN MANUFACTURING WORKERS FROM THE NINETEENTH TO THE TWENTIETH CENTURIES

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March, 2021

Working Paper No. 21-012

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February 2021

ABSTRACT

For a century, two labor market empirical regularities characterized the movements of the hours of work, employment, and hourly compensation of American manufacturing production workers. They resembled conditional labor supply functions. Increases in employment substituted for reductions in hours per worker. The implied elasticities of hours and employment with respect to hourly earnings declined in absolute value over time. The activities of trade unions and the effects of statutory legislation contribute to the explanations for what is observed. Recently, changes in real hourly earnings contribute little to understanding movements in hours of work and in employment of these workers.

Keywords: hours, employment, hourly compensation, labor supply

JEL Classification Code: J22, N31, N32

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HOURS, EMPLOYMENT, AND EARNINGS OF AMERICAN MANUFACTURING WORKERS FROM THE NINETEENTH TO THE TWENTIETH CENTURIES

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A workplace's use of labor in production is often measured by the workers' average hours of work or by the number of workers employed in the workplace or by some combination of hours and employment. In the conventional analysis of working hours and employment, a central place is occupied by the price of labor, the hourly compensation. The research in this paper examines the link between hourly compensation on the one hand and these two dimensions of labor (average hours and employment) on the other hand using observations from the mid-19th century to the early 21st century of production workers in American manufacturing industry.

As is well known, from the perspective of an individual worker, according to the orthodox reasoning, the consequence of an increase in hourly earnings on the supply of work hours consists of two opposite-signed effects: an income effect inclines the worker to supply fewer hours and a substitution effect encourages the worker to supply more hours. The sign of the net effect is ambiguous in principle. The effect of an increase in hourly earnings on a workplace's supply of workers is likely to increase that number insofar as earnings in other establishments and non-work opportunities do not change.

From the perspective of an employer, the orthodox analysis suggests an increase in hourly earnings on the demand for labor (both on hours per worker and on employment) is to discourage the use of both. The empirical inquiry below is designed to determine the presence and magnitude of these effects on hours per worker and on employment.

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[*] I thank Jed DeVaro for comments on an earlier draft.

Production workers in manufacturing are studied because information on their hours, earnings, and employment is available over a long time and they have been the subject of analysis by other researchers from which this investigation may learn. American manufacturing consists of different types of establishments organized to produce a variety of goods with workers possessing different skills so that the aggregation of these workplaces and workers into all manufacturing will conceal differences among these agents.[1]

Offsetting these aggregation problems, a time-series study such as this has the advantage that the values of the key variables exhibit a wider range than those contained in many contemporary cross-section studies. Thus, for the workers studied below, the value of their average real hourly compensation at the end of the period is almost 20 times its value at the beginning. The typical working week of these workers was about 30 hours longer in the 1830s than it was in 2010. The total number of production workers employed in manufacturing towards the end of the period of study was well over twenty times the number in the mid-19th century.

Of course, the work that these wage-earners were doing in 1830 was very different from that undertaken by the corresponding workers 180 years later and it might be thought remarkable if hours-earnings and employment-earnings patterns that describe these workers in the 19th century are also those that describe the workers at the beginning of the 21st century. This will be determined by estimating the relations to observations in separate periods. In this way, the degree to which the link between hours and earnings and the link between employment and earnings remain the same

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[1]Indeed, Rosenbloom and Sundstrom (1994) use observations on manufacturing workers in various occupations employed in different places from 1890 to 1903 and find considerable heterogeneity in the hours-earnings relationship across occupations, among regions, and over time. Similarly Bernanke (1986) makes use of monthly observations on eight manufacturing industries for the period from 1923 to 1939.

over time can be ascertained.

Throughout, although I shall refer to the pay of the workers as average hourly earnings, the variable is actually average real hourly compensation. This includes supplements to earnings in the form of employers' contributions to pension plans and to group insurance programs such as health benefits. In manufacturing, these supplements were zero until 1912. Then they constitute a relatively small addition to earnings until the Second World War when they were accepted by the National War Labor Board to attract workers to particular war-related production. By the end of the 20th century, average hourly benefits represented one-fifth of average hourly compensation. The price deflator on hourly compensation is the consumer price index constructed by Officer and Williamson (2020) whose base period is 1982-84.

The equations that will be estimated by least-squares are parsimonious specifications compared with equations often estimated with contemporary cross-section data. This is unfortunate because information on other variables would help interpret the fitted equations. This parsimony reflects the absence of information on the values of consistently-measured variables that would help to remove the variation in working hours and employment over a long period . As it is, in many periods, the right-hand side variables will be shown to remove a large fraction of the variation in the dependent variables over time. It will be evident that, in some periods, the variables examined here move from year to year in the same general direction. Conventional economic reasoning suggests an interpretation of these trends such that their mutual correlation is not adventitious but meaningful and reflects the operation of economic forces.

The association between working hours and earnings will be taken up first and then the link between employment and earnings will be investigated. Attention will be paid to the economic

interpretation of the estimated equations.

I. WORKING HOURS PER WORKER AND REAL HOURLY EARNINGS

In describing the annual movements in working hours and their associated movements in hourly earnings, there are changes in hours from year to year with earnings unchanged. In particular, it has long been noted that changes in hours are sometimes the immediate response of managers to unforeseen changes in product demand. (See, for instance, Bry (1959)) That is, to respond to a transitory shock in the demand for the product, instead of changing employment and spending resources on hiring, training, or firing workers, employers will ask their existing employees to work longer or shorter hours.

A convenient way to describe the association over time (t) between hours of work (H) and average real hourly earnings (w) and to take account of the movements in hours described in the previous paragraph is to use annual observations on hours and earnings to estimate the following simple regression equation:

(1) $$ln\,(H_t) = \kappa_1 + \alpha\, ln\,(w_t) + \theta_1\, X_t + u_{1t}$$

where *ln* indicates the natural logarithm of the variable that follows in parentheses , α , θ_1 and κ_1 are parameters to be estimated, and u_{1t} incorporates the influence on hours of omitted variables. X_t is the deviation of industrial production from its trend and is designed to measure the changes in hours induced by short-run changes in product demand. Higher values of X_t are expected to be associated with longer hours in which case θ_1 will be positive.[2]

In equation (1), α is the elasticity of hours with respect to earnings over the estimation

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[2] Precisely, suppose P_t is the value of an index of industrial production in year t . For each sixty year period, annual observations of P_t are regressed on a linear time trend and X_t is the estimated residual of this equation in year t.

period. Equation (1) restricts this elasticity to be a constant over that period. This is a partial elasticity in that X_t is held constant and it is uncompensated in that neither income nor utility is held constant. To allow more flexibility in the estimated relation, the results of estimating equation (2) will also be reported :

(2) $$ln\,(H_t) = \kappa_2 + \beta\, ln\,(w_t) + \gamma\,[ln(w_t)]^2 + \theta_2\, X_t + u_{2t}$$

In equation (2), κ_2 , β , γ, and θ_2 are parameters to be calculated and u_{2t} stands for residuals incorporating the effects on hours of omitted variables. Equation (2) allows the elasticity of hours with respect to earnings to vary with earnings. The implications of the two estimated equations will be contrasted by graphing their implied values of working hours at different earnings. In addition to the logarithmic equations (1) and (2), linear equations were estimated whose inferences were similar to those from fitting (1) and (2).

This research that uses annual observations on working hours and hourly earnings of manufacturing production workers to measure the elasticity of hours with respect to earnings within an industry or group of industries is in the tradition of Paul H Douglas (1934) Other time-series studies include those of Thomas Kniesner (1976), Abbott and Ashenfelter (1976), and Vandenbroucke (2009) which cover a shorter period than that examined in this paper. The research here that traces hours and earnings over 180 years from 1830 to 2010 proceeds by dividing these 180 years into three periods of 60 years each: from 1830 to 1890; from 1890 to 1950; and from 1950 to 2010. Approximately, the periods correspond to the late nineteenth century and the two halves of the twentieth century. Equations were also fitted to each of the six thirty-year periods, but only one of these will be reported here: the period from 1980 to 2010 as it is the most distinctive and there may well be particular interest in placing contemporary decades in historical perspective.

Within each of these periods, equations (1) and (2) will be estimated to annual observations by conventional least-squares to quantify the link between the pay of these workers and their averageworking hours. In the 19th century, much of the movement in hours of work took the form of changes in hours worked per day and, accordingly, in the analysis below, for the years from 1830 to 1890, the working hours variable measures the average length of the working day (usually worked six days a week). Once the ten hour day had been reached in many establishments by 1890, attention turned to reducing the number of days worked in the week as well as to further reductions in daily hours. From 1890 to 2010, the working hours variable is the average weekly hours worked .

I.1. The Years from 1830 to1890

In 1830, many manufacturing production workers were working 12 hours a day for six days a week. As shown in Figure 1, after 1840, their average hours of work fell and by 1890 the average work day was ten hours in manufacturing. Figure 1 also shows that, over this period, average real hourly earnings rose.[3] Descriptive statistics on these two variables over these years are presented in Table 1.

Using annual observations on daily hours of work and real hourly earnings from 1830 to 1890, a negative association between working hours and pay is expressed in the least-squares estimates of equations (1) and (2) in the top two rows of Table 2. Almost two-thirds of the annual variations in hours between 1830 and 1890 are removed by annual variations in hourly earnings

[3] Conspicuous in Figure 1 is the decline in real hourly earnings in the first half of the 1860s, the Civil War. This decline came about even though nominal earnings in 1865 were 46 percent above their 1860 level. Consumer prices (the deflator in the conversion of money earnings into real earnings) in 1865 were 96 percent above their 1860 level.

alone.[4] The squared term in hourly earnings adds a (statistically) significant amount to the variation in hours removed by the right-hand side variables.

The hours-wage elasticities implied by equations (1a) and (2a) in Table 2, namely, -0.185 in the case of equation (1a) and -0.160 in the case of equation (2a) [5] resemble most of those calculated by Atack and Bateman (1992), by Rosenbloom and Sundstrom (1994), and by Costa (2000) using disaggregated data. The implications for daily hours of the estimates of equations (1a) and (2a) given the hourly earnings observed between 1830 and 1890 are shown in Figure 2. Following Marshall's practice, Figure 2 places earnings on the vertical axis and hours on the horizontal axis. For both equations, a negative relation is apparent although there are differences between the two specifications at the end points.

