Luck vs Effort: Learning about Income from Different Friends and Neighbours

Gustavo A. Caballero *

University of Calgary

This draft March 2015

Abstract

This paper presents a model of boundedly-Bayesian learning regarding the roles of effort and luck in determining incomes when individuals live in segregated societies. Each individual uses their observation of others’ efforts and incomes, in addition to their own experience, as a sample of trials and errors to inform beliefs. However, by living in societies segregated by income and effort levels, individuals procure biased samples. Given human’s tendency to attribute representativeness to their own observation of uncertain phenomena, agents assume their samples as random. Therefore, segregated societies are expected to maintain significant disagreements about the roles of effort and luck in determining incomes. I simulate societies with varying degrees of segregation finding evidence that suggest a monotonic relationship between the variance in beliefs and the level of segregation. Moreover, high levels of segregation can lead to individuals making inefficient choices, and even converge towards an “incorrect” belief.

Keywords: Beliefs, segregation, disagreement.

*E-mail: gacaball@ucalgary.ca. I am grateful to Robert Oxoby for his guidance in this project. Also, I would like to thank Curtis Eaton, participants at the 2014 Behavioral Models of Politics Conference at Duke University, and seminar participants at the University of Calgary for their valuable comments. Finally, I would like to acknowledge generous financial support by the Vanier Canada Graduate Scholarships provided by the Social Science and Humanities Research Council.
1 Introduction

One of the things that we [have] learned from common psychology is that preferences and perceptions are more volatile than perhaps classical economists thought. [Therefore, it is very useful to go behind them and see if there are more fundamental invariant laws that explain what is going on—Mcfadden (2011)

Income is determined by various factors that can be broadly categorized as effort or luck. How much of the observed income inequality is due to differences in effort and how much to differences in luck matters because many consider that inequalities arising from differences in effort are legitimate while societies should correct for income differences due to varying luck. However, there seems to be much uncertainty about the relative roles of these factors, uncertainty demonstrated by the diversity of opinions expressed in fundamental policy debates. That is because debates in an uncertain world are driven by beliefs. Indeed, individual beliefs regarding the relative roles of effort and luck in determining incomes shape individual preferences with respect to income redistribution (Fong, 2001). Moreover, Differences in average beliefs over the relative roles of luck and effort have been found to be significantly correlated with the degree of social spending at the national level (Alesina, Glaeser & Sacerdote, 2001; Alesina & Angeletos, 2005). Hence, understanding how individuals form these beliefs allows us to inform debates over redistribution.

This paper provides a theoretical explanation for the existence of significant disagreements within societies with respect to the relative roles of effort and luck in determining incomes, even when individuals learn by observing others. Specifically, I argue that significant differences in beliefs regarding the role of effort in determining incomes may result from the interaction between our limited rationality and the fact that we live in segregated societies.

Despite its relevance, we still do not know enough about the sources of differences in beliefs. Specifically, why individuals within societies disagree so much about fundamental questions as the role of effort in determining income. Much has been said about the sources of differences in average preferences between societies and, in many cases, it could be argued
that the mechanism behind differences in preferences are varying beliefs. Examples include countries’ historical experiences, cultural differences and indoctrination.\textsuperscript{1} But, even if these variables are the source of differences in average beliefs between groups, these explanations fail to account for differences in beliefs within groups (societies). Differences in beliefs within groups are equally important—if not more. For example, countries with high levels of political disagreement are expected to hold inefficient levels of debt (Alesina & Tabellini, 1990) in part because high levels of political disagreement disincetivize governments to be committed to their policies and debt levels (Debortoli & Nunes, 2013).

Variance in beliefs within societies may be due to selfish reasons, i.e. the poor wanting more redistribution as they benefit from it, and they are indeed. Yet, as Fong (2001) points out, there is much disagreement within the rich and the poor to be accounted for. Still, models explaining variation of beliefs within societies, beyond self interest reasons, are scarce. In fact, most of the literature refers to the model developed by Piketty (1995) when they discuss within-society variation in beliefs. In his model, individuals learn about the relative roles of effort and predetermined factors only from the past history of their lineage.\textsuperscript{2} That is, similar individuals coming from lineages with different mobility stories will hold different beliefs regarding the role of individual effort in determining income. Specifically, individuals from a lineages moving down in the income distribution will reveal a higher preference towards redistribution.

