

Trends in Hours:
The U.S. from 1900 to 1950 *

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ABSTRACT

During the first half of the 20th century the length of the workweek in the United States declined, and its distribution across wage deciles narrowed. The hypothesis is twofold. First, technological progress, through the rise in wages and the decreasing cost of recreation, made it possible for the average U.S. worker to afford more time off from work. Second, changes in the wage distribution explain the changes in the distribution of hours. A general equilibrium model is built to explore whether such mechanisms can quantitatively account for the observations. The model is calibrated to the U.S. economy in 1900. It predicts 82% of the observed decline in hours, and most of the contraction in their dispersion. The decline in the price of leisure goods accounts for seven percent of the total decline in hours.

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1 Introduction

Between 1900 and 1950, in the United States, the length of the workweek –the number of hours per week a worker spends on the market– declined by a third. It went down from 60 to 40 hours. This decline was not even across workers: it benefitted mostly low-wage earners who used to work the most in 1900. Thus, the distribution of hours narrowed. This paper investigates, quantitatively, the causes of these trends. The hypothesis is that (i) the rise in wages and the decline of recreation goods’ prices drove hours down; (ii) the changing distribution of wages is the reason for the contraction of the distribution of hours. The model presented below predicts 82% of the observed decline in average hours, and most of the observed contraction in their dispersion. Counterfactual experiments show that the decline in the price of leisure goods accounts for seven percent of the total decline in hours.

Figure 1 shows the trend in the length of the average workweek. It conveys two key messages. The first is that the bulk of the decline in hours took place before the second half of the twentieth century. This observation motivates the restriction to the pre-1950 period. The second message to take from Figure 1 is that the decline in hours is not merely an artifact of the changing gender composition of the labor force. More specifically, the labor market participation of married women started to rise as early as in the 1900s. Since on average women work less than men, their participation could have driven hours down. Figure 1 shows that this effect is not quantitatively important.

Figure 2 gives a disaggregated perspective on the trends in hours. It shows that the bulk of the decline was driven by workers at the bottom of the wage distribution. More precisely, low-wage earners worked the longest week in 1900, but they reduced their hours faster than high-wage earners. The result was a contraction in the distribution of hours across wage groups.^{1 2}

At this point it is important to note a feature of the data that will be useful later, in the quantitative exercise. Specifically, the relationship between hours and labor income is decreasing in the time series and in the 1900 cross section. Thus, the quantitative strategy is, in a first step, to calibrate a general equilibrium model of the distribution of hours to the 1900 cross section. Then, in a second step, to measure the respective contribution of various forces to the time series behavior of hours, both in terms of average and dispersion.

The rest of the paper is organized as follows. Section two discusses the

¹The source for Figure 2 is Costa (1998, Table 2). This finding is robust to disaggregation by gender, industry and occupation. Does the distribution of daily hours translate into a similar distribution for weekly or annual hours? Did the 1890 low-wage workers have a long day at work because of a shorter week? Costa presents evidence that this is not the case. For instance, those who reported Sunday at work were more likely to have longer hours in the 1890s. Likewise for those who reported no reduction or increase in Saturday hours. Similarly, workers with 3 months of unemployment in a year worked less per day than workers with no unemployment during the year.

²The picture is quite different in 2000, when high-wage earners are at the top of the distribution of hours. This situation has already been pointed out in the literature. See, for example, Ríos-Rull (1993) and Aguiar and Hurst (2007).

hypothesis in two stages. The first is a discussion of the main mechanisms: the rise in wages, the contraction in their dispersion and the decline in the price of recreation goods. The second stage lays out the reason why forces such as labor laws, taxes and home sector productivity are not part of the main hypothesis. Section three presents a model of the level and dispersion of hours. The quantitative analysis and the main results are presented in Section four. Section five concludes.

2 The hypothesis

2.1 Main Forces

What are the forces behind the changing level and dispersion of hours between 1900 and 1950? The hypothesis is twofold: First, technological progress, through the rise in wages and the decrease in the price of recreation goods, made it easier and more attractive for workers to spend time off from work. Second, changes in the distribution of wages explain the shifts in the distribution of hours. These mechanisms are now discussed in details.

Between 1900 and 1950 the U.S. real wage rate was multiplied by three – see Williamson (1995). The textbook analysis of labor supply suggests that this alone could be the force behind the trend in hours. But is there an alternative? In fact, one possible competing explanation comes from observing the decline in the relative price of recreation. To understand this point let us adopt the perspective of the household production literature, as pioneered by authors such as Mincer (1962) and Becker (1965). An important idea introduced in this literature is that some commodities are produced and consumed within the household, by combining time and other goods. Consider then the home production of “leisure services.” Leisure services are enjoyed, for instance, from a bicycle ride in the country, time spent reading a book, listening to the radio, exercising in a fitness club, etc... Beside time, the production of leisure services requires another input which can be purchased on the market: a “leisure good,” e.g., bicycles, books, radios, golf passes, etc... One specificity of such goods is that they are meant to use time, not to save it.

Figure 3 shows that leisure goods became cheaper and more popular throughout the twentieth century. Their price, relative to the consumer price index, decreased by 35 percent between 1900 and 1950, while their share in expenditures rose from three to six percent. Owen (1969) reports econometric evidence that, beside real wages, the price of leisure goods significantly affects leisure time. More recently, Gonzales-Chapéla (2007) estimates labor supply functions using PSID data and also finds a significant effect of the price of recreation goods on labor supply. Part of the exercise proposed in this paper is to quantify the effect of the declining price of leisure activities on hours, during the period 1900-1950.

