The Journal of Mathematical Sociology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmas20

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Version of record first published: 31 Aug 2012

To cite this article: MICAEL EHN (2012): Temporal Discounting Leads to Social Stratification, The Journal of Mathematical Sociology, 36:4, 245-255

To link to this article: http://dx.doi.org/10.1080/0022250X.2011.597015

Journal of Mathematical Sociology, 36: 245–255, 2012

ISSN: 0022-250X print/1545-5874 online
DOI: 10.1080/0022250X.2011.597015

Routledge
Taylor & Francis Group

TEMPORAL DISCOUNTING LEADS TO SOCIAL STRATIFICATION

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Social stratification is present in all modern societies. Do income differences simply reflect inherited differences in individual abilities and resources? If not, why does not everyone choose strategies that lead to high income? This article shows that the psychological phenomenon known as temporal discounting will lead to differences in educational attainment and social stratification in any society where the demand for workers with a higher level of education is higher than for those with a lower level. The model is used to predict income differences between people with and without college education in seven developed countries, based only on official statistics of the cost and length of college education. The model explains 93% of the variance, strongly suggesting that temporal discounting is a major factor behind income differences.

Keywords: educational attainment, game theory, stratification

1. INTRODUCTION

1.1. Temporal Discounting

It is well known that people discount future payoffs in decisions regarding money, items, and health (Thaler, 1981; Benzion, Rapoport, & Yagil, 1989; Chapman & Elstein, 1995; Pender, 1996). Discounting future payoffs means that lower immediate payoffs, such as getting a job instead of an education, become more attractive than higher future payoffs, such as first getting an education and then a better paying job. The studies show that discount rates may be as high as 50% per year (Thaler, 1981) or as low as 10% (Benzion et al., 1989), depending on individual preferences and circumstances. Larger sums tend to result in lower discount rates.

Research on income and education clearly shows that a higher level of education yields a higher income. For the individual, this difference is large enough to make education a very good investment (e.g., Miller, 1960; Griliches, 1997). Differences between average income in different countries also correlates well with the level of education (O'Neill, 1995).

Previous research on temporal discounting has mostly focused on what impact it has on the individual level. This article will show that temporal discounting also

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has effects on the level of educational attainment in society and therefore social stratification due to different choices in education.

1.2. Social Stratification

Social stratification, in the sense of persistently unequal distribution of income between different groups in society, is not only present in all modern societies but also has existed for a long time. Evidence from burials suggest that marked differences between social classes emerged at least four to five thousand years ago and unequal shares of commonly produced goods have likely been common long before that (Gilman, 1981; Childe, 1958; Gimbutas, 1965). Many explanations have been offered as to why this stratification exists. For instance, functionalist explanations (e.g., Sahlins, 1972; Cohen & Service, 1978) suggest that a ruling class emerges because of the need for organization in society. For example, they might act as redistributors of goods produced by specialists, facilitate construction of irrigation systems or other costly constructions that benefit society, or as military leaders. This view has been criticized (Gilman, 1981) for lacking empirical evidence. Gilman (1981) suggests that many resources that generate long-term utility, such as dams, irrigation systems, large boats, and plantages with olive trees or vines, were constructed by workers without supervision from a ruler. Rulers rather usurped control over these resources, and archaeological evidence supports that such control was often inherited (e.g., Shennan, 1975). This, however, does not fully explain stratification in modern societies, where knowledge is valuable and education is comparably cheap and commonly available.