While the contribution by Piketty (1995) has been remarkable, by focusing in the role of social mobility, his model abstracts from individuals’ social nature. That is to say, in his model individuals live under an unimaginable level of isolation or they disregard any potentially valuable information gathered by the observation of others. This may be in part because, as he recognizes, in his model, “if societies were not comprised by disjointed sets of individuals they would eventually converge in their beliefs towards consistent estimates of the parameters.” I introduce a model that allows for social learning and still generate

\textsuperscript{1}See Alesina & Giuliano (2010, and the references therein).

\textsuperscript{2}In contrast with Piketty (1995) I use the term of lineage instead of dynasty as dynasties usually only refer to hereditary groups of rulers in a society and not all members in that society.
significant levels of disagreement.

My starting point is the fact that the people we meet (our networks) are usually not representative of the whole population as we live in segregated societies (Cutler & Glaeser, 1997). By segregation I refer to the tendency of groups of individuals with similar innate characteristics, who have made similar choices, or who have obtained similar incomes—who have had similar “life experiences”—to be spatially separated in their residence and their consumption. In fact, the U.S. is highly segregated by multiple factors including, but not restricted to, the level of education and specially by income (Massey, Rothwell & Domina, 2009). Furthermore, in the U.S. the level of segregation by income has been increasing in time (Reardon & Bischoff, 2011; Bischoff & Reardon, forthcoming). This is important as individuals meet more frequently with those who are closest in social status (Akerlof, 1997), as well as with family, neighbours, friends or peers (Scheinkman, 2008). Hence, by living in segregated societies, individuals construct networks who are over-representing their own life experience.

Second is individuals’ tendency to attribute randomness, in an statistical sense, to their own observation of uncertain phenomena (Tversky & Kahneman, 1971, 1974). As Kahneman (2013) puts it, “[individuals have a] strong bias toward believing that small samples closely resemble the population from which they are drawn.” That is, individuals are inclined to ignore sample biases that may result from having small samples. Tversky and Kahneman (1974) refer to this behaviour as believing in the Law of Small Numbers (LSN, hereafter). In fact, what the LSN captures is the use of a “representativeness” heuristic. That is, an intuitive rule of behaviour that minimizes cognitive effort by assuming that

---

3 In fact, only a slight preference (which could even be subconscious) to live close to similar peers can generate a significant degree of segregation (Schelling, 1971).

4 Many readers may think that other types of segregation, particularly by race, are more prevalent in the U.S. However, Iceland & Wilkes (2006) argues that the current level of racial segregation is mainly a result of the correlation between race and income. Specifically they find that “in both 1990 and 2000 high-[Socio-Economic Status] racial and ethnic groups were significantly less segregated from non-Hispanic whites than corresponding low-SES groups.”

5 In the bounded rationality literature, cognition is divided into two systems. First there is an intuitive system with spontaneously coming thoughts made with minimal computation, effort or consciousnesses. Second, there is reasoning system which requires a significant amount of cognitive effort (Kahneman, 2003). A representativeness heuristic is driven by the intuitive system.
small samples are representative of the population. By assuming samples are representative individuals avoid the cognitive burden of calculating the likelihood that their observation is biased and calculating the size of that bias. Indeed, Kahneman (2013) concludes that “[w]e easily think associatively, we think metaphorically, we think causally, but statistics requires thinking about many things at once, which is something that [our intuitive] system is not designed to do.”

Section 2 briefly introduces the concept of social learning, or learning from others, from the economics point of view, emphasizing in observational learning. Individuals uncertain about a factor, like the relative role of effort in determining income, can use their own effort choices and resulting incomes (their experiences) to learn about it. Furthermore, they can also use their observation of others’ experiences—a series of trials and errors—to improve their their rate of learning. It is impossible to observe the experiences lived by everyone in an economy. It is possible, nonetheless, to observe the experiences of those in our network. Therefore, the composition of each individual’s network matters. Segregation introduces a systematic and predictable bias in the composition of individual’s networks. If individuals fail to recognize the biases introduced by segregation then segregation can affect how individuals and societies learn.