Let us now turn to the question of the changing distribution of hours. The hypothesis, here, is that it contracted because, between 1900 and 1950, the distribution of wages contracted too. In other words, low-wage earners reduced

their hours faster because they experienced faster wage growth. Goldin and Katz (2001) present evidence that the wage distribution was narrower in 1950 than at the the end of the nineteenth century – see Table 1. The contraction of the wage distribution can be linked to the rise in education which took place throughout the twentieth century, and is illustrated in Figure 4. The conjecture is that the flow of educated workers on the market slowed down wage growth relative to uneducated workers. The measure of educational attainment in Figure 4 is the proportion of individuals with a high school degree or more, in the 25-and-older population. The reasons for this choice are the following. First, the high-school movement was a major transformation in American education and it took place during the time period studied here.³ The reason for choosing the 25-and-older as the reference population is that the level of educational attainment of the current workforce depends on that of current and past generations of workers.

2.2 Some Alternatives

Other forces could be at play in the determination of the level and distribution of hours. These forces are, for example, labor laws, unionization, taxation and home sector productivity. The paragraphs below do not attempt to dismiss these alternatives and claim that they were irrelevant. Rather, the goal is to point out the arguments suggesting that they may have been of secondary importance relative to technology. This paper is an attempt at measuring the importance of a few specific mechanisms. It does not suggest that these mechanisms were the only ones at work.

The labor movement in the U.S. emerged during the nineteenth century with one of its major demands being an eight-hour workday. So, to what extent did it affect the trends examined here? Panels A and B of Figure 5 show that the trend in hours was shared across most industrialized countries and sectors. For labor laws to have played a major role, different countries would have had to pass similar laws at the same time and in most sectors: an unlikely event. Furthermore, Tomlins (2000) indicates that many hours-related laws were passed in the late nineteenth and early twentieth century in the U.S. However, no laws constraining the hours of male workers were upheld by the courts who found them to be unconstitutional. It is also interesting to note that, besides the reduction of weekly hours, households reduced their working time along other margins. They now work fewer weeks per year – see Lebergott (1976) – and fewer years over their lifetime – see Kopecky (2005). The eight-hour movement may have had little impact at these margins.

Can unionization account for the trend in hours? Panel C shows the unionization rate. Despite a spike in the early 1920s, the noticeable movement appears to take place during the great depression. At this time, the trend in hours was

³Goldin (2006) cites three transformation of American education. The rise in elementary schooling during the nineteenth century, the high-school movement during the first half of the twentieth century, and the rise in tertiary or higher education in the second half of the twentieth century. Note that college educated workers are counted in the measure of educational attainment used here.

already well under way. Furthermore, one should note that unions are usually the vehicle through which workers can attempt to change labor laws. This channel, as mentioned above, may not have been the most important in explaining the trends in hours.

How about changes in the taxation of labor income? Panel D of Figure 5 shows that the marginal labor income tax rate changed little before the 1940s. At this time, however, significant reductions in hours already took place, as shown in Figure 1. Finally, the fact that hours of working males declined during a period when the vast majority of housework was done by women –see Figure 1– suggests that changes in the home sector productivity may have been of secondary importance.

3 The Model

3.1 Environment

The economy is inhabited by a measure one of agents alive for one period of time, and with preferences defined over a generic consumption good, c , a leisure good, g , and leisure time, ℓ . The production of the consumption good requires two types of labor: skilled and unskilled. The proportion of skilled and unskilled is endogenous. To become skilled, an agent has to purchase education at a fixed cost e , measured in units of the consumption good, which is the numéraire. If he does not, he is unskilled. The wage rates per efficiency unit of skilled and unskilled labor are denoted w_s and w_u , respectively. In addition to the consumption good sector, another sector produces the leisure good and sells it at price p . The only input in the leisure good technology is the consumption good.

Agents are ex-ante heterogenous. They are differentiated by their market ability, a , which is distributed according to the cumulative distribution function A . Assume that A is log-normal with mean μ_a and standard deviation σ_a . The interpretation of a is as follows. An agent with ability a supplies a efficiency units of labor to the market, regardless of his skill level. Hence, a skilled agent’s labor income is aw_s per hour. Similarly, an unskilled worker receives aw_u per hour of work.

3.2 Households

Preferences are represented by the following utility function:

$$U(c, g, \ell) = \left[\alpha c^\sigma + (1 - \alpha) (\mu g^\rho + (1 - \mu) \ell^\rho)^{\sigma/\rho} \right]^{1/\sigma} \quad (1)$$

where $\alpha, \mu \in (0, 1)$ and $\sigma, \rho \leq 1$. For convenience, denote the CES composite of g and ℓ by z . This composite can be interpreted as a household good, produced through the technology described by the inner CES aggregator in U . Leisure time, ℓ , and the leisure good g can then be thought of as intermediate inputs in

the production of this good. Let us call z “leisure” for the sake of exposition. (It is understood that ℓ , leisure time, is a different object than leisure itself.) The parameters σ and ρ govern elasticities of substitution. More precisely, the elasticity of substitution between g and ℓ is $1/(1 - \rho)$, while $1/(1 - \sigma)$ is the elasticity of substitution between c and z . This particular specification is chosen because it allows a non-constant recreation’s share of expenditure –see Figure 3.