Sørensen (1977) modeled income inequalities due to different levels of attainment by use of a fixed pyramid structure, where individuals could only move up to a higher level once there was a vacant position. The pyramid structure implies that there are always several individuals competing for each higher level vacancy. Economic theory would then predict that individuals will choose to educate themselves in order to increase their prospects of advancing in the social structure whenever they stand to gain something from it. This would result in an equilibrium where educating oneself first or going to work straight away has the same expected lifetime monetary income, which of course is not compatible with what we can observe in modern societies. Breen and Goldthorpe (1997) also studied a model with a fixed structure of income. In their model, educational choice influences which class of professions, and therefore income class, an individual will belong to. Individuals are allowed to choose freely whether to educate themselves or start working in this model. In order to achieve differentiation, individual differences are assumed in the valuation of a higher ranked profession, expectations of one's own abilities, and available resources. To achieve income differentials without assuming a limited number of positions or individual differences while at the same time allowing individuals to maximize their payoff on a market driven by supply and demand, we need to relax the assumption of perfect rationality. One of the most studied, yet simplest, psychological mechanisms that limit human rationality is temporal discounting, which I argue may be a crucial missing piece.

This article will present a model that endogenously predicts social stratification under the assumption that education takes time, that humans use temporal discounting when making decisions and that employers prefer workers with a high level of

education. A comparison of the model with available empirical data on education and income in different countries will show that these simple assumptions suffice to explain a large part of the variation in income between groups with different levels of education.

2. MODEL

The model presented in this article assumes a population where agents are divided into three subgroups: *low income* (prior to education), *in education*, and *high income* (posteducation), denoted by L, E, and H. The payoff for agents in the high group will be dependent on the proportion of agents in the high group, q_H, and a benefit b, which is how much the society values educated workers. The length of the education is the delay of the high income and denoted by d. The education may also be associated with a *cost* c for the agent. Being in the low group will result in a small, positive payoff, which can be set to 1 without loss of generality. Thus, if we denote the payoff of an agent in group x by w_x, we have:

$$w_H = (1 - q_H)b \tag{1}$$

$$w_E = -c \tag{2}$$

$$w_L = 1. \tag{3}$$

Importantly, w_H measures the society's stratification in terms of how much an educated worker earns compared to an uneducated worker.

Next, we describe how agents in the model decide whether to educate themselves or not. This part of the model is similar to the model presented by Breen and Goldthorpe (1997), but with the simplifying assumption that education is always successful and always leads to the individual being part of the high income group. I assume that agents compare the sums of expected future payoffs for the two options while assuming a remaining lifetime of t years and applying a discount factor of $R = 1 + \delta$ for every year. In other words, immediate payoffs are valued R^n times higher than the same payoff n years in the future. (Costs are not discounted in this model. Costs are incurred early in the lifetime and discounting them would not make much of a difference except making the equations more complicated. Also, empirical studies show that discount rate for future costs is lower than that for gains [Loewenstein, 1988; Benzion et al., 1989].) Since agents choose between educating themselves and staying in the low group, only the payoffs for these two groups have to be evaluated.

Summed future payoffs are denoted by w_x^f, where x is the group:

$$w_E^f = \sum_{n=d}^{t} \frac{w_H}{R^n} - cd = w_H \left(\frac{R^{1-d} - R^{-t}}{\delta} \right) - cd, \tag{4}$$

$$w_L^f = \sum_{n=0}^{t} \frac{1}{R^n} = \frac{R - R^{-t}}{\delta}. \tag{5}$$

Assuming agents evaluate perceived payoffs to decide whether to move from the low group to the education group, we find the equilibrium by solving the indifference equation $w_E^f = w_L^f$ for w_H. Solving for w_H yields

$$w_H = (1 - q_H)b = \frac{R - R^{-t} + cd\delta}{R^{1-d} - R^{-t}}. \tag{6}$$

By our definition, social stratification occurs whenever $w_H > 1$. In equilibrium, this inequality is equivalent to

$$R + cd\delta > R^{1-d}, \tag{7}$$

which is satisfied whenever $\delta > 0$ and $d > 0$. Thus, we can expect social stratification to appear endogenously whenever agents discount payoffs from education.

