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# 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 U.S. 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 7% of the total decline in hours.



## 1. Introduction

Between 1900 and 1950, in the U.S., 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 h. 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 7% of the total decline in hours.

Fig. 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 20th century. This observation motivates the restriction to the pre-1950 period. The second message to be taken from Fig. 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. Fig. 1 shows that this effect is not quantitatively important.

Fig. 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

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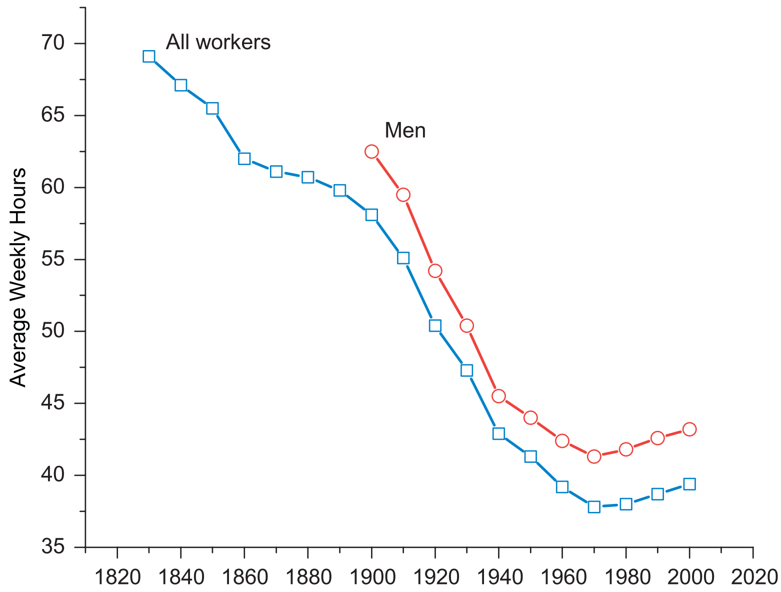


**Fig. 1.** Average weekly hours worked – *Notes*: The data for total hours is from Whaples (1990, Table 2.1, part A), for the period 1830–1880, Kendrick (1961, Tables A-IV and A-X) for the period for 1890–1940 and McGrattan and Rogerson (2004, Table 1) for the period 1950–2000. The series are spliced 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.

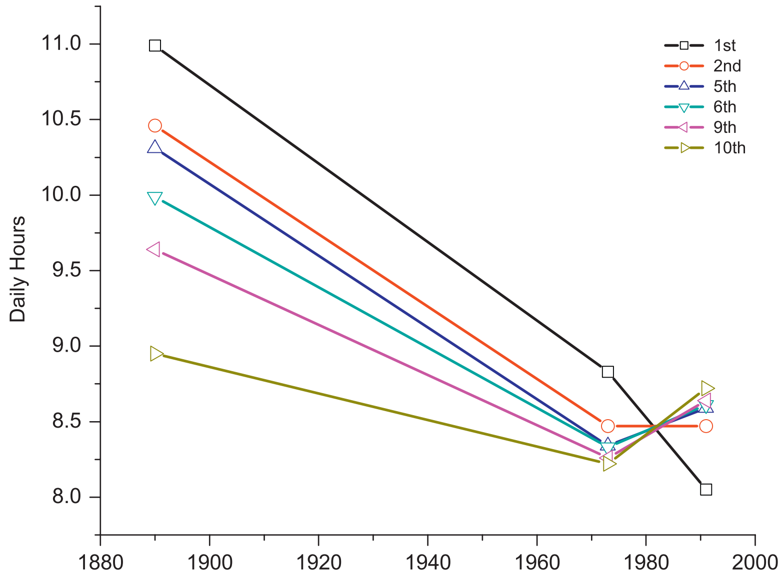


**Fig. 2.** Daily hours per wage decile.

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

[1] The source for Fig. 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 where 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.

[2] The 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).

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 2 discusses the 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 3 presents a model of the level and dispersion of hours. The quantitative analysis and the main results are presented in Section 4. Section 5 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.

Fig. 3 shows that leisure goods became cheaper and more popular throughout the 20th century. Their prices, relative to the consumer price index, decreased by 35% between 1900 and 1950, while their share in expenditures rose from 3% to 6%. 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 end of the 19th century – see Table 1. The contraction of the wage distribution can be linked to the rise in education which took place throughout the 20th century, and is illustrated in Fig. 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 Fig. 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] Second, 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 19th 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 Fig. 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)

[3] Goldin (2006) cites three transformations of American education. The rise in elementary schooling during the 19th century, the high-school movement during the first half of the 20th century, and the rise in tertiary or higher education in the second half of the 20th century. Note that college educated workers are counted in the measure of educational attainment used here.