Denote by $V_s(a)$ the value of an agent who decides to purchase education and by $V_u(a)$ the value of an agent who does not. The education choice is, therefore, summarized by

$$\max\{V_s(a), V_u(a)\}. \quad (2)$$

A skilled agent solves the following maximization problem:

$$V_s(a) = \max_{c,g,\ell} \{U(c, g, \ell) : c + pg + aw_s\ell + e = aw_s\} \quad (3)$$

while an unskilled solves

$$V_u(a) = \max_{c,g,\ell} \{U(c, g, \ell) : c + pg + aw_u\ell = aw_u\}. \quad (4)$$

For later reference, it is convenient to introduce some notation. Let $c_i(a)$, $g_i(a)$ and $\ell_i(a)$ be the optimal decisions of an agent with ability a and $i \in \{s, u\}$. Define also $h_i(a) = 1 - \ell_i(a)$ as the optimal labor supply. Finally, let $s_i(a) = pg_i(a)/[aw_i h_i(a)]$ be the leisure share.

Discussion The household’s problem does not have an analytical solution in general. The education decision can be understood, however, through a simplified version of the model where $\sigma = \rho = 0$, that is where the elasticities of substitution are set to one. (In addition, and to simplify the notation, let us ignore the weights α and μ .) The utility function is then $U(c, g, \ell) = \ln(c) + \ln(g) + \ln(\ell)$. In this case, one can concentrate on the role of wages, ability and the cost of education in the decision to acquire skills. One can show that the value functions are

$$\begin{aligned} V_s(a) &= 3 \ln(aw_s - e) - \ln(aw_s) - \ln(p) - 3 \ln(3), \\ V_u(a) &= 3 \ln(aw_u) - \ln(aw_u) - \ln(p) - 3 \ln(3). \end{aligned}$$

Observe that the value functions are monotone and increasing in a . Define $\underline{a} = e/w_s$ and note that

$$\begin{aligned} \lim_{a \rightarrow \infty} V_s(a) - V_u(a) &= 2 \ln \left(\frac{w_s}{w_u} \right), \\ \lim_{a \rightarrow \underline{a}^+} V_s(a) - V_u(a) &= -\infty. \end{aligned}$$

The value functions of skilled and unskilled agents are represented in Figure 6. When $w_s > w_u$, there exists $a^* \in (\underline{a}, +\infty)$ such that $V_s(a^*) = V_u(a^*)$.

Furthermore, $V_s(a) < V_u(a)$ whenever $a < a^*$ and $V_s(a) > V_u(a)$ whenever $a > a^*$. This proves the existence of a marginal agent and rationalizes the education decision. The interpretation of the first limit is that an agent with very high ability always chooses to acquire education when $w_s > w_u$. The reason is that, for such an agent, the cost of education is negligible. The interpretation of the second limit is as follows. An agent close to \underline{a} has an ability level so low that, even if he acquired skills and worked as much as possible, his income would only allow him to repay the education cost e but his consumption would be close to zero. His utility would then approach minus infinity. Hence, this agent prefers to remain unskilled.⁴

Heterogeneity serves the following purpose. Education is costly so skilled agents tend to work more in order to pay for it. This would be a counterfactual prediction, vis à vis the 1900 cross section distribution of hours. In the present specification, however, the hourly wage of a skilled worker is aw_s . Therefore, agents with large ability levels (i.e., a large) are able to afford education and work less than others at the same time. Agents with ability below, but close to, a^* will work less than educated agents with ability levels above but close to a^* . On average, however, uneducated agents will work more than educated agents. The particular form of the labor supply function is presented in Figure 7.

3.3 Firms

The consumption good sector is represented by a single firm with constant-returns-to-scale technology $F(s, u)$. The variables s and u represent inputs of skilled and unskilled labor, respectively. Let

$$F(s, u) = (z_s s^\theta + z_u u^\theta)^{1/\theta},$$

where $\theta < 1$ and $z_s, z_u > 0$. The parameter θ governs the elasticity of substitution between skilled and unskilled labor, while z_s and z_u are factor-specific technical variables. The firm's optimization problem is

$$\max_{s, u} \{F(s, u) - w_s s - w_u u\}. \quad (5)$$

At an optimum, the demands for skilled and unskilled are related by

$$\frac{z_s}{z_u} \left(\frac{s}{u}\right)^{\theta-1} = \frac{w_s}{w_u}. \quad (6)$$

Thus, whenever productivity growth is faster for skilled workers, the efficiency units of skilled labor increase faster than that of unskilled, *ceteris paribus*.

Good g is produced by the leisure good sector with the constant-returns-to-scale production function $G(x) = z_g x$, where x represents inputs of the consumption good and z_g is a productivity parameter. The optimization problem

⁴Although the argument is made for a special case of the model, it is also possible to show that the shape of the value functions are the same in the more general case where $\sigma = 0$ and $\rho < 1$.

of this sector is

$$\max_x \{pG(x) - x\}. \quad (7)$$

At an optimum, the relative price of good g is $p = 1/z_g$.