In Figures 1 to 4 we can see how the equilibrium value of w_H is affected by each parameter. By assuming a value for b we can also predict the proportion of the population that is in the high group. All graphs have been plotted with $b = 3$, $\delta = 0.1$, $d = 4$, $c = 0.2$, and $t = 45$; however, the qualitative results holds for any combination of parameters within the range for which they are defined. We can see that the level of social stratification increases exponentially with the two parameters that influence how much the payoff from education is discounted: the discount rate and the length of the education. The cost of education, on the other hand, has a linear relationship with the level of social stratification. This means that in a society where individuals apply a high discount to future payoffs, a goal of increasing the proportion of the population with a high level of education (which is the same as lowering the level of social stratification) might be more effectively achieved through lowering the discount rate than through the intuitive solution of lowering the cost of education. Finally, for all

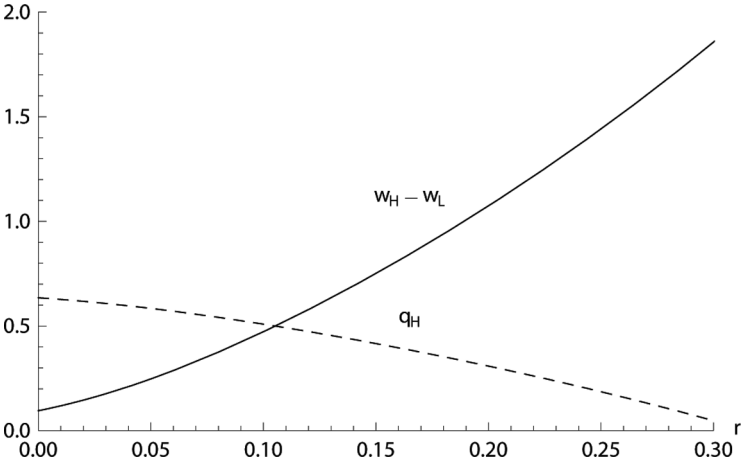

FIGURE 1 Increasing the discount rate has an exponential effect on the difference in income between the high and low group.

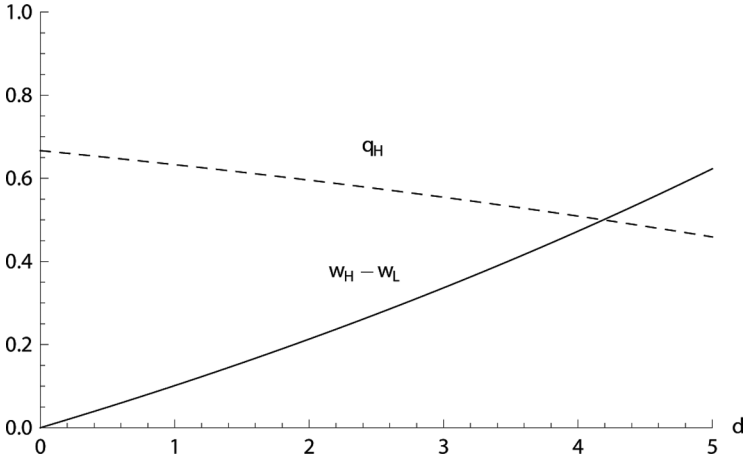

FIGURE 2 Social stratification increases exponentially with the length of education required to be a part of the high group.

realistic retirement ages, say over 40, the number of years left to work after education has only a very small influence on social stratification.

2.1. Variation in Discount Rate Within Populations

The variation in discount rate between individuals has been found to be very high and can vary between groups in society, depending on socioeconomic status (e.g., Benzion et al., 1989; Pender, 1996). The motivation for choosing further education instead of work varies, and students often claim to have other motivations than monetary rewards (Pintrich & Schunk, 1996), effectively having a discount rate of 0. Thus, the assumption of a population with no variance in discount rate might