What is the interpretation of this negative relationship between working hours and hourly earnings? One might guess that this is an expression of the typical employer's labor demand function: employers reduced hours in the face of the rising cost of hours. The reasoning might be that, in a graph such as Figure 2, a positively-sloped labor supply curve moved up and to the left over time intersecting an unchanged (negatively-sloped) labor demand curve at coordinates corresponding to higher earnings and shorter hours. The problem with this conjecture is that, at a time when the economy was growing, it is implausible to suppose the derived demand for manufacturing labor was unchanged. Another problem with this interpretation is to wonder what might cause the labor supply curve to rise over time? At this time, the typical production worker is believed to have had little or

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[4] If X_t is omitted from equations (1a) and (2a), the value of the R^2 statistic falls to 0.639 and 0.657, respectively .

[5] For equation (2a), the elasticity is computed at median real hourly earnings in the period (0.85) .

no nonlabor income.[6]

Furthermore, if these observations were mapping a conventional demand for hours function, the employer would have been amenable to reduce hours when hours became more expensive. In fact, as is well known, employers strongly resisted reductions in hours calling them "disastrous" and they spent considerable resources in opposing shorter hours.[7] The notion that employers chose shorter hours as implied by an orthodox labor demand function is to introduce a new meaning to "chose".

A stronger case can be made that the negative association between hourly wages and hours of work maps a labor supply function. H. G. Lewis (1957) stated the reasoning clearly. Lewis assumed the employers' demand for hours was a relatively wage-elastic function [8] and, in the 19th century, as the demand for the products of these manufacturers grew, it moved up and to the right (in a graph such as Figure 2 with earnings on the vertical axis and hours on the horizontal axis).

Assuming workers' preferences for income and time not worked were unchanged, the rising demand for labor intersected a fixed negatively-sloped supply function of hours at higher hourly earnings and shorter hours. The claim that the negative hours-earnings association reflects the work-income preferences of workers as revealed in their supply function is supported by the fact that the income effect of a wage increase is larger (in absolute value) at long hours such as those in the

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[6] After 1862, some of these workers may have been receiving Civil War veteran benefits, but these were not generous nor distributed widely.

[7] The word "disastrous" is used in the title of a pamphlet "Disastrous Effects of a National Eight-Hour Law" written by David M. Parry, President of the National Association of Manufacturers, about a proposed eight-hour working day required of government contractors.

[8] If more workers (employment) can be substituted easily for shorter hours per worker, the demand for hours would tend to be relatively wage-elastic.

nineteenth century.

Following this reasoning, in this paper, when the following identifying conditions are satisfied :

1. the demand for the labor of these workers is rising;

2. the preferences of workers for income and time not worked (which underlies their supply function of hours) may be assumed to be given and unchanged;

3. transitory variations in employers' demand for hours are recognized;

the resulting association between working hours and earnings is interpreted as the workers' conditional supply function of working hours where "conditional" recognizes the presence of X_t that holds constant transitory or unforeseen changes in demand.

However, in setting work schedules, how were employers able to intuit workers' preferences for shorter hours when their earnings rose? In this instance, some employers were well-informed of workers' preferences because organizations of workers - trade unions - gave voice to their members' wants . This explanation confronts the objection that trade unions had organized a small fraction of the labor force in the nineteenth century. Indeed, by 1899, union membership constituted only 4.9 percent of non-agricultural employment. (Troy and Sheflin (1985) Appendix A, p. A-1). Nevertheless, trade unions were growing and, at least for the wages of workers in manufacturing industry, it was the rate of change of union membership that generated the most pressure on employers as shown by Ashenfelter *et al.* (1972) . What held for wages is likely also to have held for the other principal goal of unions: to reduce hours of work.

I. 2. The Years from 1890 to 1950

The decline in working hours and concomitant rise in hourly earnings of manufacturing production workers continued after 1890 and into the twentieth century as illustrated in Figure 3. The decline was interrupted during the years from 1939 to 1944 when American civilian workers workiedlonger hours in preparing for and then in engaging in a major war. Descriptive statistics on weekly hours and real hourly earnings for the 1890-1950 period are given in Table 1 and least-squares estimates of equations (1) and (2) are reported in Table 2 as equations (1b) and (2b) respectively. The implications for the hours-earnings relation of the estimated equations in Table 2 (given the earnings observed between 1890 to 1950) are graphed in Figure 4 in which a negative associaion is evident.[9] For the years 1890-1950, the addition of the square of hourly earnings adds significantly to the variation in hours removed by the right-hand side variables.

Unlike the sixty years from 1830 to 1890, these years from 1890 to 1950 are distinctive in the role played by the Federal Government in the determination of hours. One manifestation of this was the Federal Public Works Act of 1912 according to which government contractors were required to schedule eight hour work days of their employees. However, the Act was of questionable effectiveness because it was poorly enforced and its language allowed for various interpretations (Cahill 1932, pp. 77-81).[10]

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[9] Note that from 1900 to 1950, the weekly hours of work observations are those constructed by Jones (1963) who recognized that the growth of paid vacations and holidays gave rise to a distinction between hours paid for and hours actually worked. Her figures on working hours subtracted time paid for but not worked.

[10] Whaples (1990) provides a thorough analysis of the decline in hours in the second decade of the 20th century. He concludes, "The most important force reducing the work week was the rise in wages..."

The Federal Government's influence on hours and earnings during the First World War was expressed through the National War Labor Board which was created to prevent labor-management disputes from interrupting the production of goods relevant to the war effort. An example of a dispute over working hours was that at the Worthington Pump Company in which, after much deliberation, the Board ruled a decrease in hours to a standard of eight hours per day. This became the Board's norm.[11]

After the war and after the short sharp recession that followed, working hours changed little notwithstanding Henry Ford's introduction in 1926 of a five day working week. Other employers denounced Ford's action and employers' federations such as the National Association of Manufacturers urged its members not to follow Ford's action. Real hourly earnings tended to rise in the 1920s though not quite as much as during the previous decade.

Federal Government activity concerning hours and earnings was much in evidence in the 1930s. For instance, in June 1933 the National Industrial Recovery Act charged the government to develop industry codes that became effective in 1934. As far as manufacturing was concerned, these codes mandated a decline in weekly hours without a change in weekly earnings thereby raising hourly earnings. In May 1935 the Supreme Court determined this Act was unconstitutional, a month before it was due to expire.

Three years later, the Fair Labor Standards Act specified a minimum wage and overtime pay (1.5 times the standard wage rate) for each hour worked beyond 44 hours a week . This applied to many workers. In two years, this threshold became 40 hours. The work schedule of eight hours a

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[11] The War Labor Board ".....almost invariably awarded the basic eight-hour day when the question of hours was at issue." (Cahill, 1932, p. 81)

day for five days a week was to become standard for manufacturing production workers.

In the late 1930s, the anticipation of war and the subsequent declaration of war resulted in a decrease in the supply of labor to the civilian labor market as workers were conscripted into the Armed Forces and in an increase in the demand for labor to produce the material requirements of the military. Average weekly hours of work rose from 37.6 in 1940 to 44.2 in 1944. Notwithstanding wage and price controls, the real hourly compensation of manufacturing workers increased. After the war, working hours declined to their prewar levels and earnings continued to increase.

If the years of the Second World War are put aside as exceptional, certain features of the movement of hours and earnings in the 1890-1950 period are similar to those that were used earlier to interpret the hours-earnings relation from 1830 to 1890 where it was argued that the hours-earnings relation traced the workers' conditional supply function of hours . The weekly hours of work of these workers at the end of the period were less than two thirds of their hours at the beginning.[12] As in the nineteenth century, employers strongly opposed the reductions in hours while trade unions voiced the preferences of these workers for shorter hours. At times, in the 1890-1950 period, the Federal government joined trade unions in expressing the preferences of workers for shorter hours.

As a portent of what was to follow, note that average weekly hours of work from 1945 to 1950 were 39.4.....close to the hours at which premium pay was required for these workers by law.

I.3. The Years from 1950 to 2010

The movements in weekly hours and real hourly earnings from are pictured in Figure 3 and the descriptive statistics are reported in Table 1. There is a modest downward trend in weekly hours

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[12] Average weekly hours in 1950 were 38.7 and they were 60 in 1890.

over the years from 1950 to 1980 and an offsetting modest upward trend in hours from 1980 to 2010. Over the entire sixty year period, there is little trend in weekly hours.[13] The contrast in Figure 3 between the movements in hours of work from 1890 to about 1940 and those after 1940 is plain.

Real hourly compensation trended upward from 1950 to 2010 with the trend being stronger in the thirty years from 1950 to 1980 than in the years from 1980 to 2010. Again the contrast in Figure 3 between the strong upward movement in hourly compensation before 1980 and the small rise after 1980 is also evident.

Examination of Figure 3 and the descriptive statistics in Table 1 reveal the small variation in hours in the years from 1950 to 2010 compared with those in the other periods. This comparison is summarized in Table 3 using as indicators of variation the coefficient of variation (σ / μ) and the quartile deviation relative to the median (QD / M) . Of the three sixty year periods from 1830 to 2010, the variations of working hours and the variations in real hourly compensation are least for the period 1950-2010. Of the six thirty year periods, the least variations in hours are for the periods 1860-90, 1950-80, and 1980-2010 and the thirty year period with the least variation in earnings is that for 1980-2010. The most recent years are distinctly different from the earlier years.

Table 2 reports the least-squares estimates of equations (1) and (2) fitted to the years from 1950 to 2010and from 1980 to 2010 where real hourly earnings (a variable with a modest trend and little variation) removes little of the variation in weekly hours of work (another variable with little trend and little variation) compared with earlier periods. For these equations, the squared term in

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[13]Kniesner (1976) shows that the growing importance of paid vacations and holidays does not account for the absence of a negative trend in published working hours observations.

hourly earnings adds almost nothing to removing the variation in hours.

The hours-earnings relations implied by the estimates of equations (1c) and (2c) in Table 2 (given earnings from 1950 to 2010) are graphed in Figure 5 ; they are close to vertical lines at about 40 hours a week. In other words, the hours threshold beyond which employers are required by the Fair Labor Standards Act to pay their (covered) workers premium rates of pay became for these workers the default scheduled hours, a focal point. Employers avoided paying workers premium earnings by specifying a working week of 40 hours or less regardless of the earnings in these years.[14]

I.4 The Elasticity of Hours per Worker with respect to Hourly Earnings

Table 4 collects the estimates of equations (1) and (2) to compare the differences over time in the elasticity of hours worked with respect to hourly earnings. This was interpreted as a conditional labor supply elasticity. For equation (1), this elasticity, call it Ω_1 is simply α in the equation

(1) $$ln(H_t) = \kappa_1 + \alpha\, ln(w_t) + \theta_1 X_t + u_{1t} \quad ,$$

For equation (2),

(2) $$ln(H_t) = \kappa_2 + \beta\, ln(w_t) + \gamma\, [ln(w_t)]^2 + \theta_2 X_t + v_{2t}$$

the elasticity is Ω_2 where $\Omega_2 = \beta + 2.\gamma\ ln(w)^M$ and $(w)^M$ is the median wage in the period to which the estimated parameters relate. A third elasticity added to Table 4 is Allen's (1934) Arc Elasticity, Ω_A , defined as

$$\Omega_A = [(H_T - H_O)/(H_T + H_O)]\ [(w_T - w_O)/(w_T + w_O)]^{-1}$$

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[14]The Current Population Survey of households reports that, in 2019, 46.9 percent of all wage and salary workers in nonagricultural industries worked exactly 40 hours. https://www.bls.gov/cps/cpsaat19.pdf

The subscripts on hours (H) and real hourly earnings (w) are to the initial year O and to the terminal year T. Although the Arc Elasticity has the appealing feature of being independent of functional form, it is sensitive to the (possible outlier) values of H and w in the initial and terminal years, a feature to be encountered.