3.4 Equilibrium

In equilibrium, agents with abilities higher than a^* choose to become skilled. Agents with abilities lower than a^* remain unskilled. The determination of a^* is endogenous. Given prices $\{p, w_s, w_u\}$ and a threshold a^* , the equilibrium equations for the labor markets are

$$\int_{a^*}^{\infty} h_s(a)adA = s \quad \text{and} \quad \int_{a^*}^{\infty} h_u(a)adA = u,$$

respectively. The equilibrium condition for the leisure good market is

$$\int_{a^*}^{\infty} g_s(a)dA + \int_{a^*}^{\infty} g_u(a)dA = G(x).$$

Finally, the consumption good market is in equilibrium by Walras' law:

$$\int_{a^*}^{\infty} [c_s(a) + e]dA + \int_{a^*}^{\infty} c_u(a)dA + x = F(s, u).$$

To summarize, an equilibrium consists of (i) allocations for households, $c_s(a), g_s(a), \ell_s(a)$ and $c_u(a), g_u(a), \ell_u(a)$ for all a ; (ii) allocations for firms, s, u , and x ; (iii) prices w_s, w_u and p ; and (iv) a partition of agents between skilled and unskilled such that

1. Agents choose their education optimally given prices, or $V_s(a^*) = V_u(a^*)$;
2. The allocations $c_s(a), g_s(a), \ell_s(a)$ solve problem (3) given prices;
3. The allocations $c_u(a), g_u(a), \ell_u(a)$ solve problem (4) given prices;
4. The allocations s, u solve problem (5) given prices;
5. The allocation x solves problem (7) given prices;
6. Markets clear.

4 Quantitative Analysis

4.1 Computational Experiment

The computational experiment is a comparative static exercise. Two equilibria are computed. One corresponds to the U.S. economy in 1900 and the other to 1950. The time-invariant parameters of the model (preference and technology)

are chosen using a priori information or are calibrated to match key statistics of the 1900 U.S. economy. The time varying parameters (technological progress) are chosen to compute the second equilibrium. It is important to note that, in this exercise, the time series behavior of hours, both in level and dispersion, is left unconstrained. The mechanisms discussed in Section 2.1 are evaluated on their ability to replicate the key observations related to hours of work. The details of the experiment are discussed below.

The time-invariant parameters of the model are the preference parameters, the substitution parameter in the market technology and the distribution parameters:

$$(\alpha, \mu, \sigma, \rho, \theta, \mu_a, \sigma_a)$$

The time varying parameters are technology variables and the cost of education:

$$(z_s, z_u, z_g, e).$$

Following Caselli and Coleman (2006), set $\theta = 1.0 - 1.0/1.24$. Choose $\mu_a = \sigma_a = 1/2$. Some robustness checks are done with respect to these parameters (see Section 4.3). Finally, set the 1900 values of z_u and z_g to unity. One must choose values for the four preference parameters $\alpha, \mu, \sigma, \rho$ and the 1900 values of z_s and e .⁵ This is achieved by matching six statistics: the average level of hours, their distribution between skilled and unskilled, the skill premium, the percentage of skilled workers, the share of expenditures devoted to leisure goods, and the cost of education to GDP ratio. These statistics are computed, from the model, as described in Table 2.

In Table 2, the symbols A_s and A_u refer to the distribution of abilities, conditional on being skilled and unskilled, respectively. Assuming that there are 100 hours available for work during the week, the target for the average number of hours is computed as the ratio of hours (58 in 1900) to 100. The dispersion of hours is summarized by the ratio of hours of unskilled to skilled. The target value is taken from the data in Table 1. The skill premium is measured by the average hourly earnings of skilled workers divided by that of unskilled workers. The target value is again taken from the data in Table 1. The share of expenditures devoted to leisure is defined in Section 3.2. Its value in 1900 is three percent, as transpires from Figure 3. Finally, the total cost of education is the price of education multiplied by the mass of skilled workers. In the U.S. data, the cost of education is computed as the total expenditures of educational institutions divided by GDP.⁶ Finally, the gross domestic product, y , is the sum of expenditures on consumption, leisure goods and education.

Once the 1900 equilibrium is computed, move on to 1950. This is accomplished by letting the exogenous driving forces change. Namely, let z_g increase so that the price of leisure goods decreases as it does in the U.S. data. Let also the cost of education, e , change so that its ratio to GDP increases from one to

⁵Observe that setting $z_u = 1$ and calibrating z_s amounts to calibrating the ratio z_s/z_u which is key in the determination of the relative demand for skilled and unskilled workers.

⁶The source is the U.S. Department of Education, National Center for Education Statistics: <<http://nces.ed.gov/programs/digest/d03/tables/dt030.asp>>.

three percent, its value in the U.S. data in 1950. Finally, let z_s and z_u change so that the number of skilled workers increases to 35% and GDP is multiplied by 2.7. Both these values correspond to the actual changes observed in the U.S. economy between 1900 and 1950.⁷ The average level of hours, their dispersion, the skill premium and the share of expenditures devoted to recreation are left unconstrained. Table 3 summarizes the parameters and targets for the 1950 equilibrium. The final calibration is reported in Table 4.

4.2 Results

Table 5 presents the results of the computational experiment. The model generates a decline in hours of a magnitude comparable to that observed in the U.S. data. This decline is mostly driven by unskilled workers, as the contraction in the (model) dispersion of hours shows. This contraction in the distribution of hours, in turn, is fueled by the contraction in the distribution of labor earnings. Specifically, the fact that the earnings of unskilled workers are increasing faster than that of skilled workers implies that the former reduce their hours faster than the latter, causing the decrease in the dispersion of hours.

At this point, it is good to remember that the 1950 statistics presented in Table 5 are not targets of the calibration exercise. These results can therefore be interpreted as measures of the contribution of the exogenous technical parameters of the model. More precisely one can say that, conditional on matching the targets of Table 3, that is in particular the change in high-school achievement and GDP growth, the model generates $(44 - 58)/(41 - 58) = 82\%$ of the decline in hours between 1900 and 1950. It also generates most the contraction in the distribution of hours, as measured by the ratio of hours of unskilled to skilled. Observe also that the model predicts a sizeable increase in the share of expenditures devoted to leisure goods. This increase is of a magnitude similar to what is observed in the U.S. data: from three to 5.2 percent in the model, vis à vis three to 5.8 percent in data.