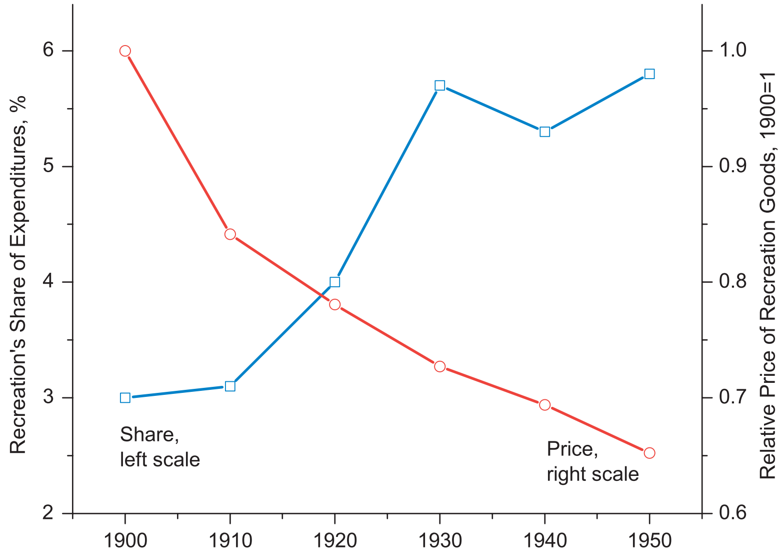


**Fig. 3.** Relative price of leisure goods and recreation's share of expenditures – *Notes*: The data for the price of leisure goods is from Kopecky (2005); for the recreation's share of expenditures for the years 1900–1929: Lebergott (1996, Table A.1). After 1929 the data is taken from the Statistical Abstract of the U.S.

**Table 1**
Summary statistics for the dispersion of hours and earnings

| | Ratio of hours | 90–10 earnings ratio |
|---|---|---|
| 1890s | 1.25 | 2.81 |
| 1950 | 1.18 | 1.85 |

*Notes*: The source of data is Costa (1998, Table 2) and Hazan (2006, Fig. 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 $2.15 \times 0.86 = 1.85$.

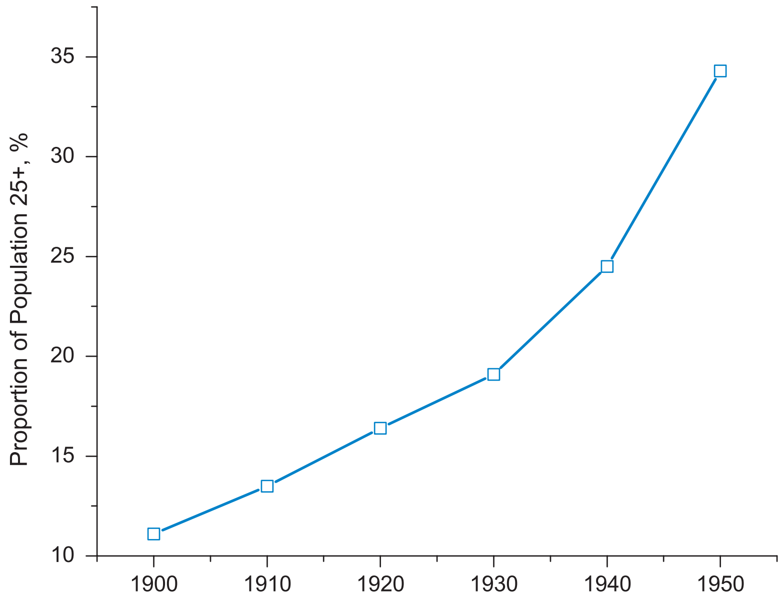


**Fig. 4.** Percentage of persons 25 and over with at least a high-school degree – *Notes*: The source of data is the digest of education statistics.