In Table 4, of the 9 entries corresponding to the three sixty year periods, those describing the years from 1830 to 1950 are all negative; the three elasticities corresponding to the 1950-2010 period are positive and, in absolute value, they are the smallest three of the nine estimated elasticities.

All of the 12 elasticity estimates for the four thirty year periods from 1830 to 1950 are negative. The estimates of Ω_1 and Ω_2 for 1890-1920 in Table 4 of -0.293 and -0.266, respectively, are similar to those computed by Douglas (1930, p. 306) who used time-series observations on weekly hours and real hourly earnings on 15 industries from 1890 to 1926. He concluded that the average elasticity estimate was -0.30.

Half of the elasticities calculated from observations for the two thirty year periods between 1950 and 2010 are positive. Evidently, as far as the relation between hours worked and hourly earnings is concerned, the years from 1950 to 2010 are different from the earlier years.[15] How different? Can a simple hours-earnings relationship describe all 180 years from 1830 to 2010?

To respond to this question and to accommodate the observations on daily hours of work in the nineteenth century, consider these slight modifications of equations (1) and (2):

(3) $$ln\,(H_t) = \kappa_3 + \rho_3 D_t + \alpha\, ln\,(w_t) + \theta_3 X_t + u_{3t}$$

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[15] In the case of Allen's arc elasticity from 1980 to 2010, the positive value reported is anomalous. If the arc elasticity is constructed with the hours and earnings figures for 1979 and 2009, the value of the arc elasticity is -0.412. This illustrates the point that the arc elasticity is sensitive to the (possibly atypical) values of the observations at the beginning and end of the period.

and

(4) $ln\,(H_t) = \kappa_4 + \rho_4 D_t + \beta\, ln\,(w_t) + \gamma\,[ln(w_t)]^2 + \theta_4\, X_t + u_{4t}$.

where $D_t = 1$ when the hours variable relates to hours per day (from 1830 to 1889) and $D_t = 0$ in all other years. The least-squares estimates of these equations fitted to all annual observations from 1830 to 2010 are given by equations (3a) and (4a) in Table 5 and Figure 6 graphs the relationship between hours and earnings implied by the estimates of equations (3) and (4) fitted to all the years from 1830 to 2010. Notwithstanding the weak relationship between hours and earnings in the years from 1950 to 2010, movements in earnings and variations in production around a trend line remove 99 per cent of the annual variations in hours over 180 years since 1830. Figure 7 graphs the elasticity of hours with respect to hourly earnings as measured by $\Omega_2 = \beta + 2.\gamma\ ln(w^D)$ implied by equation (4a) in Table E where w^D is the value of the real hourly compensation at each decade from 1830 to 2010 on the horizontal axis. Figure 7 shows that this elasticity was most negative in the mid-nineteenth century since when it has become less negative . The elasticity has been close to zero in recent years.

I.5 Conclusions about Hours and Earnings of Manufacturing Production Workers

For those inclined to view the operation of labor markets through the framework of orthodox micro-economics, the movements of the hours and earnings of manufacturing workers from the mid-nineteenth century to the mid-twentieth century are consistent with increases in the demand for labor intersecting an unchanged negatively-sloped supply of hours curve. This negatively-sloped supply curve of hours implies a negative income effect of a given wage increase that exceeds (in absolute value) a positive substitution effect. Moreover, this income effect becomes less negative as hours fall so the (uncompensated) elasticity of hours with respect to earnings falls as hours declines over

time.

This interpretation becomes less persuasive in the years after the Second World War when the link between variations in hours and variations in hourly compensation becomes weaker. In the years from 1980 to 2010, the hours of these workers were independent of movements in their hourly earnings Consequently, at least for these workers in recent years, changes in hourly compensation do not merit the attention given to them in orthodox models of hours of work.

The reason for this may be that the conditions (listed in Section I.1 above) under which the hours-earnings observations identifies the workers' supply curve of hours have not been satisfied. Since 1950, the growth in the demand for these workers has been weaker than in earlier years and the increase in nonlabor income may have undermined the condition of an unchanged supply curve. If this is correct, it raises analogous concerns about what is being estimated in the literature that claims to measure labor supply responses from contemporary cross-section hours-earnings observations.

Those inclined to emphasize the role of trade unions in labor markets will have little difficulty in accounting for the patterns found. Shorter hours and higher earnings have been the principal objectives of unions and they have provided the voice for workers to express their preferences. Trade unions tend to be more effective when they are growing as they were from the mid-nineteenth century until the mid-1970s. When they are growing, unions are able to induce non-union and anti-union employers (such as Henry Ford) to raise the pay and to schedule shorter hours so their workers are less disposed to turn to unions to achieve their aims.[16] Between 1980 and 2010,

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[16]In 1914, Henry Ford doubled the pay of his workers and reduced their daily hours from 9 to 8. In the previous year, the IWW had organized workers in neighboring Ohio and they announced their intention of organizing the automobile workers of Michigan. Ford recognized "a growing

meager wage growth and little change in hours have coincided with declining unionism. Of the six thirty year periods specified in ths paper, the proportionate increase in real hourly compensation was least between 1980 and 2010. Of six thirty-year periods, hours increased in only one period: between 1980 and 2010 when they increased from 39.2 hours to 41 hours.

Tn this analysis of hours and hourly earnings over time, there is a clear role for statutory legislation in understanding the decline in hours. Since 1940, the Fair Labor Standards Act requires premium pay to those who work beyond 40 weekly hours and manufacturing employers have responded by avoiding (as much as is profitable) an hours schedule beyond 40. From 1950 to 2010. the slope of the hours-earnings curve has been effectively zero.

Hours have responded to transitory shocks in the demand for labor: in all of the hours-earnings equations reported above (and in all the hours-earnings equations fitted to six thirty year periods), the estimated coefficient on X_t an indicator of transitory shocks, is positive and, in many instances, significantly greater than zero (in a statistical sense). A typical finding is that a one standard deviation increase in X_t is associated with one additional hour in the working week. This constitutes further evidence that variations in hours of work are associated with movements in the demand for labor and are not exclusively a consequence of differences in workers' preferences and budget constraints.

II. EMPLOYMENT AND REAL HOURLY EARNINGS

In the explanation (attributable to Lewis) offered above for the negative association over time between average hours of work and average hourly earnings, the precipitating factor was successive increases in the demand for labor (accompanying the growth of the economy) that raised hourly

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threat of unionization" (Curcio (2013, p. 77)) .

earnings to which workers (their supply curve of labor assumed to be "very stable") responded by reducing their hours ; their negative income effect of earnings increases dominated their positive substitution effect. The hours-earnings observations traced out a "stable" supply curve of hours.

If the demand for labor increased and if hours per worker declined, how were these increases in the demand for labor satisfied ? : by employing more workers. Higher employment substituted for fewer hours per worker.[17] Furthermore, if Lewis' claim that workers' tastes for "leisure" time relative to labor income are "very stable" is correct, then increases in the demand for labor raised hourly earnings and traced out the "stable" supply curve of workers to employment in manufacturing. To examine this implication regarding the employment of manufacturing production workers, consider the following two regression equations :

$$ln\,(E_t) = \kappa_5 + \delta\, ln(w_t) + \theta_5\, X_t + u_{5t} \qquad (5)$$

$$ln\,(E_t) = \kappa_6 + \eta\, ln(w_t) + \mu\, [\, ln(w_t)\,]^2 + \theta_6\, X_t + u_{6t} \qquad (6)$$

where E_t denotes the number of manufacturing production workers employed in year t and, again, w_t is the real hourly compensation of these workers in year t. The effects of omitted terms are contained in u_{5t} and u_{6t}, which are assumed to be distributed independently of hourly earnings.

To preserve symmetry between the supply of hours per worker and the supply of workers to manufacturing employment, equations (5) and (6) (as equations (1) and (2)) include X_t , the deviation in year t from a trend in industrial production. It was argued above that such deviations encourage transitory variations in working hours in lieu of changes in employment and support for

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[17] A given proportional reduction in hours does not imply the same proportional reduction in output because individuals work more effectively at shorter hours. Nevertheless, more employees would help to meet the purported increased demand for labor. Samuel Gompers recognized these substitution possibilities when he said "So long as there is one man who seeks employment and cannot find it, the hours of labor are too long."

this argument was found in the estimated hours equations above.

If this is correct, changes in X_t should not be associated with changes in E_t. The reasoning in the previous paragraphs suggests that, in periods when the demand for labor increased and real earnings rose, hours declined and employment grew : E_t and w_t are positively correlated. Shorter hours were replaced with more workers employed and the association between employment and hourly earnings is the workers' supply function to employment in manufacturing. Higher earnings in manufacturing encouraged individuals to work in manufacturing.

Unfortunately, annual observations on the employment of manufacturing production workers since the mid-19th century appear not to exist. This will mean that the same three 60 year periods used in the previous pages for analyzing working hours and earnings cannot be replicated in the analysis of employment and earnings. Instead, for the 19th century, I use the decennial observations on "all persons engaged" in manufacturing for the seven years 1840, 1850, 1860, 1870, 1880, 1890 and 1900.[18] Annual observations on the employment of production workers in manufacturing are available from 1900. In the analysis of employment and hourly earnings that follows, I divide the period from 1840 to 2010 into four periods: 1840-1900; 1900-1940; 1940-1980; and 1980-2010. Descriptive statistics on employment and real hourly earnings in these periods are given in Table 6.

The paragraphs above suggested that employers responded to falling hours by increasing employment so an immediate test of this proposition is to determine whether the correlation between working hours and employment is negative: during the years from 1840 to 1900, the correlation

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[18]These are from Lebergott (1964) Table A-1 and include production and non-production employees, the self-employed and unpaid family workers. No observation is provided for 1830. These figures show manufacturing employment in 1900 was almost twelve times the number in 1840. Real hourly compensation in 1900 was 2 ½ times its value in 1840.

coefficient between annual observations of employment and of hours of work is -0.940 ; it is -0.445 from 1900 to 1940; it is +0.543 from 1940 to 1980; and it is + 0.016 from 1980 to 2010. Therefore, on a first examination, the notion that reductions in hours were replaced with increases in employment appears to have been true in the years from 1840 to 1940, but not in the years after.