With such results in hand, one can ask what the contribution of the driving forces in the model to the trends in hours are. This question can be answered through a series of counterfactual exercises. For instance, what would have happened if the price of the leisure good did not decline, while everything else remained the same as in the baseline calibration? Similarly, what would have happened if skill-specific technical parameters, such as z_s , remained constant at their 1900 values, while other parameters changed as in the baseline calibration? Table 6 summarizes the results of such experiments. It transpires that the most important driving force behind the trends in hours is technological progress associated with skilled workers. It increases from 0.21 to 0.80 in the baseline case (see Table 4). Thus, holding it constant amounts to shutting down the source of economic growth in the model and, therefore, agents increase their work effort. At the same time the dispersion of hours decreases, that is skilled

⁷The annual growth rate of real GDP per capita is 2%. The number used for GDP growth is then $1.02^{50} = 2.7$.

agents increase their work effort more than unskilled agents. Note that the number of skilled agents hardly changes relative to the 1900 equilibrium and, since unskilled wages (per efficiency units of labor) decrease, the skill premium increases. When z_g is constant, the price of the leisure good does not decline. The change in hours becomes slightly less pronounced: a decline from 0.58 to 0.45, vis à vis 0.58 to 0.44 in the baseline case. Thus, the price of leisure goods accounts for $(45 - 44)/(58 - 44) = 7\%$ of the decline in the length of the average workweek.

On the basis of this experiment, it is fair to say that the rise in real wages is the primary cause of the reduction in the length of the workweek, and that changes in its distribution can be related to changes in the distribution of wages. The price of leisure goods is second in importance in explaining the decline in hours. Its contribution is seven percent. The reason for the limited contribution of leisure goods to the trend in hours can be attributed to their near-unity elasticity of substitution with leisure time. As discussed earlier, this elasticity is in line with the changes in the leisure share of expenditures, and is likely to remain the same under an alternative calibration exercise. If, as discussed earlier, the parameter ρ was arbitrarily set to $\rho = -1/2$ instead of its baseline value, hours would decrease by 25 percent between 1900 and 1950 – they decrease by 24 percent in the baseline calibration.

4.3 Discussion

Preferences Observe that, under the calibration presented in Table 4, preferences exhibit complementarity between consumption and leisure (the composite of leisure time and leisure good), since $\sigma < 0$. Leisure good and leisure time, however, have an elasticity of substitution close to one. Remember that, in the calibration procedure, the restrictions imposed by the 1900 dispersion of hours and earnings, as well as the recreation share of expenditures are driving this result. But which aspect of the data is critical in the determination of a given parameter? Let us start with ρ , which governs the elasticity of substitution between leisure time and leisure goods. A simple exercise to assess which moments determine ρ consists of computing the 1900 equilibrium with a value for ρ arbitrarily set to $-1/2$ (ρ is about zero in the baseline calibration) while leaving other parameters at their baseline value. Under this alternative calibration, the statistic which differs the most from its baseline value is the share of leisure expenditures. It reaches 5.6 percent as opposed to three in the baseline calibration. Thus, the low share of leisure expenditures observed in the 1900 U.S. economy is the reason for the low degree of complementarity between leisure goods and leisure time, in the calibrated model.

At this point, note that the parameter ρ is important in determining the effect of the price of leisure good on hours, in the time series. Hence, one can ask whether a different calibration procedure would yield a significantly different value for ρ . An alternative strategy is, for example, to calibrate ρ in order to replicate the time series behavior of hours given that of prices and the leisure share of expenditures. This was not the procedure chosen in this exercise, but

it is possible to build a back-of-the-envelope calculation to see how much of a difference in ρ this strategy delivers. Between 1900 and 1950, the wage rate was multiplied by three – see Williamson (1995). Write this as $w'/w = 3.0$. The price of leisure goods decreased by 35% so $p'/p = 0.65$, and hours decreased from 58 to 41 so $h'/h = 0.70$ while $\ell'/\ell = 1.40$. The share of expenditures devoted to leisure, $s = (pg)/(wh)$, was multiplied by two –from three to six percent. Given the observed change in prices and hours, the change in g must have satisfied $s'/s = 2$, which implies $g'/g = 6.3$. These figures yields an elasticity of substitution between g and ℓ of

$$\epsilon_{g,\ell} \simeq \frac{d(g/\ell)/(g/\ell)}{d(w/p)/(w/p)} = \frac{(g'/\ell' - g/\ell)/(g/\ell)}{(w'/p' - w/p)/(w/p)} = \frac{6.3/1.4 - 1}{3.0/0.65 - 1} \simeq 0.97.$$

This calculation suggests that a near-unity elasticity of substitution between leisure time and leisure goods is consistent with the time-series behavior of prices, hours and the share of leisure expenditures. This value is close to the elasticity of substitution implied by the calibrated value of ρ . Thus, it is likely that an exercise where ρ would be calibrated to the time series behavior of hours and the share of leisure expenditures would deliver a similar value.⁸ In fact, and as will become clear shortly, the model predicts a large fraction of the time series behavior of hours and the leisure share of expenditures under its baseline calibration.

