Why Social Stratification is to be Expected
Working Paper

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Abstract

Social stratification is present in all modern societies and humans have developed systems where individuals can greatly improve their lot through strategies such as education. Thus social stratification in modern societies presents us with a dilemma: why don't people with low income simply change their strategies to mimic the high earners?

This paper uses a mathematical model with minimal assumptions that show how social stratification might evolve from education when people are equal and discount their future payoffs. The model is shown to fit well with statistical data on income and education in several countries, suggesting that the kind of social stratification that we observe is to be expected to appear endogenously, whether or not individuals have equal chances. Furthermore, the results yield concrete suggestions on how to increase the proportion of educated people in society.

1 Introduction

Social stratification has existed for a long time and is present in all modern societies. Evidence from burials suggest that marked differences between social classes emerged at least four to five thousand years ago ([Gilman, 1981], [Childe, 1958], [Gimbutas, 1965]). Unequal shares of commonly produced goods have likely been common long before that.

Many researchers have offered explanations as to why this stratification exists. Functionalist explanations (eg. [Sahlins, 1972] and [Cohen and Service, 1978]) suggest that the ruler class emerges because of a need in society for some kind

of organization. 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 act like military leaders. This view has been criticized [Gilman, 1981] for lacking empirical evidence. Gilman suggest that many resources that generate long term utility such as dams, irrigation systems, large boats, plantages with olive trees or vines are constructed by the workers without supervision from a ruler. Instead the rulers occur as protectors of these resources and as such often receive control over them.

It is also common to assume that access to resources, such as land, and other valuables is inherited. This is supported by archaeological evidence [Shennan, 1975]. This however, does not fully explain stratification in modern societies where knowledge is very valuable and education is fairly cheap and commonly available.

Other explanations include individual differences and genetic or cultural group selection. In a recent paper [Henrich and Boyd, 2008] it is suggested that with limited possibility of moving between groups, but with frequent interaction between groups in a complementarity game, social stratification might evolve. Basically it would be a way of solving the coordination problem.

There are of course a large number of ways to become wealthy, so several of these explanations might be correct. Today many people inherit a fortune, there are also movie and rock stars that become very wealthy because of their talent and some win the lottery. Perhaps the most common way to make more money today is to get an education. Economic theory would then predict that individuals will choose to educate themselves whenever they stand to gain something from it. This would result in an equilibrium where getting an education 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.

1.1 Temporal Discounting

It is well known that people discount future payoffs in decisions regarding money, items and health ([Thaler, 1981], [Benzion et al., 1989], [Chapman and 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 high 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 situation. This paper will show how education

can lead to social stratification because individuals discount future payoffs.

2 Model

The model presented in this paper consists of a repeated game where there are three different strategies, *high, low* and *education*, denoted H, L and E. The high and low strategies correspond to the different levels of education that an individual can have. The payoff for the high strategy will be dependent on the proportion of other high players, q_H, and a benefit b, which is how much the society values educated workers. d is the *delay*, or length of the education. This is the amount of time a player have to spend in education to be allowed to use the high paying strategy and the length of one round in the game. Players have to pay a *cost* c, which can be zero, for their education. Playing the low strategy will result in a small, positive payoff. Payoffs are denoted w_x where x is the strategy.

$$\begin{aligned} w_H &= (1 - q_H)b \\ w_E &= -c \\ w_L &= 1 \end{aligned}$$

Thus, w_H predicts how much an educated worker earns, compared to an uneducated, i.e. it measures the society's stratification. When players decide whether to educate themselves or not they sum their expected future payoffs and compare the strategies. When performing this calculation they assume a lifetime of l years, or time units, and apply a discount r for every round, or d time units, so that

$$r = (1 + \delta)^d - 1,$$

where δ is the yearly discount rate. Thereby, they value immediate payoffs higher than those far in the future. For notational simplicity $R = 1 + r$ and $t = \frac{l}{d}$ will be used in the equations. Costs are not discounted, they are incurred early in the lifetime and discounting them would not make much of a difference, but would make the equations more complicated. There is evidence [Loewenstein, 1988] and [Benzion et al., 1989] of discounting costs, but in this model the qualitative results will not be affected by including that possibility. Also, the report show that discount rate for future costs is lower than that for gains. Since players only choose between educating themselves or keep on playing the low strategy, only those two strategies have to be evaluated. Summed future payoffs are denoted w_x^f, where x is the strategy.