Notice that, on the one hand, using the LSN is not necessarily a problem. That is, if individuals are able to obtain truly random samples through their social interactions then the heuristic and reality coincide. In fact, that they obtain random samples on average would be sufficient for consistency in the model I present in this paper. Moreover, in such case, by using a heuristic instead of analyzing their sample problem they would minimize cognitive effort while still reaching consistent estimates. On the other hand, procuring biased samples through social interactions should also not be a problem if individuals are aware of their bias. That is, one can suppose that—similar to an econometrician—individuals may be able to correct for biases in their samples if they know about them. Hence, it is a combination of individual specific sample bias and the application of the LSN that allows for significant differences in beliefs.
Section 3 presents an agent-based model of boundedly Bayesian social learning under an overlapping generations framework. In my model I define a boundedly Bayesian agent as one that learns using Bayesian updating but does not consider the potential biases in the samples she uses for learning. Income is either high or low, which can be considered as representing a two-sector small open economy or a partial equilibrium model. In the model, agents must decide whether they exert costly effort when young to increase their probability of receiving a high income when old. However, they are uncertain about how much effort matters in determining income.

Agents face a notable degree of uncertainty as (i) some who do not exert effort may be “lucky” and receive high incomes, while (ii) others who exert effort may be “unlucky” and receive low incomes. In the model this means that agents not exerting effort have a positive probability of receiving a high income, and while exerting effort increases the probability of receiving a high income, effort does not assure a high income. Agents differ in their cost of effort, high or low in the model, and the difference in costs is sufficiently high that if they could know the real probabilistic returns to effort (or they hold a correct belief) only agents having a low cost find it optimal to exert effort.

To make the effort choice when young, each generation of agents use beliefs bequeathed to them by their parents. In the transition to their old age, income is realized (according to the real probabilities in the economy) and after living their experience they update their beliefs before bequeathing them to the next generation. Beliefs are Bayesian updated using their own experience in addition to the observation of the experiences lived by those in their particular network. As agents are boundedly rational, they ignore sample biases while updating their beliefs even though in the model samples are systematically biased towards each individual’s experience. That is, the probability of meeting an agent with a certain experience is a decreasing function of social distance, both in terms of effort choices and income. By applying the Law of Large Numbers—this time an actual law of statistics—agents meet the same proportion of agents with that experience so the individual’s network provides a biased sample.
There is a caveat when solving this problem in such an environment: beliefs at any given time are path dependent and must be traced to all decisions, incomes and samples that a lineage has thus far observed. This is especially important as some individual beliefs may exceed critical levels after which effort decisions are independent of the possible individual costs. That is, beliefs may evolve in such a way that the choice to exert effort becomes independent of the possible costs of effort as expected returns are excessively over-(under-) estimated. Hence, finding a closed form solution for this problem is not possible as the evolution of individual beliefs will depend on the choices made by all individuals and the unfolding of risk. For this reason a simulation exercise in order to compare different environments is presented.

Section 4 presents the results of a series of simulations under reasonable parameters varying the level of segregation and the relative sources of segregation. We observe how relying on the LSN when individuals live in segregated societies lead to significant differences in individual beliefs about the returns to effort, including cases where the decision thresholds are surpassed. In these environments, the variance in beliefs regarding the role of effort increases with the level of segregation in the society. Moreover, only under high levels of segregation will we observe inefficient learning.

1.1 Segregation and disagreement: an illustrative example

As an illustration, we can study the relationship between economic segregation and disagreement about the role of effort in determining success. For this purpose, I bring together data on economic segregation by the American Communities Project (2011), which includes several measures of segregation by family income made every decade from the 1970’s to 2011, and the Trends in Political Values and Core Attitudes 1987-2009 database by the Pew Research Center for the People & the Press (2009). Specifically I look into the level of disagreement, at the metropolitan area level, between random samples of individuals when asked to rate the statement that “[h]ard work offers little guarantee of success.” I use the Dissimilarity index to have a measure of variance or disagreement given that we are dealing
with an ordinal variable. Figure 1 presents the relationship between the level of income segregation and the level of disagreement with all metro areas having 5 or more respondents and weighted by the number of respondents.

![Hard work offers little guarantee of success.](image)

**Figure 1** – Relationship between the level of disagreement about the returns to effort and income segregation (5 or more respondents).

This data suggests a positive relationship between the level of segregation and how much people disagree about the importance of effort in guaranteeing success. Regression analyses find a positive a significant relationship when the sample is restricted to metro areas with 5 \( (n=107, p<.1) \), 10 \( (n=58, p<.1) \), or 20 \( (n=18, p<.01) \) respondents.\(^6\)

Section 5 discusses the results obtained and concludes.