The connection between the elasticity of substitution and the share of leisure expenditures can be understood as follows. Suppose that there is a “strong” degree of complementarity. As the leisure good becomes relatively cheaper the agent purchases more and, by effect of complementarity, also purchases more leisure time. In order to achieve this, however, he must increase the share of spending on the relatively more expensive good: leisure time; and decrease the share of the relatively cheaper good: the leisure good. Thus, strong complementarity is not necessarily consistent with the observed increase in the leisure share of expenditures.

Turn now to the parameter σ . Compute the 1900 equilibrium with $\sigma = 0$ as opposed to $\sigma = -1.0$ in the baseline calibration. Under this alternative calibration, the statistics which are mostly affected are the total number of hours, which increases to 86 (vis à vis 58 in the baseline), and the share of leisure expenditures, which decreases to 0.65 percent. The reason for this is that more substitution between market and household goods implies a shift of resources away from leisure time and goods. Thus, work time increases and the share of leisure expenditures decreases.⁹

⁸The calculation presented here is only an indication of what the elasticity of substitution would be, if it was calibrated to time series data. Strictly speaking, the elasticity of substitution measures the curvature along a given indifference curve. It is conceivable, however, that welfare changed between 1900 and 1950.

⁹In the same spirit, setting the cost of education to zero yields a larger fraction of educated workers (twelve percent as opposed to eleven in the baseline), and a decline in the earnings ratio between skilled and unskilled: from 2.8 in the baseline to 2.6 when $e = 0$. Finally, setting z_s to 0.4 as opposed to 0.2 implies an increase in the number of skilled workers from 11 to 20 percent.

Sensitivity In the exercise above, the mean and standard deviation of the distribution of abilities are arbitrarily set to $\mu_a = \sigma_a = 0.5$. To assess the sensitivity of the results to this choice, Table 7 reports the statistics for the 1950 equilibrium for alternative values of μ_a and σ_a . In each case the model is calibrated as described in Section 4.1. The table shows that, conditional on being calibrated to the same moments, the predictions of the model remain almost the same under alternative values for the distribution of abilities.

The post-1950 period McGrattan and Rogerson (2004) document a small decrease in hours from 1950 to 1970, and an increase between 1970 and 2000. In comparison with the changes observed and discussed earlier, the trend in the length of the workweek during the post-1950 period is negligible. In addition, the distribution of hours at the end of the twentieth century is reversed compared with its 1900 counterpart: high-wage earners work longer hours than low-wage earners. Although this aspect of the data was not investigated in this paper, one can think of the following mechanism to generate such changes. Suppose that there is a “subsistence” level of consumption, driving the income effect of wages on hours. In 1900, the low level of wages implies that the income effect is strong for low-wage earners. Hence, they work longer hours. In 2000, the importance of the income effect is much smaller because the general level of wages is high. It is then possible that a substitution effect dominates, driven by another parameter in the utility function, and pushes high-wage earners to work more. Such a mechanism would predict that the rise in wages may initially reduce average hours but eventually lead to an increase.

5 Concluding Remarks

This paper explored the trends in the length of the workweek and its dispersion across workers during the first half of the twentieth century. The hypothesis was that technological progress is the engine of such changes. Technological progress affects wages and the price of recreation goods. The model exhibits an endogenous wage dispersion, generated by the possibility for agents to purchase education. The model was calibrated to match moments of the U.S. economy in 1900. Then, conditional on replicating the increase in the proportion of skilled workers and GDP per capita, it predicts 82% of the observed decline in average hours, and most of the observed contraction in their dispersion. Counterfactual experiments show that the decline in the price of leisure goods accounts for seven percent of the total decline in hours.

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	Ratio of Hours	90-10 Earnings ratio
1890s	1.25	2.81
1950	1.18	1.85

Table 1: Summary Statistics for the Dispersion of Hours and Earnings

Source – Costa (1998, Table 2) and Hazan (2006, Figure 11) for the first column. The ratio of hours corresponds to the ratio of hours for workers in the bottom decile of the wage distribution to hours of workers in the top decile. The figures presented in the second column are derived from Goldin and Katz (2001, Table 2.1) for the 1890s. Then, using Goldin and Margo (1992, Table 1), one can derive that the wage ratio in 1950 is about 86% of what is was in 1940, which was 2.15. Hence $2.15 \times 0.86 = 1.85$.

Free parameters	$\alpha, \mu, \sigma, \rho, z_s, e$	
Moments	Model's Counterpart	1900 Target
Average level of hours	$\int_{a^*} h_s(a)dA + \int^{a^*} h_u(a)dA$	0.58
Distribution of hours	$\int^{a^*} h_u(a)dA_u / \int_{a^*} h_s(a)dA_s$	1.25
Skill premium	$\int_{a^*} aw_s dA_s / \int^{a^*} aw_u dA_u$	2.81
Proportion of skilled	$1 - A(a^*)$	0.11
Share of leisure expenditures	$\int_{a^*} s_s(a)dA + \int^{a^*} s_u(a)dA$	0.03
Cost of education to GDP	$e(1 - A(a^*))/y$	0.01

Table 2: Free parameters and targets for the 1900 equilibrium

Free parameters	z_s, z_u, z_g, e	
Moments	Model's Counterpart	Target
Price of leisure good	$1/z_g$	35% decline relative to 1900
GDP	y	2% annual increase from 1900 to 1950
Cost of education to GDP	$e(1 - A(a^*))/y$	0.03 in 1950
Proportion of skilled	$1 - A(a^*)$	0.35 in 1950