Figure 8 shows an upward trend in both employment and hourly earnings between 1900 and 1940, an indication of a growing demand for these workers around recessions and a responsive supply . The economy's contractions in 1907-08, 1920-21, 1929-33, 1937-38, 1980-82, and 2007-09 are apparent in employment but not in real hourly earnings.

After the Second World War, Figure 8 shows that, around cyclical movements, an upward trend in employment is not conspicuous. The employment of these workers reached a maximum of 14½ million in 1979 after which employment fell to 8 million in 2010.[19] In contrast, their real hourly compensation trended upwards from 1940 to the late 1970s and there was meager growth thereafter. (The compound annual increase in real hourly compensation was 1.8% in the thirty years between 1950 and 1980 and 0.37% between 1980 and 2010.) These are signs of a weak or declining demand for the labor of these workers. Without unionism, the growth in real compensation may have been negative after 1980.

The estimates of equations (5) and (6) in the four periods between 1840 and 2010 are contained in Table 7 A positive and statistically significant association between employment and hourly earnings is evident in the regressions fitted to the periods from 1840 to 1940, but a negative or a statistically insignificant association is estimated to the observations after 1940. The implied

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[19]Of the four periods in Table F, on the criteria of both the coefficient of variation and of the quartile deviation as a fraction of the median, the years from 1940 to 1980 is the period with the least variation in employment.

elasticity of employment with respect to hourly earnings in each period is reported in Table 8.

When the employment equations estimates in Table G are simulated at different earnings, a positive employment-earnings relation is mapped for those fitted to observations before 1940. An illustration of this is provided in Figure 9 which simulates employment for various levels of earnings using the parameter estimates of equations (5) and (6) for the years from 1900 to 1940. The positive relation is what we would expect if it were a supply curve of workers to manufacturing employment. This positive association is less apparent in the post-1940 equations.. Indeed, the equations fitted to observations from 1980 to 2010 imply either a negative relation or no relation.[20]

Unlike the invariably positive link between X_t and hours, there is no consistent pattern in the association between X_t and employment. This supports the notion that the fixed costs of altering employment make hours the cheaper means of responding to transitory shocks to the demand for labor.

When analyzing working hours above, it was found that, even though the elasticity of hours with respect to earnings changed materially over time, variations in earnings from the mid-19th century to 2010 removed 99 per cent of the variations in hours. Can the same statement be made about employment? To address this, consider equations (7) and (8) below which resemble equations (3) and (4) except the logarithm of hours is replaced in equations (7) and (8) by the logarithm of the employment of production workers. In these equations D_t takes the value of unity for the decennial observations in the nineteenth century and of zero thereafter.

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[20] When equation (6d) of Table 7 is simulated at the earnings observed in the period, the negative effects of $[ln(w)]^2$ dominate and employment falls gradually as earnings increase. It might have greater claim as a labor demand function than as a supply function.

(7) $$ln\,(E_t) = \kappa_7 + \rho_7 D_t + \delta\, ln\,(w_t) + \theta_7 X_t + u_{7t}$$

(8) $$ln\,(E_t) = \kappa_8 + \rho_8 D_t + \eta\, ln\,(w_t) + \mu\,[ln(w_t)]^2 + \theta_8 X_t + u_{8t}.$$

The consequences of estimating equations (7) and (8) by least-squares to all the observations from 1840 to 2010 are shown in Table 9 by the equations (7a) and (8a). Unlike the estimates of equations (3) and (4) where the right-hand side variables (principally real hourly earnings) removed 99 per cent of the variation in working hours from the 19th century to 2010, less than one-quarter of the variations in employment over these years is removed by the right-hand side variables in equations (7) and (8). The point estimates on earnings imply that increases in earnings tend to be associated with increases in employment but there is little precision in some of these estimates.

On the other hand, if equations (7) and (8) are fitted to the years from 1840 to 1940 , the results in equations 7(b) and (8b) of Table 9 suggest a much better fit. If the estimates of equation (8b) are used to calculate the elasticity of employment with respect to hourly earnings from 1840 to 1940, the results are shown in Figure 10. This elasticity declines from values greater than 3 in the mid-19th century to zero in the years of the Great Depression.

A positive association between the employment of these workers and their hourly earnings that has claim to being an employment supply function operated for one hundred years from the mid-19th century. Since then this association is weak and inconsistent. This may well be the consequence of the omission from our estimating equations variables that have shifted both the demand and supply functions of labor. All in all, the case that our estimates trace out the supply of production workers to manufacturing for the entire period from 1840 to 2010 is not persuasive. Yet these variables were also omitted in the employment equations fitted to pre-1940 observations and there the case for identifying the employment supply function appeared more plausible.

Of course, in recent years, the U.S. manufacturing industry's travails have been well documented and especially those of semi-skilled manufacturing workers. For example, see Baily and Bosworth (2014) and Houseman (2018). Technological change and competition from overseas manufacturing have been charged as causes of U.S. manufacturing's woes. There has also been substantialcomputerisation that has not encouraged employment.

III. SUMMARY AND CONCLUSIONS ABOUT HOURS, EMPLOYMENT, AND EARNINGS

By necessity, the equations estimated in this paper have omitted variables that are called for in the conventional theory of the supply of and demand for labor. This is not unusual in empirical work spanning many years, but on the other hand this type of research is sometimes able to place research on contemporary data in perspective. In this instance, recent decades have been shown to be distinctly different from those that apply before mid-20th century. The conventional models of hours of work and employment in which real hourly earnings occupy a key role have been shown to account for little of the movements over time in working hours and in employment of manufacturing production workers in recent years.

As a consequence, two empirical regularities that operated for at least one hundred years - a negative association between average hourly earnings and hours of work and a positive association between average hourly earnings and employment - have not applied to manufacturing production workers in recent decades. Perhaps with a careful search for and selection of other variables, these two patterns can be resuscitated, but the uncontrived relationships have disappeared.

In the years that the orthodox model operated in these labor markets, both the elasticity of the hours with respect to hourly earnings and the elasticity of employment with respect to earnings declined (in absolute value). In both cases, the association between these two dimensions

of labor and hourly compensation is approximately zero recently.

The demand for the labor of manufacturing production workers was growing in the nineteenth century. It is ebbing today as reflected in their earnings growth.[21]. In such an environment, some workers seek longer hours to augment their weekly earnings. Reder (1957) cites one union leader[22] as saying, "....there is no evidence that workers want shorter daily or weekly hours. The evidence is all on the other side. Hundreds of local and International officials have testified that the most numerous and persistent grievances are disputes over the sharing of overtime work. The issue usually is not that someone has been made to work, but that he has been deprived of a chance to make overtime pay. Workers are eager to increase their income, not to work fewer hours."

In other words, the intent of lawmakers to discourage long hours of work by requiring premium pay after 40 weekly hours has worked only too well. With hourly earnings almost stagnant, workers have been denied the longer work hours that would enhance their weekly earnings. These workers are not free to choose their working hours. Workers' preferences given their ostensible earnings opportunities are not being revealed in their working hours. With little reduction in hours per worker, there is less pressure to increase employment.

These findings suggest that, for production workers in American manufacturing industry, the

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[21] The compound annual increase in real hourly earnings was 0.037% between 1980 and 2010, lowest growth of the six thirty year periods from 1830 to 2010.

[22] The union leader was George Brooks of the International Brotherhood of Pulp, Sulphate and Paper Mill Workers. Reder also quotes the miners' union leader John L. Lewis as saying "It has been thought.....that the preponderance of our membership prefer to have more to eat for their families rather than having two hours less work a day. Any time the organization as a whole wants to stop eating so much and loaf a little more, we can get a six hour day for you."

key role assigned to real hourly earnings in orthodox models of the supply of labor was appropriate to the years from the mid-18th century to the mid 19[19] century, but its importance in recent decades in understanding movements in hours of work and employment is negligible. [23]

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FIGURES

Figure 1

Daily Working Hours and Real Hourly Earnings:1830 - 1890

Average daily hours of work are measured on the left-hand vertical axis and drawn in the figure by the solid series. Real hourly earnings in 1982-84 dollars are measured on the right-hand vertical axis and drawn in the figure by the dashed series.