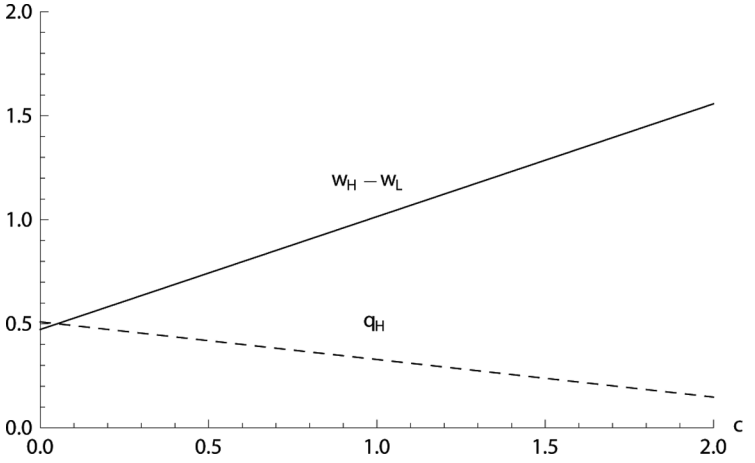

FIGURE 3 Social stratification increases linearly with increased cost of education.

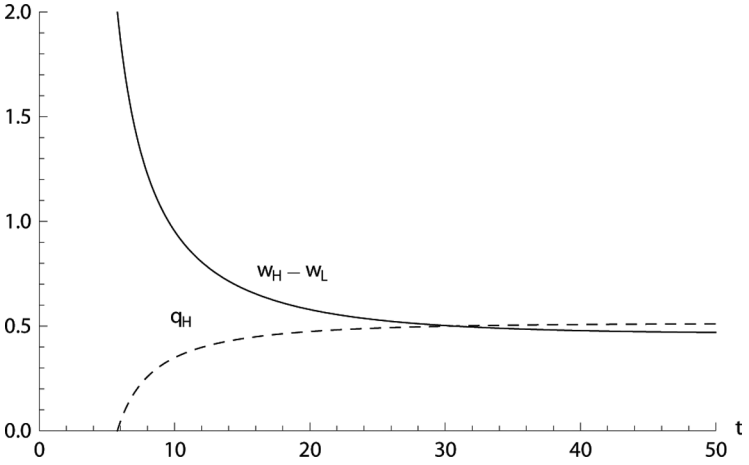

FIGURE 4 Social stratification will increase if the number of years left to work after education are few. When set to a realistic value, t has very little impact on the result.

seem unrealistic. The model, however, would not be influenced by assuming individual variation in discount rates as long as there is a large enough proportion with discount rate δ. Assume that the proportion of the population with discount rate lower than x is given by $g(x)$ and that $\hat{q}_H$ is the proportion of the population with the higher level of education at equilibrium. At equilibrium, individuals with discount rate δ are indifferent to choosing education or work, individuals with discount rate $< \delta$ prefer to educate themselves, and individuals with discount rate $> \delta$ prefer to start work immediately. The equilibrium found in the model without individual variation in discount rates then remains intact if

$$g(\delta) \geq \hat{q}_H \tag{8}$$

$$g(\delta - \epsilon) < \hat{q}_H, \tag{9}$$

where ε is some small, positive number. Thus, introducing individuals with a lower discount rate would decrease the average level of education of individuals with discount rate δ to compensate. Conversely, introducing a group with a higher discount rate would increase the average level of education for individuals with discount rate δ. The average level of education in the entire population and the social stratification between the high and low group would remain unchanged if these new individuals are not very numerous. Further study of this would require incorporation of dynamics, which is outside the scope of this article.

3. MODEL VALIDATION

I test the predictions from the model using published statistics on the cost (c), length of education (d), and differences in income according to level of education (w_H), from seven different countries. As described below, the countries were selected

on the basis of whether all necessary data were available, either from official institutes in each country or from official international sources such as the Organisation for Economic Co-operation and Development (OECD).

The model predicts income differences between different levels of education. We assume the decision on whether to work or to continue education relates to the tertiary level. Most countries have bachelor's and master's degrees or similar (3–6 years of university level education), so the high income group will consist of the individuals that finished one of these educations (honor's degrees were also included where applicable).

To calculate the *social stratification* parameter (w_H) for each country, we compare the income of people with upper secondary, but no tertiary, education with those who hold a bachelor's or master's degree:

$$w_H := \frac{\text{Average income with a tertiary degree}}{\text{Average income with upper secondary education}}. \tag{10}$$

When data on income for the latter group were not available from the national statistics institutes, the category "Tertiary-type A and advanced research programmes" from OECD (2007) was used instead.