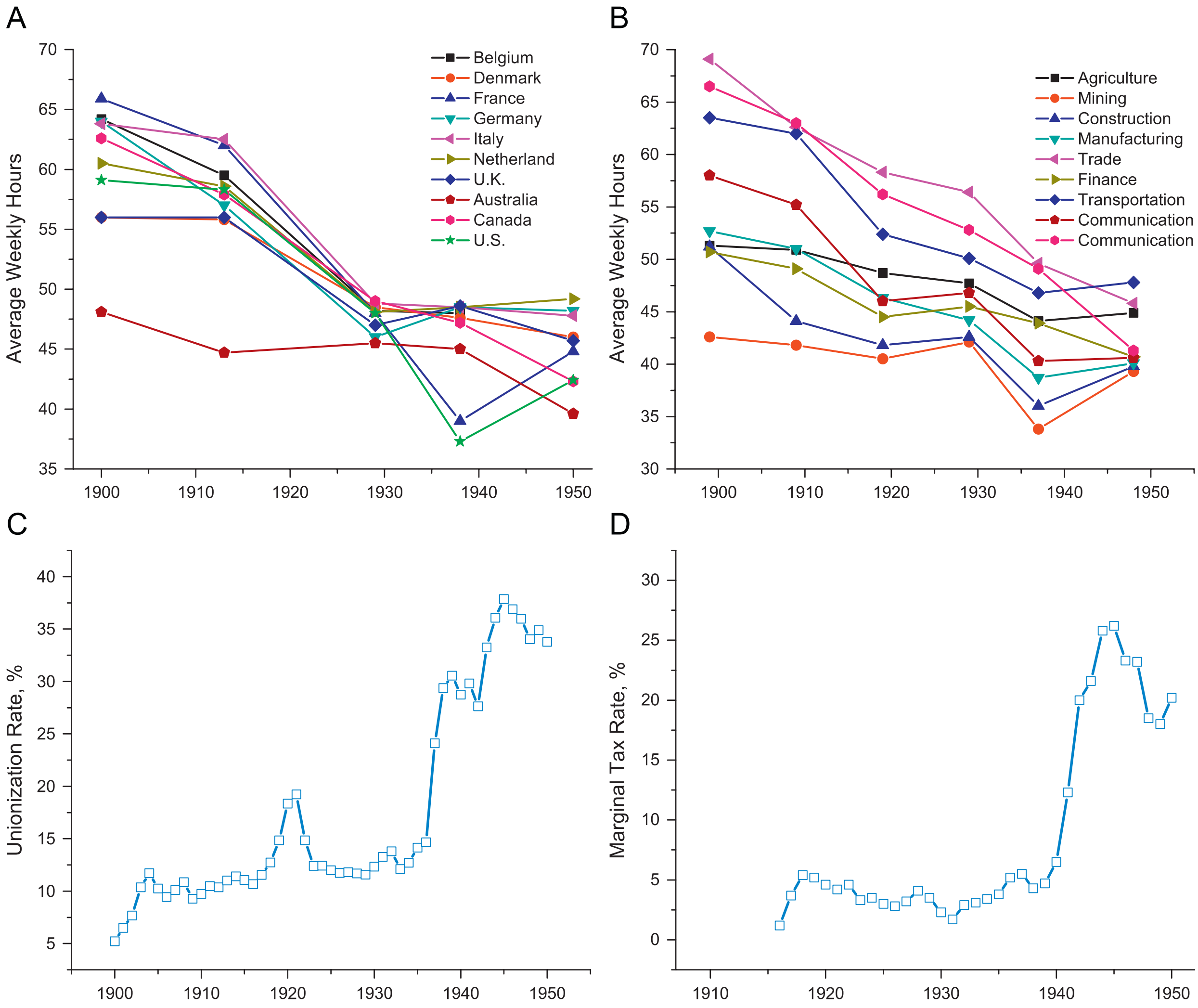


**Fig. 5.** Hours by sectors and countries, the unionization rate and the marginal tax rate – *Notes*: The source of data is Kendrick (1961, Table A IX), Huberman and Minns (2007, Table 1), Barro and Sahasakul (1986, Table 2) and Historical Statistics, Series D940, D948 and D127.

indicates that many hours-related laws were passed in the late 19th and early 20th 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 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 Fig. 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 Fig. 1. Finally, the fact that hours of working males declined during a period when the vast majority of housework was done by women – see Fig. 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, $\ell$. 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 goods sector, another sector produces the leisure good and sells it at price $p$. The only input in the leisure goods 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 $\mu_a$ and standard deviation $\sigma_a$. 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:

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

where $\alpha, \mu \in (0,1)$ and $\sigma, \rho \leqslant 1$. For convenience, denote the CES composite of $g$ and $\ell$ 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, $\ell$, and the leisure goods $g$ can then be thought of as intermediate inputs in the production of these goods. Let us call $z$ 'leisure' for the sake of exposition. (It is understood that $\ell$, leisure time, is a different object than leisure itself.) The parameters $\sigma$ and $\rho$ govern elasticities of substitution. More precisely, the elasticity of substitution between $g$ and $\ell$ 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 Fig. 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

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

A skilled agent solves the following maximization problem:

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

while an unskilled solves

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

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 $s_i(a) = pg_i(a)/[aw_ih_i(a)]$ be the leisure share.