Figure 2

Simulations of Daily Working Hours from Equations (1a) and (2a) :1830 - 1890

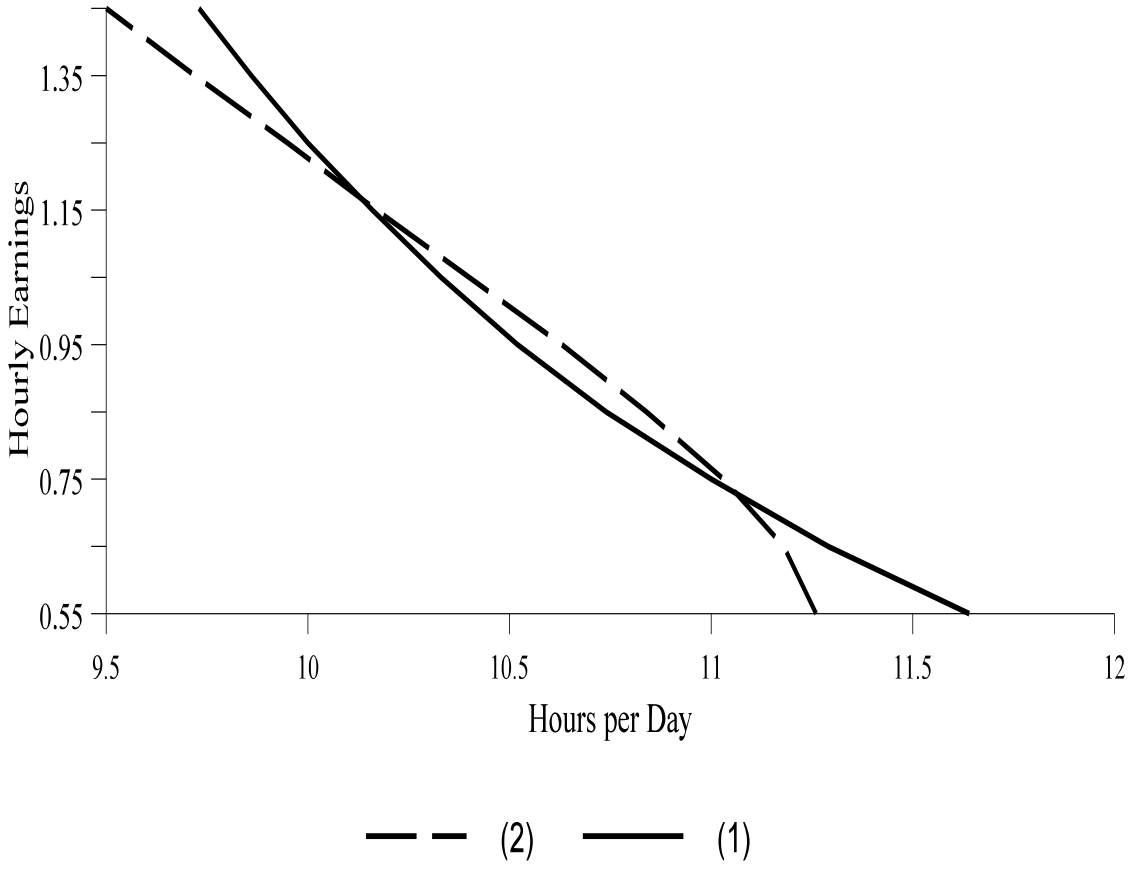
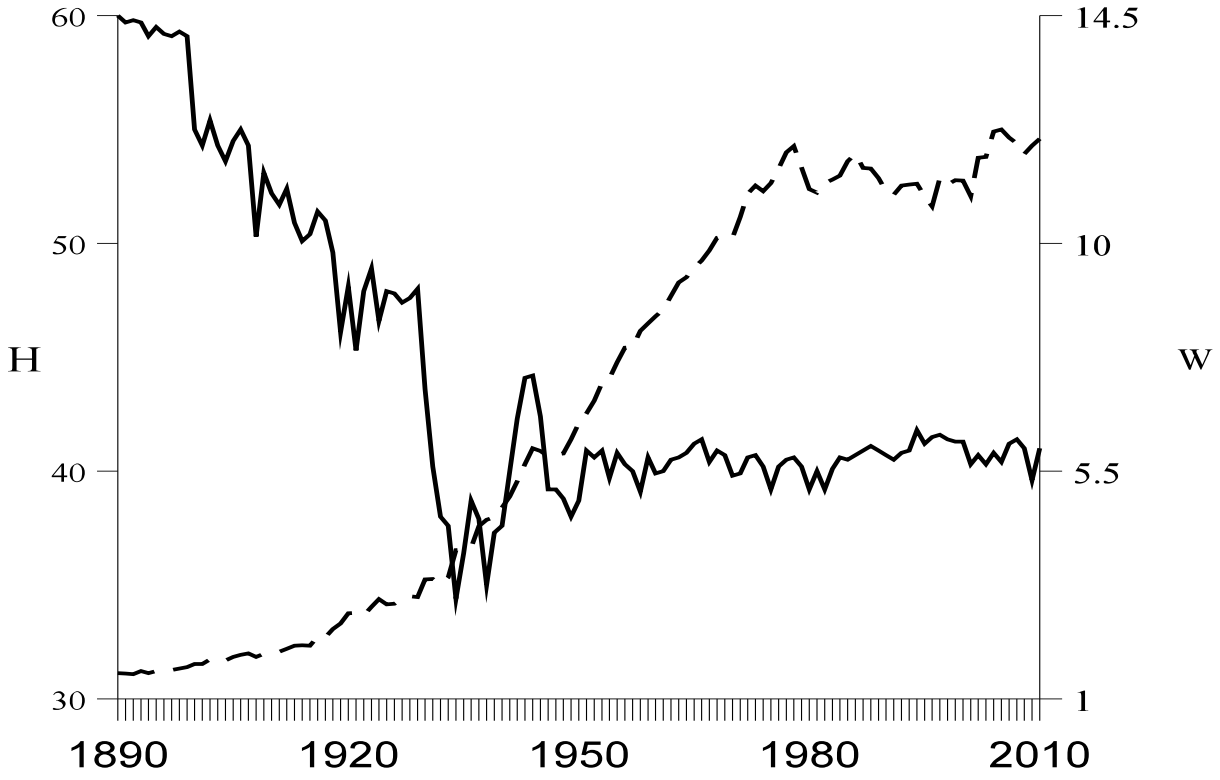


Figure 3

Weekly Hours of Work and Real Hourly Earnings 1890-2010



Weekly hours are measured on the left-hand vertical axis and drawn in the figure by the solid series. Real hourly earnings are measured on the right-hand vertical axis and drawn in the figure by the dashed series.