Table 3: Free parameters and targets for the 1950 equilibrium

Preferences	$\alpha = 0.86, \mu = 0.04, \sigma = -1.05, \rho = 0.00$
Technology	$\theta = 0.28$
Distribution of abilities	$\mu_a = 0.5, \sigma_a = 0.5$
1900	$z_s = 0.21, z_u = 1.0, z_g = 1.0, e = 0.18$
1950	$z_s = 0.80, z_u = 0.79, z_g = 1.53, e = 0.48$

Table 4: Baseline calibration

		1900	1950
Average hours	model	0.58	0.44
	data	0.58	0.41
Distribution of hours	model	1.25	1.17
	data	1.25	1.18
Skill premium	model	2.81	2.20
	data	2.81	1.85
Leisure share of expenditures	model	3.0%	5.2%
	data	3.0%	5.8%

Table 5: Baseline model, results

Experiment	Average hours	Distribution of hours	Skill premium	Number of skilled
Baseline model	0.44	1.17	2.20	35%
z_s constant	0.69	1.13	3.29	6%
z_u constant	0.37	1.21	2.14	30%
z_g constant	0.45	1.17	2.20	35%

Table 6: Counterfactual experiments, 1950 moments

	Hours (1950)	Distribution of hours (1950)	Skill Premium (1950)	Leisure share (1950)
Baseline model	0.44	1.17	2.20	5.2
$\sigma_a = 0.5, \mu_a = 0.6$	0.43	1.18	2.25	5.5
$\sigma_a = 0.5, \mu_a = 0.4$	0.45	1.16	2.15	5.0
$\sigma_a = 0.52, \mu_a = 0.5$	0.44	1.18	2.25	5.8
$\sigma_a = 0.48, \mu_a = 0.5$	0.44	1.17	2.15	5.0

Table 7: Sensitivity analysis

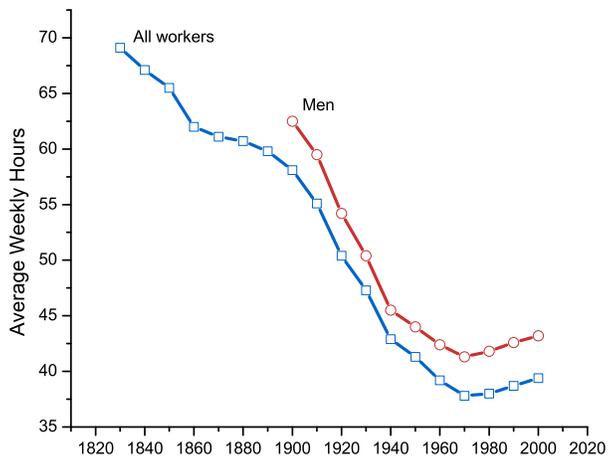


Figure 1: Average Weekly Hours Worked

Source – The data for total hours is from Whaples (1990, Table 2.1, part A) for the period 1830-1880, Kendrick (1961, Tables A-IV and A-X) for the period for 1890-1940 and McGrattan and Rogerson (2004, Table 1) for the period 1950-2000. The series are spliced together in 1890 and 1950. The source of data for male hours is Whaples (1990, Table 2.1, part B) for the period 1900-1950 and McGrattan and Rogerson (2004, Table 2) for 1950-2000.

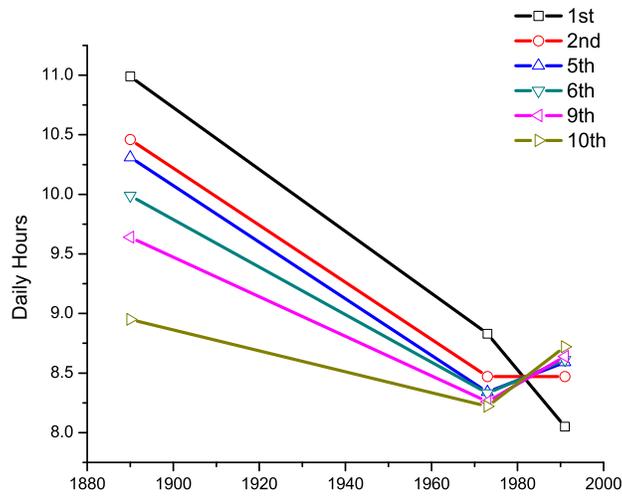


Figure 2: Daily Hours per Wage Decile

Source – Costa (1998, Table 2). The data includes all workers in all sectors and at all occupations. Costa shows that if one disaggregates by sex or occupation or industry, the general pattern remains: There has been a contraction in the distribution of hours per wage decile.

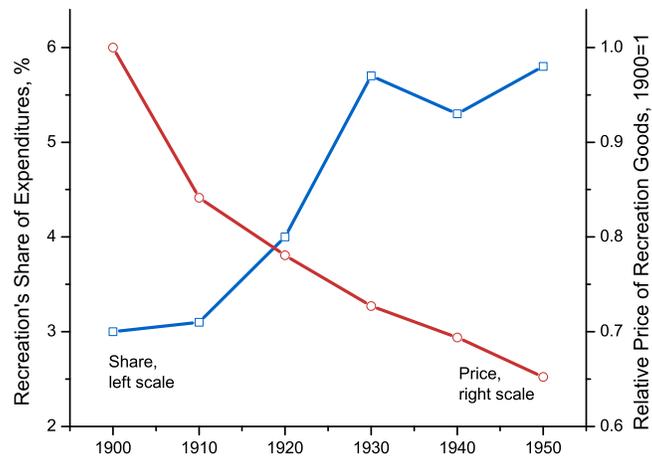


Figure 3: Relative Price of Leisure Goods and Recreation's Share of Expenditures U.S., 1900-2000.