#### 3.2.1. 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 $\alpha$ and $\mu$.) 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

$$V_s(a) = 3\ln(aw_s - e) - \ln(aw_s) - \ln(p) - 3\ln(3),$$

$$V_u(a) = 3\ln(aw_u) - \ln(aw_u) - \ln(p) - 3\ln(3).$$

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

$$\lim_{a\to\infty} V_s(a) - V_u(a) = 2\ln\left(\frac{w_s}{w_u}\right),$$

$$\lim_{a\to\underline{a}^+} V_s(a) - V_u(a) = -\infty.$$

The value functions of skilled and unskilled agents are represented in Fig. 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

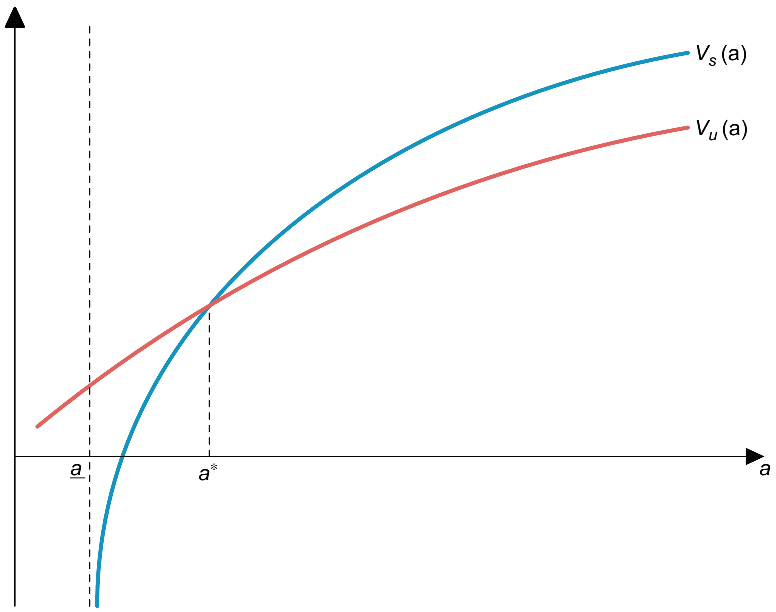


**Fig. 6.** Value functions of skilled and unskilled when $w_s > w_u$.

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 Fig. 7.

### 3.3. Firms

The consumption goods 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 $\theta$ 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

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

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

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

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

$$\max_{x}\{pG(x) - x\}. \tag{7}$$

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

[4] Although 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 $\rho < 1$.

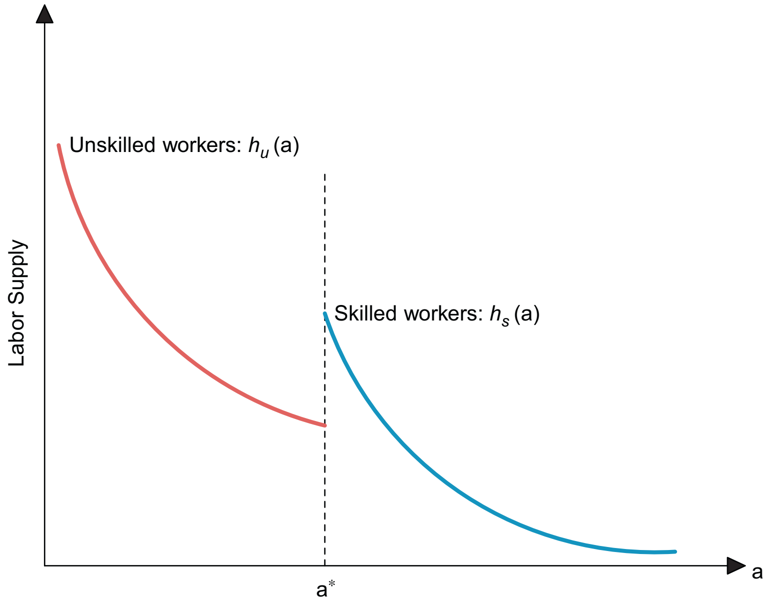


**Fig. 7.** Labor supply.

### 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

$$\int_{a^*} h_s(a) a \, dA = s \quad \text{and} \quad \int^{a^*} h_u(a) a \, dA = u, \tag{8}$$

respectively. The equilibrium condition for the leisure goods market is

$$\int_{a^*} g_s(a) \, dA + \int^{a^*} g_u(a) \, dA = G(x). \tag{9}$$

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

$$\int_{a^*} [c_s(a) + e] \, dA + \int^{a^*} c_u(a) \, dA + x = F(s, u). \tag{10}$$