Figure 4

Simulations of Weekly Working Hours from Equations (1b) and (2b) :1890 -1950

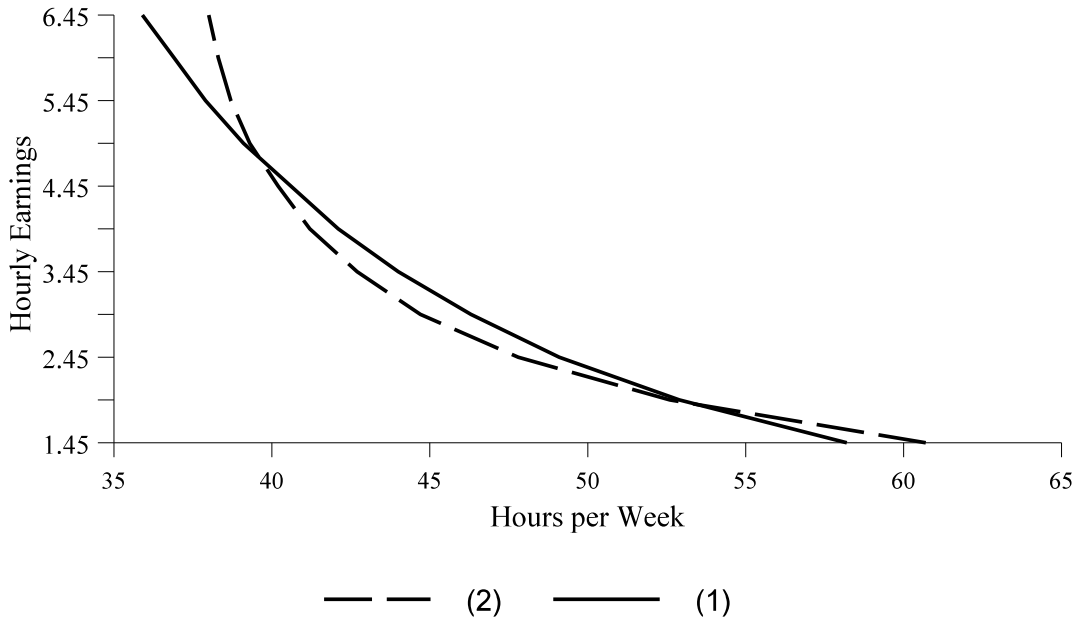


Figure 5

Simulations of Weekly Working Hours from Equations (1c) and (2c) : 1950 - 2010

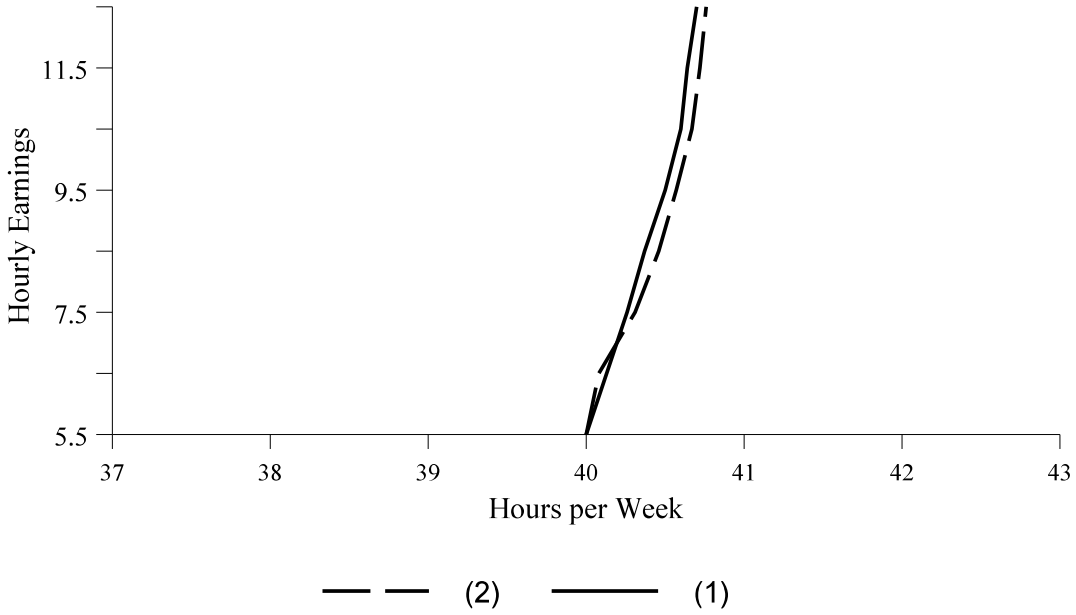


Figure 6

Simulations of Weekly Working Hours from Equations (3a) and (4a): 1830 - 2010

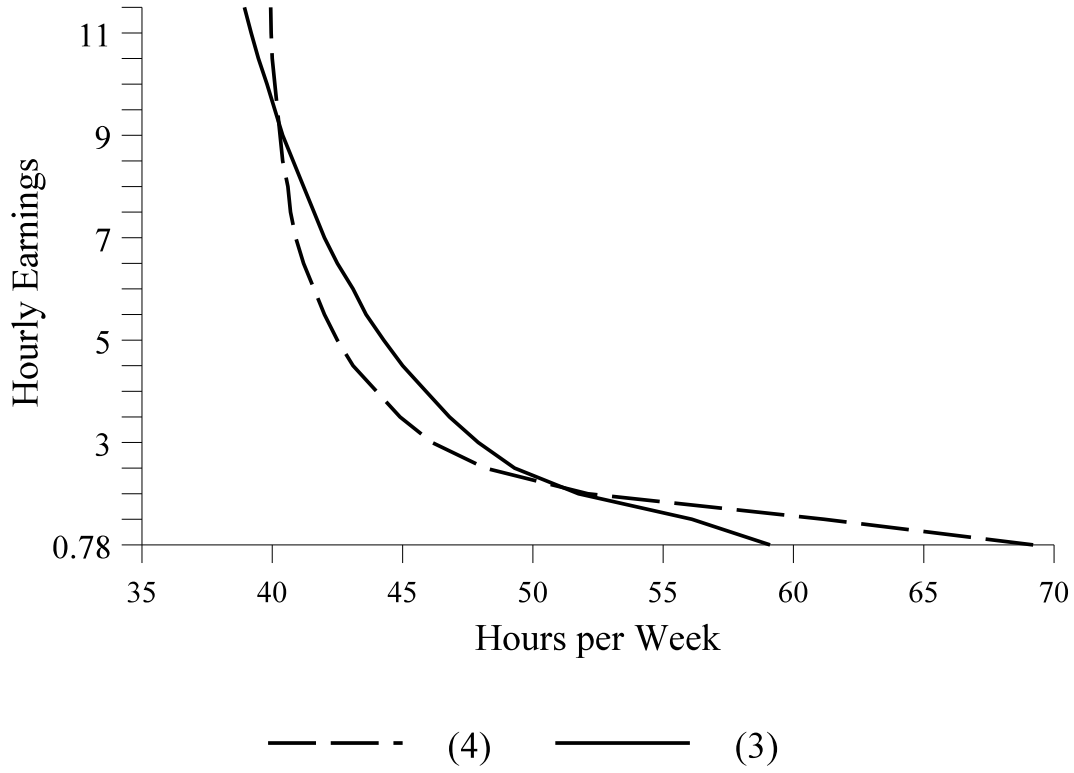
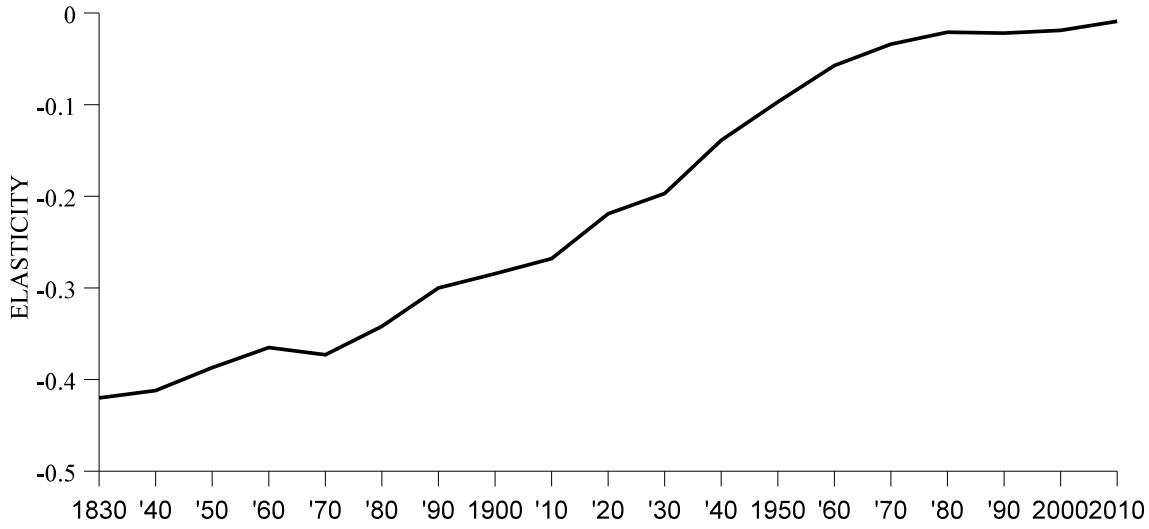


Figure 7

Elasticity of Hours with Respect to Hourly Earnings as Implied by Equation (4a)

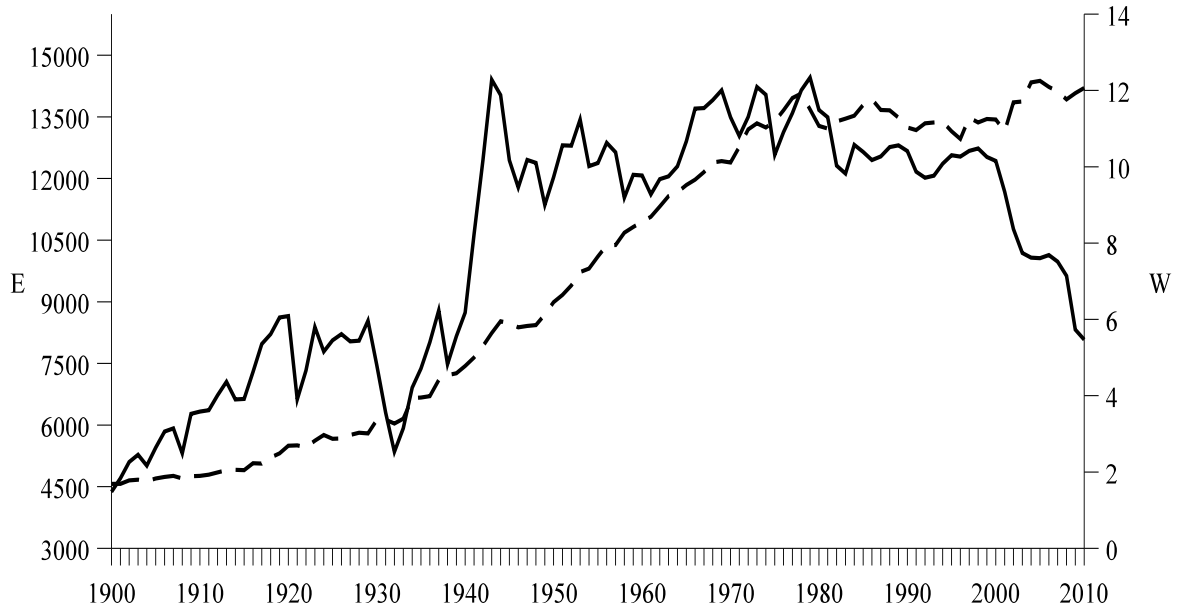
Decade by Decade from 1830 to 2010



In this figure, each year identified on the horizontal axis is associated with the value of real hourly compensation in that year. The value of the estimated elasticity is on the vertical axis.

Figure 8

Employment and Real Hourly Earnings of Production Workers in Manufacturing, 1900-2010



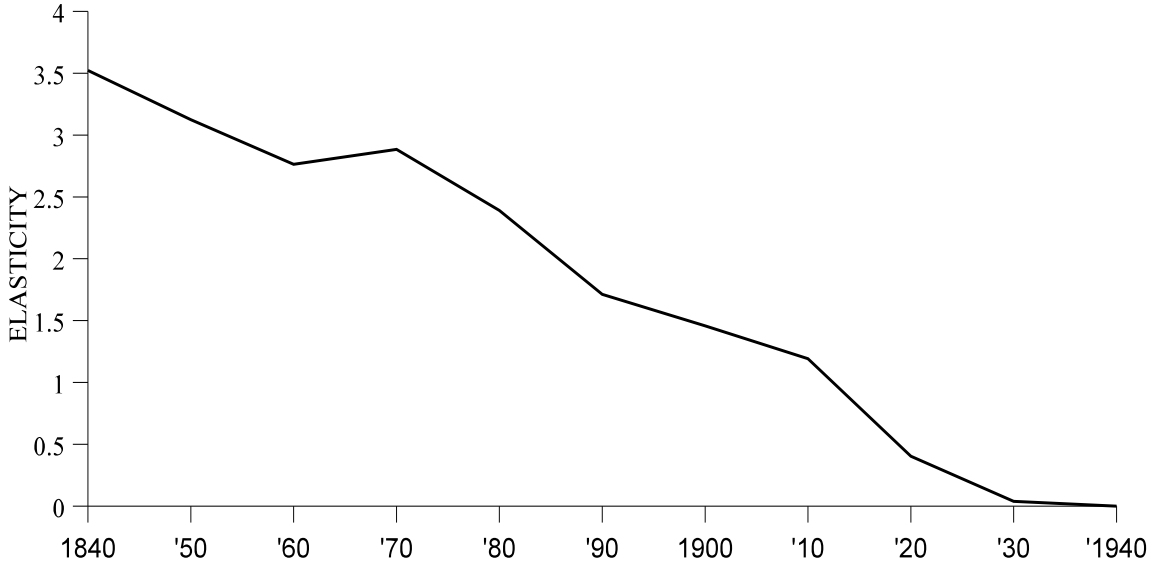
Employment (in thousands) of production workers is measured on the left-hand vertical axis and shown in the figure by the solid series and their real hourly compensation is measured on the right-hand vertical axis and shown by the dashed series.

Figure 9

Simulations of Employment from Equations (5b) and (6b) :1900 - 1940

Figure 10

Elasticity of Employment with respect to Hourly Earnings as Implied by Equation (8b) Decade by Decade from 1840 to 1940



Each year identified on the horizontal axis is associated with the value of real hourly compensation in that year. The value of the estimated elasticity is on the vertical axis.

Table 1
Descriptive Statistics on Hours of Work and Real Hourly Earnings in periods from 1830 to 2010

	Daily Hours from 1830-90 & Weekly Hours from 1890-2010			
	1830-1890	1890-1950	1950-2010	1980-2010
mean	10.66	48.18	40.57	40.74
standard dev.	0.574	7.708	0.609	0.642
minimum	9.95	34.4	39.1	39.2
25th percentile	10.11	40	40.2	40.4
median	10.59	48.1	40.6	40.8
75th percentile	11.34	54.3	40.9	41.2
maximum	11.45	60.0	41.8	41.8
N	61	61	61	31

	Real Hourly Earnings			
	1830-1890	1890-1950	1950-2010	1980-2010
mean	0.911	3.03	10.405	11.43
standard dev.	0.226	1.51	1.574	0.419
minimum	0.58	1.49	6.45	10.73
25th percentile	0.74	1.80	9.33	11.14
median	0.85	2.65	11.07	11.29
75th percentile	1.09	3.99	11.49	11.77
maximum	1.51	6.45	12.25	12.25
N	61	61	61	31

Table 2

Estimates of Hours Equations (1) and (2) fitted to observations in four periods from 1830 to 2010

		estimated coefficients on					
years	equation	constant	$ln\ (w_t)$	$[\ ln\ (w_t)\ ]^2$	X_t	R^2	*see*
1830–1890	(1a)	2.344	-0.185		0.024	0.723	0.029
		(0.004)	(0.016)		(0.006)		
	(2a)	2.353	-0.213	-0.164	0.036	0.740	0.028
		(0.006)	(0.021)	(0.087)	(0.008)		
1890-1950	(1b)	4.185	-0.324		0.531	0.868	0.061
		(0.019)	(0.017)		(0.105)		
	(2b)	4.326	-0.644	0.147	0.343	0.886	0.057
		(0.050)	(0.108)	(0.049)	(0.117)		
1950-2010	(1c)	3.651	0.022		0.038	0.167	0.014
		(0.025)	(0.011)		(0.012)		
	(2c)	3.550	0.113	-0.020	0.039	0.168	0.014
		(0.348)	(0.314)	(0.070)	(0.013)		
1980-2010	(1d)	3.873	-0.068		0.035	0.178	0.015
		(0.182)	(0.075)		(0.014)		
	(2d)	4.895	-0.905	0.171	0.035	0.179	0.015
		(12.433)	(10.185)	(2.086)	(0.015)		

Estimated standard errors are in parentheses beneath their estimated coefficients.