The cost (c) for tertiary education must be normalized relative to w_L:

$$c = \frac{\text{Cost of tertiary education}}{\text{Average income with upper secondary education}}. \tag{11}$$

The retirement age is roughly 45 years after secondary education in all countries. We therefore assume a constant *working lifetime* of $t = 45$; as discussed earlier, results are quite insensitive to this parameter.

To find the average *length of higher education* (d) in each country, the typical lengths of the bachelor and masters degrees (and honors where applicable) were weighted with the number each degree according to official statistics:

$$\begin{aligned} d = {} & \text{Length of bachelor} \cdot \text{Proportion of bachelors} \\ & + \text{Length of master} \cdot \text{Proportion of masters}. \end{aligned} \tag{12}$$

This parameter proved to be the bottleneck in data collection. Although Education at a Glance (OECD, 2007) contains data for a large number of countries, it reports the length of education only as a range (e.g., 54% of first-time tertiary graduates in the United States attended a program of "between 3 and 5 years"). As the length of education has a significant impact on the results, this sort of statistic is not of sufficiently high resolution for our purposes. Instead, data on length of education were gathered from official statistics from each country, and so far I have been able to locate the necessary information for seven countries: Canada, Denmark, Finland, Israel, New Zealand, Sweden, and the United States. Table 1 shows all the parameter values for each country.

Assuming societies are close to equilibrium, the model presented in this article predicts the social stratification in a country from the other parameters. Of course, there is no official data available on the discount factor of individuals for this type

TABLE 1 Model Parameters for Seven Countries According to Official Statistics

Country	w_H	c	t	d
Canada	1.68[a]	0.12[a]	45	4.45[b]
Denmark	1.42[c]	0.00[a]	45	4.06[c]
Finland	1.71[a]	0.00[a]	45	4.96[d]
Israel	1.69[a]	0.19[a]	45	4.56[e]
New Zealand	1.44[a]	0.08[a]	45	3.41[f]
Sweden	1.38[g]	0.00[a]	45	3.42[h]
United States	1.77[i]	0.30[a]	45	4.54[i]

[a]Education at a Glance (2007).
[b]Statistics Canada (2007).
[c]Statistics Denmark (2008).
[d]Statistics Finland (2007).
[e]Central Bureau of Statistics, Israel (2004).
[f]Statistics New Zealand (2006).
[g]Statistics Sweden (2008).
[h]Statistics Sweden (2007).
[i]U.S. Census Bureau (2007).

of decision. However, there is no obvious reason why individuals' discounting would differ between developed countries. Assuming it to be constant across the seven countries, in our study we can estimate it using the method of least squares. To this end, we set up a regression model of the social stratification in a given country as

$$w_{H,i} := f(\delta, d_i, c_i, t_i) + e_i, \tag{13}$$

where i is the index for the country, e_i is the error term, and

$$f(\delta, d, c, t) := \frac{R - R^{-t} + cd\delta}{R^{1-d} - R^{-t}} \tag{14}$$

according to the equilibrium of our mathematical model. The method of least squares gives $\delta = 0.104$, and the proportion of variance explained by the model is $r^2 = 0.93$. The results are shown in Table 2 and Figure 5.

Further, the model can also be used to predict differences between different levels of education within a country. Two of the countries included in the previous

TABLE 2 Comparison Between Actual and Predicted Differences in Income

Country	Actual w_H	Predicted w_H	e_i
Canada	1.68	1.64	0.04
Denmark	1.42	1.50	−0.08
Finland	1.71	1.65	0.06
Israel	1.69	1.71	−0.02
New Zealand	1.44	1.45	−0.01
Sweden	1.38	1.41	−0.03
United States	1.77	1.78	−0.01