$$w_E^f = \sum_{n=1}^{t} \frac{(1 - q_H)b}{R^n} - c$$

$$w_L^f = \sum_{n=0}^{t} \frac{1}{R^n}$$

In the dynamic system, players die with probability $\frac{1}{t}$, resulting in an expected lifetime of l time units. Dead players are replaced with new low players.

$$\begin{aligned} \dot{q_H} &= q_E - \frac{1}{t} q_H \\ \dot{q_E} &= q_L(w_E^f - w_L^f) - q_E - \frac{1}{t} q_E \end{aligned}$$

Since $w_H = (1 - q_H)b$, we just have to solve for b, which has an unique solution, to find the equilibrium for w_H.

$$\begin{aligned} w_H &= \frac{q_H\,(1 + cr)}{(1 - R^{-t})\,(q_H + t(q_H - 1))} \\ &- \frac{q_H r}{t\,(1 - R^{-t})\,(q_H + t(q_H - 1))} \\ &+ \frac{t(q_H - 1)(R + cr)}{(1 - R^{-t})\,(q_H + t(q_H - 1))} \\ &- \frac{R^{-t}}{(1 - R^{-t})} \end{aligned}$$

Since the death rate is very low, we can eliminate that part of the dynamic system, but still let the individuals evaluate their payoff using the expected lifetime. This gives us an approximation of the results, with a much simpler expression.

$$\begin{aligned} \dot{q_H}^{approx} &= q_E \\ \dot{q_E}^{approx} &= q_L(w_E^f - w_L^f) - q_E \end{aligned}$$

Since there is no death rate in this equation, q_E have to be 0 at equilibrium, therefore we just have to solve $w_E^f = w_L^f$ for w_H which yields

$$w_H^{approx} = \frac{R - R^{-t} + cr}{1 - R^{-t}}.$$

Another benefit from the approximation is that w_H^{approx} is not dependent on b or q_H.

3 Analysis

In figure 1 we can see how the equilibrium value of w_H is affected by each parameter.

- Retirement age has very little impact on the results when it is fairly high.
- The income for educated individuals increase exponentially with the length of their education.
- Cost of education has a linear effect on income for educated individuals.
- The discount rate has an exponential effect

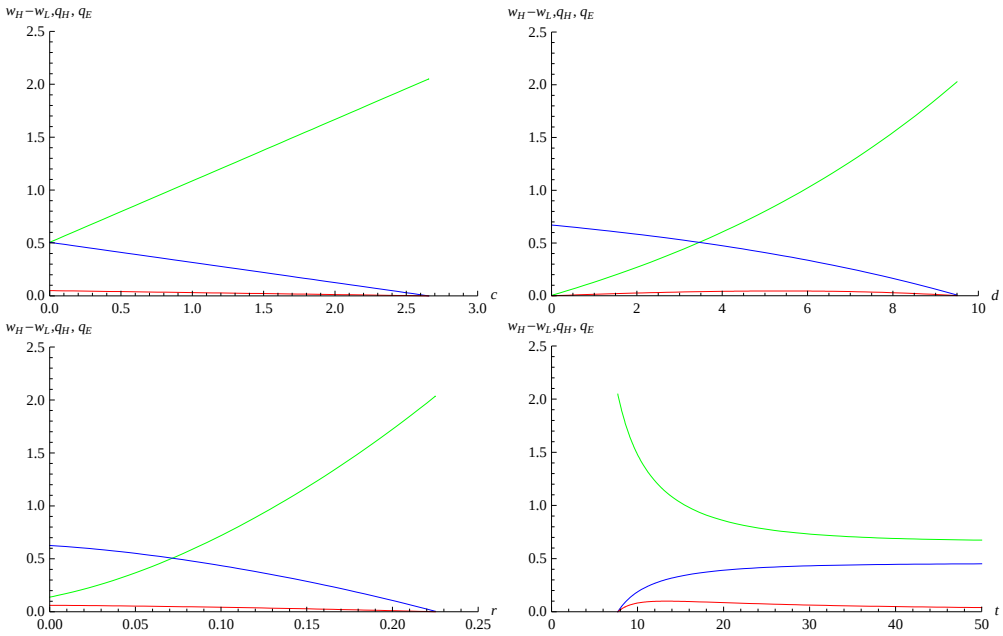

Figure 1: These graphs show how each of the variables affect the difference between the payoff for the high and low strategy. The green line is $w_H - w_L$, the blue is q_H and the red is q_E. The graphs have been plotted with $c = 0.5,\ d = 3,\ r = 0.2,\ b = 3,\ l = 45$.