Table 3

Measures of Variation in Annual observations of Working Hours and Real Hourly Earnings over 60 and 30 Years

years ⇓	**Three Sixty Year Periods**			
	Working Hours		Real Hourly Compensation	
	σ / μ	QD / M	σ / μ	QD / M
1830-1890	0.054	0.058	0.248	0.206
1890-1950	0.160	0.149	0.497	0.413
1950-2010	0.015	0.009	0.151	0.132
	Six Thirty Year Periods			
	Working Hours		Real Hourly Compensation	
	σ / μ	QD / M	σ / μ	QD / M
1830-1860	0.027	0.026	0.140	0.122
1860-1890	0.014	0.011	0.208	0.128
1890-1920	0.074	0.075	0.165	0.128
1920-1950	0.109	0.117	0.305	0.338
1950-1980	0.014	0.009	0.174	0.162
1980-2010	0.016	0.010	0.037	0.028

σ / μ is the coefficient of variation of the variable in the years specified where μ is the arithmetic mean and σ is the standard deviation. QD/M is the quartile deviation divided by the median. The quartile deviation is one-half of the difference between the third quartile (the 75th percentile) and the first quartile (the 25th percentile) when ordering the values of the variable in ascending order of magnitude.

Table 4

Estimates of the Elasticity of Hours with respect to Hourly Earnings over Time

Period	Using Equation (1) Ω_1	Using Equation (2) * Ω_2	Arc Elasticity Ω_A
Fitted to Three Sixty Year Periods			
1830-1890	-0.185	-0.160	-0.152
1890-1950	-0.324	-0.357	-0.348
1950-2010	0.022	0.017	0.016
Fitted to Six Thirty Year Periods			
1830-1860	-0.096	-0.128	-0.170
1860-1890	-0.049	-0.053	-0.123
1890-1920	-0.293	-0.266	-0.391
1920-1950	-0.267	-0.293	-0.263
1950-1980	0.029	0.020	-0.066
1980-2010	-0.068	-0.076	0.521

* Equation (2)'s elasticities are evaluated at the median wage observed during the specified period.

Table 5

Estimates of Hours Equations (3) and (4) fitted to observations from 1830 to 2010

estimated coefficients on ⇓	equation (3a)	equation (4a)
constant	4.040 (0.015)	4.144 (0.018)
D_t	-1.693 (0.018)	-1.827 (0.023)
$ln(w_t)$	-0.155 (0.008)	-0.358 (0.026)
$[ln(w_t)]^2$		0.070 (0.009)
X_t	0.027 (0.013)	0.027 (0.011)
R^2	0.990	0.993
see	0.068	0.058

Estimated standard errors are in parentheses beneath their estimated coefficients. The standard error of estimate of the regression equation is given by *see* in the last row .

Table 6

Descriptive Statistics on Employment and Real Hourly Earnings1840-2010

	Employment in thousands			
	1840-1900	1900-1940	1940-1980	1980-2010
mean	2,754	6,959	12,776	11,718
standard deviation	1,910.7	1,260.4	1,132.5	1,444.8
minimum	500	4,377	8,737	8,077
25th percentile	1,200	5,918	12,032	10,189
median	2,470	7,054	12,797	12,361
75th percentile	4,390	8,061	13,908	12,669
maximum	5,896	8,791	14,458	13,667

	Real Hourly Earnings			
	1840-1900	1900-1940	1940-1980	1980-2010
mean	1.094	2.72	8.48	11.43
standard deviation	0.374	0.902	2.185	0.419
minimum	0.68	1.69	4.78	10.73
25th percentile	0.81	2.22	6.13	11.14
median	0.95	2.65	8.56	11.29
75th percentile	1.51	3.27	10.52	11.76
maximum	1.69	4.78	11.92	12.25

Table 7

Estimates of Employment Equations (5) and (6) fitted to decennial observations from 1840 to 1900 and to annual observations between 1900 and 2010

		estimated coefficients on					
years	equation	constant	$ln\ (w_t)$	$[\ ln\ (w_t)\ ]^2$	X_t	R^2	*see*
1840-1900	(5a)	7.422	2.547		-0.638	0.937	0.260
		(0.119)	(0.331)		(0.310)		
	(6a)	7.630	2.776	-1.643	-0.335	0.949	0.269
		(0.271)	(0.433)	(1.907)	(0.477)		
1900-1940	(5b)	8.466	0.379		-0.169	0.424	0.149
		(0.076)	(0.079)		(0.366)		
	(6b)	7.670	2.137	-0.881	-0.375	0.589	0.127
		(0.219)	(0.461)	(0.228)	(0.318)		
1940-1980	(5c)	6.310	1.377		0.971	0.058	1.408
		(2.111)	(0.973)		(3.342		
	(6c)	4.542	3.154	-0.437	0.833	0.058	1.426
		(15.648)	(15.614)	(3.834)	(3.598)		
1980-2010	(5d)	15.986	-2.722		0.007	0.572	0.091
		(1.138)	(0.467)		(0.089)		
	(6d)	-100.99	93.121	-19.627	0.028	0.608	0.088
		(74.22)	(60.81)	(12.451)	(0.088)		

Table 8

Estimates of the Elasticity of Employment with respect to Hourly Earnings over Time

Years	Using Equation (5)	Using Equation (6) *	Arc Elasticity
1840-1900	2.55	2.97	1.98
1900-1940	0.38	0.42	0.71
1940-1980	1.38	1.30	0.55
1980-2010	-2.72	-2.03	-5.98

* Equation (6)'s elasticities are evaluated at the median wage observed during the specified period.

Table 9

Estimates of Employment Equations (7) and (8) fitted to observations from 1840 to 2010 and from 1840 to 1940

	(7) $ln(E_t) = \kappa_7 + \rho_7 D_t + \delta\, ln(w_t) + \theta_7 X_t + u_{7t}$		(8) $ln(E_t) = \kappa_8 + \rho_8 D_t + \eta\, ln(w_t) + \mu\, [ln(w_t)]^2 + \theta_8 X_t + v_{8t}$	
equation ⇒	(7a)	(7b)	(8a)	(8b)
years ⇒	1840-2010	1840-1940	1840-2010	1840-1940
constant	8.373 (0.222)	8.288 (0.126)	8.220 (0.495)	7.454 (0.106)
D_t	-0.955 (0.431)	-0.869 (0.185)	-0.790 (0.642)	0.104 (0.138)
$ln(w_t)$	0.420 (0.117)	0.559 (0.126)	0.665 (0.713)	2.607 (0.212)
$[ln(w_t)]^2$			-0.078 (0.223)	-1.112 (0.108)
X_t	0.362 (0.553)	-0.379 (0.282)	-0.374 (0.557)	-0.428 (0.153)
R^2	0.233	0.790	0.234	0.940
see	0.847	0.261	0.850	0.142

Estimated standard errors are in parentheses beneath their estimated coefficients. The standard error of estimate of the regression equation is given by *see* in the last row . D_t is a dichotomous variable that takes the value of unity for observations in the 19th century and of zero in other years.

APPENDIX

SOURCES AND CONSTRUCTION OF OBSERVATIONS

Hours of Work

Average daily working hours from 1830 to 1890 are from Officer (2009) Table A.5, p.191-2

Average weekly hours of work from 1890 to 1899 are from Douglas (1930) Table 30, p. 116. and from 1900 to 1957 from Jones (1963) and from 1950 to 2010 from the Current Employment Statistics (CES) survey of the Bureau of Labor Statistics, U.S. Department of Labor

Employment

For the seven years 1840, 1850, 1860, 1870, 1880, 1890, and 1900 (no figure is provided for 1830), employment in manufacturing is the series "total persons engaged" in Table A-1 of Lebergott (1964). This includes employees, self-employed, and unpaid family workers. Lebergott provides a series of employees in manufacturing establishments from 1900 in TableA-5 but this is not restricted to production workers. A series on manufacturing production workers in available on the BLS web site which covers the years 1909, 1914, 1919, and then annually to 1939. For the missing years, I regressed the BLS series on production workers (call this *EBLS*) on Lebergott's employment in manufacturing observations (call this *ELEB*) for the years 1909, 1914, 1919 and 1920-38: $EBLS = 19.0605 + 0.8058$ (ELEB) with an R^2 statistic of 0.957 and, from this fitted regression, I predicted production worker employment in 1900, 1908, 1910-13, and 1915-1918. From 1939 to 2010 I used production worker employment from the Current Employment Statistics survey on the Bureau of Labor Statistics web site.

Real Average Hourly Compensation in 1982-84 Dollars

From 1830 to 2006, annual observations are from Officer (2009), Table 7.2, p.170. For the years from 2007 to 2010, I used the BLS index of employer costs for employee compensation (ECEC) for

manufacturing blue collar occupations per hour worked which takes the value of 100 in December 2005. The fourth quarter values of nominal ECEC from 2005 to 2010 are 101.8 in 2006, 103.8 in 2007, 105.9 in 2008, 107.0 in 2009 1nd 110.0 in 2010.

Officer's figure of nominal hourly compensation (on page168 of Officer (2009) in 2005 is 23.92 so, to extend his nominal series to 2010, I multiplied the ECEC figures by 0.2392 (which is 23.92/100). If we do this for 2006, we arrive at nominal compensation in 2006 of 101.8 (the ECEC figure) x 0.2392 = 24.35 which compares favourably with Officer's own figure for nominal hourly compensation in 2006 of 24.37. So multiplying the ECEC figures from 2007 to 2010 by 0.2392 yields figures of 24.83 for 2007, 25.33 for 2008, 25.59 for 2009, and 26.31 for 2010. Now convert these nominal figures to real values by using Officer and Williamson's (2020) CPI index (which has a base of 100 in 1982-84) and we arrive at real hourly compensation of 11.975 in 2007, 11.765 in 2008. Of 11.928 in 2009, and 12.065 in 2010. was inflated by the same ratio of supplementary benefits to earnings as in 2006.

Deviations from a Trend in Industrial Production, X_t

Three indices of industrial production were used. For the period from 1830 1o 1890, I used Joseph Davis' index (2004) whose base year is 1849-50 . Denoting the value of this index in year *t* by P_t and the value in year *t* of a linear trend by T_t, then the least-squares regression of P_t on T_t, and an intercept from 1830 to 1890 yields P_t = -0.82764 + 0.0975 T_t, and the residuals from this equation constituted the values of X_t for this period.

Davis' index was spliced with Miron and Romer's (1990) index (base year 1909) for the years from 1890 to 1940 and for the years from 1890 to 1940 the values of X_t are the residuals from $P_t = -0.01597 + 0.0066\ T_t$,. In 1940, Miron-Romer's index was spliced with the Federal Reserve's index of industrial production (available on the Federal Bank of St. Louis' web site - base year 2012). For the observations

from 1950 to 2010, $P_t = 0.2604 + 0.045\ T_t$.