## 2 Learning from others

As Piketty (1995) highlights, “completely learning the relative role of effort in the generation of inequality would require a lot of costly experimentation that each single generation is not willing to undertake.” Nevertheless, lineages do not need to undertake all of the experi-

\(^6\)In order to avoid a mechanical relationship between the sample size available for each metro area and the potential level of disagreement, 500 random samples of the same size (5,10 or 20) for each metropolitan area are used. Reported p-values are defined with respect to the distribution of the estimated betas.
immentation themselves as they can obtain this information from the observation of others. In fact he also pointed out that, by observing others, lineages are usually expected to reach consistent estimates. Moreover, lineages would avoid potentially costly experimentation—specially with choices that they believe to be dominated—and should help them in reaching faster consistent estimates. Indeed, in my model if there is no segregation or individuals do not use the LSN this is true.

To take into account the social nature of individuals, the literature has developed the concept of social learning, or the ability of a population to aggregate information (Mobius & Rosenblat, 2014). Such definition, nevertheless, encompasses many different types of situations and behaviours.

Much emphasis has been done in situations when individuals with different beliefs meet to reach an agreement over an action that they must collectively make but don’t have the option to experiment. DeGroot (1974) in his seminal paper describes how consensus over subjective distributions of a relevant parameter can be achieved. Beliefs are iteratively updated using an individual’s priors and the beliefs of others according to a vector of weights that represent how informative the individual considers the opinion of others. For example, more weight can be given to those with more experience or knowledge about the subject. DeGroot (1974) shows how, under very few conditions, individuals are able to converge towards a consensus. In this type of social learning, individuals can only gather information by sharing their beliefs and excludes the possibility of observing the choices and outcomes of others. Therefore it is best at describing situations of deliberation without knowing each others’ experience.

Less emphasis has been done in situations when both the choices and the outcomes made by others can be observed. This is partly because social learning of this type is believed to almost certainly lead to consistent estimates of underlying parameters (Gale & Kariv, 2003), even if individuals are not sophisticated learners (Bala & Goyal, 1998). Moreover,

\footnote{An intermediate case, also extensively studied in the literature, is one named by Mobius and Rosenblat (2014) as observational learning. There is only one state of the world and individuals can only observe the actions made by others and make a once and only action. This literature has been instrumental to study “herd” behaviour (e.g. Banerjee, 1992).}
allowing subjects to observe the full experience of others makes convergence (in an statistical sense) possible, even if the unknown parameters are time varying and individuals are not sophisticated (Acemoglu, Nedic & Ozdaglar, 2008).

Learning about others’ effort choices and income (experiences) is possible through social interactions. Therefore, individuals can use the information from their sample of experiences to inform their beliefs regarding the role of effort and luck in determining incomes. As stated in the introduction, if individuals are able to observe a sample representative of their society in their interactions, or they are able to recognize any biases their samples have, using the information of others’ experiences should lead to consistent estimates of the returns for their effort. Consequently the main questions to make are (i) how individuals’ samples are procured?, and (i) how individuals use their samples to make inferences about the relative roles of luck and effort in determining income?

3 Learning in a segregated society (The model)

In this section we develop an understanding of how segregation can affect how individuals learn about the role of effort in determining income. I present a model of overlapping generations where agents from every generation are confronted with the choice to exert (or not) costly effort when they are young.\(^8\) Agents consider exerting effort as it is believed to increase their probability of receiving a high income when old. Income is only high or low. Therefore, the difference between a high and a low income, weighted by the increase in probability associated to effort, corresponds to the expected returns to effort.

All agents face the same probability of receiving a high income when not exerting effort and a unique higher probability when exerting effort. Hence, the probabilities, conditional on effort, are the same for all individuals in the economy. However, the probabilities of receiving a high income associated with each level of effort are never one or zero. Namely, some of the agents choosing a low effort may be “lucky” and receive a high income while

\(^8\)For tractability I assume no population growth so every individual that dies is replaced by another of the same lineage.
others exerting effort may be “unlucky” and receive a low income. In this context, agents are uncertain about the relative roles of effort and luck in determining incomes.