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

(i) Agents choose their education optimally given prices, or $V_s(a^*) = V_u(a^*)$,
(ii) The allocations $c_s(a), g_s(a), \ell_s(a)$ solve problem (3) given prices,
(iii) The allocations $c_u(a), g_u(a), \ell_u(a)$ solve problem (4) given prices,
(iv) The allocations $s, u$ solve problem (5) given prices,
(v) The allocation $x$ solves problem (7) given prices,
(vi) 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 (preferences 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

**Table 2**
Free parameters and targets for the 1900 equilibrium

| Free parameters<br>Moments | $\alpha, \mu, \sigma, \rho, z_s, e$<br>Model's counterpart | 1900 target |
|---|---|---|
| Average level of hours | $\int_{a^*} h_s(a)\,\mathrm{d}A + \int^{a^*} h_u(a)\,\mathrm{d}A$ | 0.58 |
| Distribution of hours | $\int^{a^*} h_u(a)\,\mathrm{d}A_u / \int_{a^*} h_s(a)\,\mathrm{d}A_s$ | 1.25 |
| Skill premium | $\int_{a^*} aw_s\,\mathrm{d}A_s / \int^{a^*} aw_u\,\mathrm{d}A_u$ | 2.81 |
| Proportion of skilled | $1 - A(a^*)$ | 0.11 |
| Share of leisure expenditures | $\int_{a^*} s_s(a)\,\mathrm{d}A + \int^{a^*} s_u(a)\,\mathrm{d}A$ | 0.03 |
| Cost of education to GDP | $e(1 - A(a^*))/y$ | 0.01 |

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), let $\theta = 1.0 - 1.0/1.24$. Choose $\mu_a = \sigma_a = \frac{1}{2}$. 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 3%, as transpires from Fig. 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 1% to 3%, 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

[5] Observe 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.

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

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

**Table 3**
Free parameters and targets for the 1950 equilibrium

| Free parameters | $z_s, z_u, z_g, e$ | |
|---|---|---|
| Moments | Model's counterpart | Target |
| Price of leisure goods | $1/z_g$ | 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 4**
Baseline calibration

| | |
|---|---|
| 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 5**
Baseline model, results

| | 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 |

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 3% to 5.2% in the model, vis à vis 3% to 5.8% 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 goods 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 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 goods 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

**Table 6**
Counterfactual experiments, 1950 moments

| 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 |

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 7%. 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. These results are likely to remain the same under an alternative calibration exercise. If, for example, the parameter $\rho$ was arbitrarily set to $\rho=-\frac{1}{2}$ instead of its baseline value, hours would decrease by 25% between 1900 and 1950 – they decrease by 24% in the baseline calibration.

## 4.3. Discussion

### 4.3.1. Preferences

Observe that, under the calibration presented in Table 4, preferences exhibit complementarity between consumption and leisure (the composite of leisure time and leisure goods), since $\sigma<0$. Leisure goods 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 $\rho$, which governs the elasticity of substitution between leisure time and leisure goods. A simple exercise to assess which moments determine $\rho$ consists of computing the 1900 equilibrium with a value for $\rho$ arbitrarily set to $-\frac{1}{2}$ ($\rho$ 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% as opposed to 3% 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 $\rho$ is important in determining the effect of the price of leisure goods on hours, in the time series. Hence, one can ask whether a different calibration procedure would yield a significantly different value for $\rho$. An alternative strategy is, for example, to calibrate $\rho$ 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 $\rho$ 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 3% to 6%. 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 $\ell$ of

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

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 $\rho$. Thus, it is likely that an exercise where $\rho$ 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

[8] The 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.

**Table 7**
Sensitivity analysis

| | 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 |

agent purchases more and, by effect of complementarity, also purchases more leisure time. In order to achieve this, however, he must increase his share of spending on the relatively more expensive good: leisure time; and decrease his 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 $\sigma$. 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%. 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]

### 4.3.2. *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 $\mu_a$ and $\sigma_a$. 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.

### 4.3.3. *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 20th 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 20th 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 7% of the total decline in hours.

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[9] In the same spirit, setting the cost of education to zero yields a larger fraction of educated workers (12% as opposed to 11 in the baseline), and a decline in the earnings ratio between skilled an 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%.

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