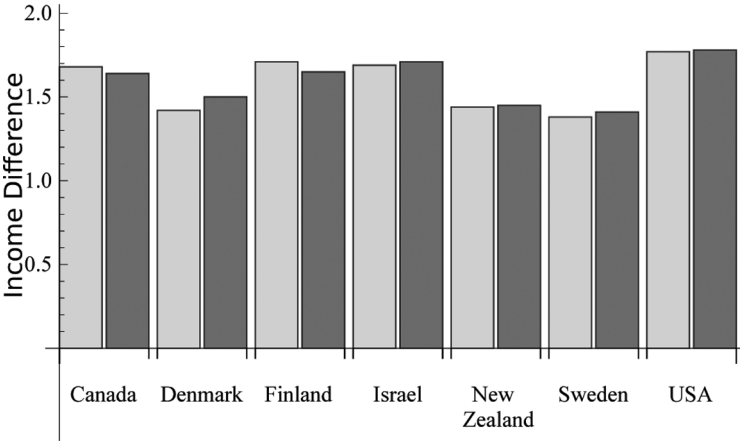

FIGURE 5 Differences in income according to education in some countries, actual and predicted values.

TABLE 3 Comparison Between Actual and Predicted Differences in Income

Education level	Actual w_H	Predicted w_H	e_i
Denmark medium	1.39	1.41	−0.02
Denmark long	1.56	1.72	−0.16
U.S. Associate	1.25	1.29	−0.04
U.S. Bachelor	1.66	1.65	0.01
U.S. Master	2.08	2.11	−0.03

comparison publish all the needed parameters for different education levels: Denmark and the United States. Using the same discount rate as for the comparison between countries, we obtain the results shown in Table 3. We can see that the difference between actual and predicted values is small even when comparing different lengths of tertiary education within countries. The largest deviation is in the Danish long cycle, where the model predicts about 10% higher income than what we can observe in the data.

4. DISCUSSION

I have presented a model showing that even absent any differences between individuals, social stratification in terms of monetary income will appear endogenously as soon as individuals value future payoffs lower than immediate payoffs. Previous models (Sørensen, 1977; Breen & Goldthorpe, 1997) have assumed individual differences or fixed structures with limited positions to achieve similar results. It is shown that due to a psychological mechanism, education generates economic rent, which, as argued by Sørensen (1996, is the basis of social stratification and the position of individuals in the social structure.

The simplicity of the model yields several benefits. First, it shows that many assumptions of previous models are not required to explain income differentials from

educational attainment. Second, since the model has a simple, analytical solution, it provides a good basis for future research. All the interactions in the model have been investigated and can be expressed with mathematical formulas. It is easy to see how results from changed assumptions or the introduction of dynamics differ from the basic model.

Inequality in resources can lead to differences in educational attainment and is often used as an assumption of models of social mobility (Breen & Jonsson, 2005). However, inequality in resources has a much lower impact in countries without tuition fees and even less so in countries where the government provides financial support to all students. The model presented in this article is fitted to available statistics and found to make highly accurate predictions of education-based income differences in seven developed countries, some of which have no tuition fees and financial support for students. This suggests that temporal discounting is a major cause for social stratification in diverse countries and that the large variation in individual discount rates (Thaler, 1981) could possibly explain some of the class differences in educational attainment, especially in countries where education is free.

The value of the discount rate parameter that best fitted the data was 10.4%, which is consistent with earlier findings (Benzion et al., 1989).[1] The model also quite accurately predicts differences in income according to level of tertiary education.

Furthermore, the model yields predictions on the extent to which the proportion of educated workers can be influenced by policy. One policy measure is to lower the cost of education, which according to this model has a linear influence on the level of education in the population. In contrast, there is an exponential dependence on the discount rate. If it is possible to lower the discount rate of individuals through policy measures (e.g., by providing more information about the benefit of studies and how large the difference in income is over a longer period of time), this might therefore be a more powerful way to go.

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[1]As discussed in the Introduction, results on discounting rates have varied between 10% and 50% across previous studies of temporal discounting. Thus, a discount rate of 10.4% is in the lower end. This seems plausible in the given context, considering the positive connotations of education and that the decision is about a large sum of money, which has been shown to lower the discount rate.

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