My model differs from others in which groups of individuals have unequal returns on effort or chances of upward luck (e.g. Piketty, 1995). This is not to say that differences in opportunities between groups or the actual returns to effort are not a fundamental part of explaining the diversity of beliefs in societies. Differences in opportunities or the returns to effort potentially affect individual beliefs regarding the role of effort and luck in determining incomes. The main contribution of this model is to present an explanation of why beliefs are expected to vary even in fairly homogeneous societies.

This is a dynamic model of belief formation where beliefs are formed at the lineage level. When agents are young, each of them is bequeathed a set of beliefs by the old in their lineage which they use to make their effort choice. When they become old, income is realized according to the true probabilities in the economy and an agent’s experience (effort choice and income received) is determined. In addition to their own experience, agents learn about others’ experiences through social interaction. However, the others they meet, their network, over-represent their type as there is segregation in the economy. Having procured a sample, agents update beliefs in a Bayesian manner, but do not correct for the sample bias resulting from segregation, and bequeath their updated beliefs to their descendants.

The timing of decisions, procurement of samples, and updating of beliefs is presented in Figure 2 for generations $t$ and $t + 1$. Below I provide a detailed description of the model.

### 3.1 The economy

Agents live in an environment where (i) income can only be high or low, that is $\omega_i \in \{\omega_h, \omega_l\}$, (ii) there is always a chance of $\theta \in (0, 1)$ to earn a high income even if effort is not exerted (being lucky), (iii) individual chances increase by $\delta \in (0, 1 - \theta)$ if costly effort is exerted, and (iv) even if effort is exerted there is a chance of $1 - \theta - \delta$ of earning a low wage (being unlucky). Table 1 summarizes this economy. Outside the model, examples of being lucky correspond to cases when, given asymmetries in networks or corruption, an individual not
exerting a high effort earns a high income. On the other hand, being unlucky could reflect cases of unexpected health breakdowns, for example.

In this model, both the true $\theta$ and the true $\delta$ are unknown and in every period agents must use estimates $\hat{\theta}_t^i$ and $\hat{\delta}_t^i$. While exerting effort increases the chance of receiving a higher income, effort has a cost. This means that not knowing the actual returns to effort can be costly as (i) agents could fail to exert effort when the cost is actually lower than the expected returns to effort, or (ii) they could be exerting effort when the expected returns are less than the cost of effort. That is why lineages seek to have the most accurate belief.

### 3.2 The agent’s effort choice

Agents differ in the cost of effort $\xi_t^i \in \{\xi_l,\xi_h\}$ and the difference in costs is such that, if agents could know the real returns to effort only those with a low one should exert effort. The problem to be solved by agents of generation $t$ from lineage $i$ is to choose whether to exert effort when young $e_t^i \in \{0,1\}$. By exerting effort they believe to increase their chances of a high income when old. They make this decision conditional on a randomly determined
individual cost of effort $\xi_i^t \in \{\xi_l, \xi_h\}$ which is only privately known.\(^9\)

Then, time advances one period and incomes are determined by the unfolding of risk according to their effort choice. Receiving a high income is determined according to the probabilities presented in Table 1. For now, we do not consider any intertemporal choice in consumption so generations do not interact actively beyond the transmission of beliefs. Therefore, agents consume $c_{i,t+1}^t$ an exogeneously determined portion $(1 - \eta) \in [0, 1)$ of their earnings $\omega_i^t$ when old, leaving the remaining portion $\eta$ for the consumption of their descendants.\(^10\) Nevertheless, this model is flexible enough to allow, for example, decisions to invest in modifying the probabilities of subsequent generations faced by all individuals, or just those in their lineage.\(^11\) Similarly, I assume there are no savings so, without loss of generality, I also assume no time discounting.

The problem to be solved when an agent $i$ is young is:\(^12\)

$$\max_{e_i^t \in \{0, 1\}} u_i^t = c_{i,t}^t + c_{i,t+1}^t - \xi_i^t e_i^t \quad \text{s.t.}$$

$$c_{i,t}^t \leq \eta \omega_i^{t-1}$$

$$c_{i,t+1}^t \leq \begin{cases} (1 - \eta)\omega_l \text{ with prob. } = 1 - \hat{\theta}_i^t - \hat{\delta}_i^t e_i^t \\ (1 - \eta)\omega_h \text{ with prob. } = \hat{\theta}_i^t + \hat{\delta}_i^t e_i^t \end{cases}$$