The observations from 1830 to 2010 on daily and weekly hours of work, real hourly compensation, employment, X (deviations of production from a trend in industrial production) and the index of industrial production are below.

1830-1890	Hours per Day	Real Hourly Earnings	Employment	X	Index of Production
1830	11.33	0.64		0.968	0.238
1831	11.33	0.67		0.914	0.281
1832	11.34	0.63		0.850	0.315
1833	11.36	0.70		0.789	0.352
1834	11.37	0.63		0.676	0.336
1835	11.38	0.64		0.618	0.376
1836	11.40	0.58		0.547	0.4025
1837	11.41	0.66		0.444	0.3968
1838	11.42	0.65		0.356	0.407
1839	11.44	0.65		0.313	0.461
1840	11.43	0.68	500	0.194	0.439
1841	11.45	0.68		0.121	0.464
1842	11.45	0.81		0.037	0.477
1843	11.26	0.79		-0.007	0.531
1844	11.33	0.78		-0.041	0.5945
1845	11.41	0.78		-0.080	0.6536
1846	11.37	0.77		-0.071	0.7593
1847	11.35	0.76		-0.054	0.8739
1848	11.34	0.85		-0.077	0.9489
1849	11.32	0.85		-0.140	0.9833
1850	11.32	0.81	1,200	-0.197	1.0239
1851	11.16	0.87		-0.258	1.0605
1852	10.85	0.90		-0.188	1.2284

1853	10.81	0.91		-0.114	1.3998
1854	10.78	0.83		-0.184	1.4272
1855	10.75	0.81		-0.274	1.4344
1856	10.68	0.81		-0.312	1.4944
1857	10.67	0.82		-0.442	1.4617
1858	10.67	0.94		-0.626	1.3754
1859	10.64	0.94		-0.535	1.5639
1860	10.59	0.95	1,530	-0.618	1.5786
1861	10.39	0.95		-0.729	1.5647
1862	10.33	0.93		-0.718	1.6735
1863	10.31	0.79		-0.616	1.8731
1864	10.31	0.69		-0.580	2.0061
1865	10.28	0.71		-0.783	1.9011
1866	10.29	0.74		-0.843	1.9391
1867	10.31	0.78		-0.779	2.1005
1868	10.14	0.81		-0.768	2.2090
1869	10.15	0.85		-0.700	2.3747
1870	10.13	0.90	2.470	-0.742	2.4297
1871	10.14	0.98		-0.717	2.5529
1872	10.16	0.99		-0.610	2.7574
1873	10.17	1.03		-0.443	3.0217
1874	10.18	1.06		-0.555	3.007
1875	10.01	1.09		-0.818	2.842
1876	10.01	1.10		-0.817	2.94
1877	10.05	1.09		-0.877	2.978
1878	10.04	1.11		-0.812	3.14
1879	10.05	1.10		-0.486	3.564

1880	10.05	1.12	3,290	-0.138	4.009
1881	10.07	1.11		0.536	4.781
1882	10.08	1.14		0.753	5.095
1883	10.10	1.18		0.798	5.238
1884	10.11	1.22		0.515	5.053
1885	10.18	1.24		0.272	4.907
1886	10.05	1.30		0.772	5.505
1887	9.95	1.37		1.217	6.047
1888	9.97	1.39		1.639	6.567
1889	10.0	1.49		1.729	6.754
1890	10.02	1.51	4,390	0.062	7.810
1900	9.2**	1.69	5895*		
1830-1890	Hours per Day	Real Hourly Earnings	Employment	*X*	Index of Production

* For the employment regression from 1840-1900

**For the calculation of the correlation between employment and hours from 1840 to 1900. This 9.2 is arrived at by dividing Jones' weekly hours figure of 55.0 in 1900 by six days.

1890-1950	weekly hours	hourly earnings	employment	production	X
1890	60	1.51		0.053	0.062
1891	59.7	1.50		0.057	0.060
1892	59.8	1.49		0.060	0.056
1893	59.7	1.55		0.052	0.042
1894	59.1	1.51		0.053	0.036
1895	59.5	1.55		0.063	0.039
1896	59.2	1.58		0.058	0.028
1897	59.1	1.57		0.068	0.031
1898	59.3	1.60		0.064	0.020
1899	59.1	1.63		0.072	0.022
1900	55.0	1.69	4377	0.069	0.012
1901	54.3	1.69	4706	0.079	0.016
1902	55.4	1.78	5100	0.079	0.009
1903	54.3	1.80	5279	0.083	0.006
1904	53.6	1.76	5014	0.082	-0.001
1905	54.5	1.83	5449	0.093	0.003
1906	55.0	1.87	5842	0.093	-0.003
1907	54.3	1.90	5919	0.094	-0.009
1908	50.3	1.83	5313	0.081	-0.029
1909	53.1	1.89	6272	0.100	-0.016
1910	52.2	1.90	6327	0.099	-0.024
1911	51.7	1.93	6361	0.097	-0.032

1912	52.4	1.99	6725	0.111	-0.025
1913	50.9	2.05	7054	0.112	-0.031
1914	50.1	2.06	6624	0.104	-0.045
1915	50.4	2.05	6635	0.126	-0.03
1916	51.4	2.23	7295	0.147	-0.016
1917	51.0	2.22	7974	0.161	-0.008
1918	49.6	2.38	8212	0.157	-0.019
1919	46.1	2.49	8617	0.164	-0.018
1920	48.1	2.69	8652	0.162	-0.027
1921	45.3	2.70	6622	0.125	-0.071
1922	47.9	2.65	7327	0.166	-0.032
1923	48.9	2.82	8388	0.191	-0.018
1924	46.6	2.97	7789	0.176	-0.039
1925	47.9	2.87	8061	0.198	-0.024
1926	47.8	2.88	8214	0.207	-0.022
1927	47.4	2.97	8037	0.203	-0.032
1928	47.6	3.03	8051	0.207	-0.035
1929	48.0	3.01	8567	0.240	-0.008
1930	43.6	3.16	7464	0.206	-0.049
1931	40.2	3.37	6301	0.190	-0.072
1932	38.0	3.27	5351	0.148	-0.120
1933	37.6	3.40	5924	0.59	0.315
1934	34.4	3.94	6909	0.165	-0.116
1935	36.4	3.95	7374	0.173	-0.115

1936	38.7	3.99	8014	0.192	-0.103
1937	37.9	4.41	8791	0.221	-0.080
1938	35.0	4.54	7478	0.155	-0.153
1939	37.3	4.59	8,163	0.190	-0.125
1940	37.6	4.78	8,737	0.277	-0.044
1941	40.0	5.0	10,641	0.349	0.021
1942	42.3	5.30	12,447	0.404	0.07
1943	44.1	5.64	14,407	0.487	0.146
1944	44.2	5.95	14,031	0.523	0.175
1945	42.4	5.90	12,445	0.448	0.094
1946	39.2	5.79	11,781	0.387	0.026
1947	39.2	5.83	12,453	0.436	0.069
1948	38.8	5.85	12,383	0.454	0.08
1949	38.0	6.13	11,355	0.429	0.048
1950	38.7	6.45	12,032	0.496	0.109
	weekly hours	hourly earnings	employment	production	*X*

1950-2010	weekly hours	hourly real earnings	Employment	production	X
1950	40.6	6.45	12,032	0.496	0.190
1951	40.9	6.64	12,808	0.538	0.187
1952	40.6	6.89	12,797	0.559	0.162
1953	40.9	7.24	13,437	0.596	0.154
1954	39.7	7.33	12,300	0.572	0.084
1955	40.8	7.65	12,375	0.645	0.112
1956	40.3	7.94	12,869	0.673	0.095
1957	40.0	7.95	12,640	0.683	0.059
1958	39.1	8.27	11,532	0.638	-0.031
1959	40.6	8.42	12,089	0.715	0.003
1960	39.9	8.56	12,074	0.731	-0.029
1961	40.0	8.69	11,612	0.736	-0.07
1962	40.5	8.96	11,986	0.797	-0.054
1963	40.6	9.23	12,051	0.846	-0.05
1964	40.8	9.33	12,298	0.903	-0.039
1965	41.2	9.52	12,905	0.993	0.006
1966	41.4	9.66	13,703	1.08	0.047
1967	40.4	9.86	13,714	1.10	0.022
1968	40.9	10.11	13,908	1.16	0.036
1969	40.7	10.15	14,147	1.22	0.051
1970	39.8	10.11	13,490	1.18	-0.034
1971	39.9	10.52	13,034	1.19	-0.07

1972	40.6	10.98	13,497	1.31	0.025
1973	40.7	11.14	14,227	1.42	0.069
1974	40.2	11.03	14,040	1.41	0.014
1975	39.2	11.19	12,576	1.29	-0.152
1976	40.2	11.48	13,127	1.39	-0.097
1977	40.5	11.80	13,591	1.50	-0.032
1978	40.6	11.92	14,150	1.58	0.002
1979	40.2	11.50	14,458	1.62	-0.003
1980	39.2	11.07	13,667	1.58	-0.089
1981	40.0	11.0	13,492	1.60	-0.114
1982	39.2	11.19	12,315	1.52	=0.24
1983	40.1	11.26	12,121	1.56	-0.245
1984	40.6	11.34	12,821	1.70	-0.15
1985	40.5	11.62	12,648	1.72	-0.176
1986	40.7	11.77	12,449	1.74	-0.201
1987	40.9	11.49	12,537	1.83	-0.157
1988	41.1	11.48	12,765	1.92	-0.112
1989	40.9	11.29	12,805	1.94	-0.138
1990	40.7	11.03	12,669	1.96	-0.163
1991	40.5	10.96	12,164	1.93	-0.238
1992	40.8	11.14	12,020	1.99	-0.222
1993	40.9	11.16	12,070	2.05	-0.209
1994	41.8	11.18	12,361	2.16	-0.145
1995	41.2	10.93	12,567	2.26	-0.09

1996	41.5	10.73	12,532	2.36	-0.036
1997	41.6	11.29	12,673	2.53	0.089
1998	41.4	11.16	12,729	2.68	0.194
1999	41.3	11.25	12,524	2.80	0.268
2000	41.3	11.24	12,428	2.91	0.333
2001	40.3	10.93	11,677	2.82	0.197
2002	40.7	11.69	10,768	2.83	0.162
2003	40.3	11.71	10,189	2.87	0.156
2004	40.8	12.21	10,072	2.94	0.181
2005	40.4	12.25	10,060	3.04	0.236
2006	41.2	12.09	10,137	3.10	0.25
2007	41.4	11.975	9,975	3.19	0.295
2008	41.0	11.765	9,629	3.08	0.139
2009	39.6	11.928	8,322	2.73	-0.256
2010	41.0	12.065	8,077	2.88	-0.152
	weekly hours	real hourly earnings	Employment	production	X