Source – The data for the price of leisure goods is from Kopecky (2005); for the recreation's share of expenditures for the years 1900 to 1929: Lebergott (1996, Table A.1). After 1929 the data is taken from the Statistical Abstract of the United States.

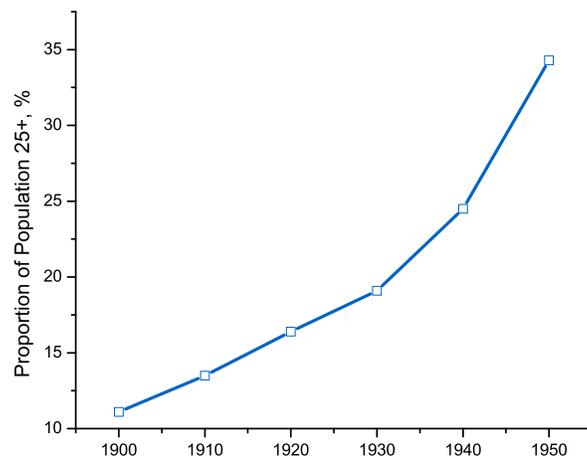
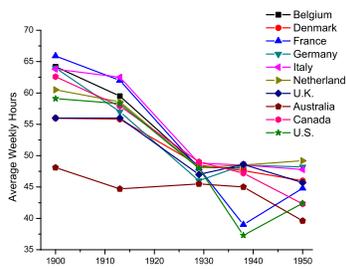
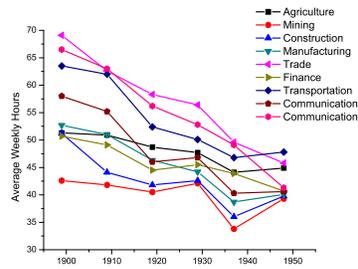


Figure 4: Percentage of Persons 25 and Over with at Least a High-School Degree

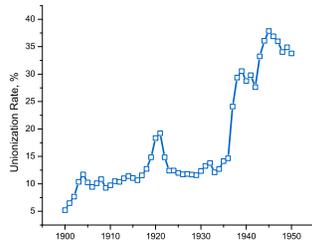
Source – Digest of Education Statistics.



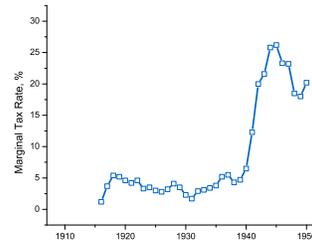
- A -



- B -



- C -



- D -

Figure 5: Hours by Sectors and Countries, the Unionization Rate and the Marginal Tax Rate

Source – Kendrick (1961, Table A IX), Huberman and Minns (2007, Table 1), Barro and Sahasakul (1986, Table 2) and Historical Statistics, series D940, D948 and D127.

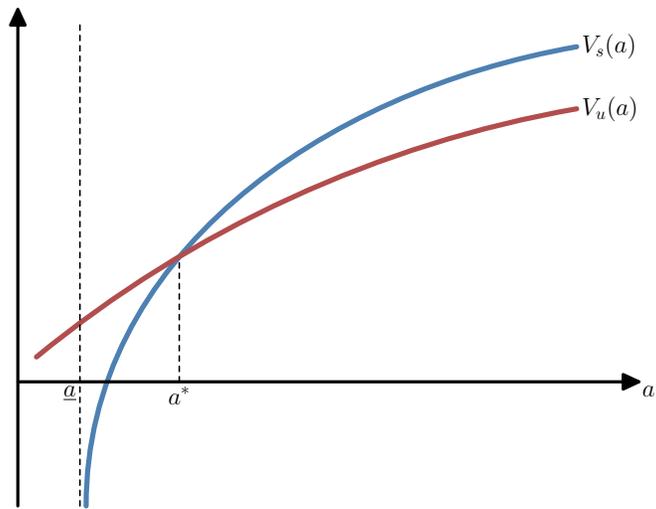


Figure 6: Value Functions of Skilled and Unskilled when $w_s > w_u$

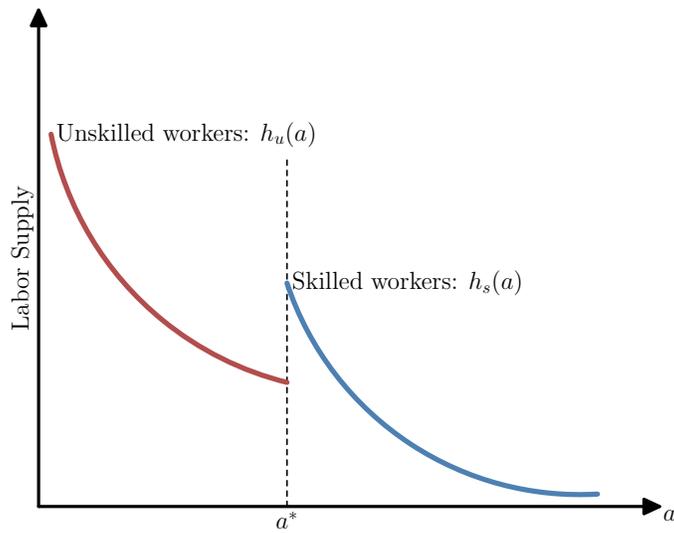


Figure 7: Labor Supply