4 Testing the predictions of the model with data

Assuming societies are close to equilibrium, the above analysis yields predictions of the social stratification. We can test these predictions using statistics on retirement age (l), length (d), cost (c) and differences in income according to level of education (w_H) from a few different countries. The data has been gathered from official statistics institutes in each country and also from the OECD report Education at a Glance [OEC, 2007]. First we have to decide on two educational levels to compare. Since upper secondary education is very common throughout the western world [OEC, 2007] and the first real decision on whether to continue education or not seems to be at tertiary education, we choose to compare them. Specifically we look at bachelors and masters degrees.

First we use statistics on difference in income between people with upper secondary, but no tertiary education with those who have a bachelor or masters degree. Since $w_L = 1$ and corresponds to the average income of a person with upper secondary education, we normalize the income for both types. Using the same method, we normalize the cost for tertiary education to be relative to w_L.

q_H is calculated by comparing the number of people with upper secondary education with those who have a bachelor or masters degree.

The retirement age is approximately the same in all countries (around 65) which means around 45 years left after secondary education. Since it has very little impact on the results when it is this high, we assume a working lifetime of $l = 45$ for all countries. To find the average length of higher education (d), we studied statistics on the amount of bachelor and masters degrees in a country and the average length for each of those.

Table 1 presents data from a few different countries together with the predictions given by our model.

We can see that there is no difference between the approximation and the model. There is also a very small difference between the actual income and the income predicted by the model, suggesting that this model is a very good predictor of social stratification. When calculating w_H and w_H^{approx} a discount rate of 0.1 per year was used for all countries. The actual discount rates predicted by the model is 0.102 for New Zealand, 0.097 for Sweden and 0.099 for USA.

		Israel	New Zealand	Sweden	USA
Data	q_H		0.4^a	0.32^b	0.45^c
	w_H^{actual}	1.69^d	1.44^d	1.38^b	1.71^c
	c	0.19^d	0.08^d	0^d	0.3^d
	l	45	45	45	45
	d	4.56^e	3.4^a	3.4^b	4.4^c
Predicted	b		2.37	2.05	3.13
	w_H		1.43	1.39	1.72
	w_H^{approx}	1.68	1.43	1.39	1.72
Difference	$w_H^{actual} - w_H$		0.01	-0.01	-0.01

[a]Statistics New Zealand[Sta, b]
[b]Statistics Sweden[SCB, 2007]
[c]US Census Bureau[UsC, 2007]
[d]OECD[OEC, 2007]
[e]Central Statistics Bureau Israel[Sta, a]

Table 1: Comparing predictions with data

5 Conclusion

The results from this model show that social stratification in terms of monetary income is expected to appear endogenously, even when there are no individual differences. This is done by incorporating a discounting of future payoffs to individuals utility function. Individuals simply do not value future payoffs high enough to pay the immediate cost of studying when the future payoffs decline due to a lower demand of educated workers.

The model has been applied to statistical data and found to be a very good predictor of social differentiation in the tested countries. The discount rate used for fitting the models predictions to the data is also consistent with the results from [Benzion et al., 1989]. The discount rate is in the lower end of those found in earlier studies, but this is reasonable considering the positive connotations of education.

Further, the model yields predictions on how to influence the proportion of educated workers. To encourage more people to start studying, lowering the cost would seem very reasonable. This model show that the populations level of education will just increase linearly with a decreased cost. Lowering the discount rate on the other hand, would yield an exponential increase in the proportion of educated individuals. The discount rate might be affected by more information about the benefit of studies and how large the difference in income is over a longer period of time.

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