Notice that, agents use beliefs regarding $\theta$ and $\delta$ when solving their problem as these are their best estimates of the parameters. Given that all constraints are binding, this problem can be restated as

$$\max_{e_i^t \in \{0, 1\}} E[u_i^t] = \eta \omega_i^{t-1} + (1 - \eta) \left( \omega_l + (\hat{\theta}_i^t + \hat{\delta}_i^t e_i^t)(\omega_h - \omega_l) \right) - \xi_i^t e_i^t$$

\(^9\) Initially, I assume that the cost is not related to the lineage so each generation receives a new independent draw given a constant probability $\lambda$ of having a low cost $\xi_l$.

\(^10\) This means that they consume the same portion of their parents’ income when young.

\(^11\) This, and other possibilities for agents to be able to affect the economy, is left for future research.

\(^12\) Because the cost of effort appears in the utility function and not in the budget constraint, all individuals who desire to assume the cost can do it, therefore the decision to save has no significant implications. Rabin (1995) discusses the difference between having the cost as a constraint or in the utility function. Galor & Zeira (1993) study the case when the cost of effort is financial and agents are financially constrained in an education decision.
Consequently, if we assume that when they are indifferent they decide to exert effort, an agent exerts effort when young, i.e. \( e_t^i = 1 \), if

\[
\hat{\delta}_t^i (1 - \eta) (\omega_h - \omega_l) \geq \xi_t^i \tag{3}
\]

or

\[
\hat{\delta}_t^i \geq \frac{\xi_t^i}{(1 - \eta) (\omega_h - \omega_l)} \tag{4}
\]

That is, they exert effort if the gains in earnings weighted by their belief of the probabilistic returns to effort is higher than the individual cost drawn by generation \( t \). Notice that \( \hat{\theta}_t^i \) does not matter for the decision as their probability to receive a high income for both levels of effort include this factor.

As hinted before, this decision rule implies that, if an agent have a sufficiently high belief regarding the returns to effort then she exerts effort even if the cost is high. Similarly, an agent with a believe low enough does not exert effort, even if she faces a low cost of effort. Throughout the paper I refer to such cases as extreme beliefs.

### 3.3 Network formation and segregation

Agents form a network when old that they use to obtain a sample of others’ effort-income combinations (experiences), in addition to their own experience. Then, they use this sample of experiences to inform their beliefs. In this model there are only four possible experiences: (i) having exerted effort and receiving a high income, (ii) exerting effort and receiving a low income (being unlucky), (iii) not exerting effort and receiving a high income (being lucky), and (iv) exerting low effort and receiving a low income. By living in a segregated economy, the sample each agent procure is biased towards their own experience.

Segregation in the model is captured by having individuals interacting the most with others choosing the same level of effort and receiving the same income, and the least with people that chose different effort and receive a different income. Whether they interact more with agents exerting the same effort but receiving a different income or with those
who exert a different level of effort but receive the same income depends on the type of society modelled.

I model segregation by setting the probability that an individual that exerted effort $e_i^t$ and obtained an income of $\omega_i^t$ meets another person with effort $e_j^t$ and income $\omega_j^t$ as:

$$\psi \gamma_e |e_i^t - e_j^t| + \gamma_\omega |I^h[\omega_i^t] - I^h[\omega_j^t]|$$

where $\psi \in (0, 1)$ and the parameters $\gamma_e > 0$ and $\gamma_\omega > 0$ captures how much segregation there is with respect to effort and income respectively. $I^h[\cdot]$ is an indicator whether the individual received a high income. By the Law of Large Numbers it is expected that individual $i$ meets this proportion of individuals with $j$’s story when they are old.

### 3.3.1 Example

To observe the effects of segregation in the procurement of samples, let’s consider an economy with 96 agents with the ex-post distribution in terms of experiences is shown in Table 2. For instance, this table tells us that 32 agents exerted effort and received a high income.

Assume that segregation is such that $\psi = 1/2$, $\gamma_e = 1$ and $\gamma_\omega = 2$. Hence agents with different stories will observe samples as presented in Table 3. For example, an agent that exerted a high effort and received a high income would observe himself and all other 31 agents with their same story, four other agents having exerted effort but not receiving a high income, eight agents who did not exert effort but received a high income, and two agents not exerting effort and receiving the low income.

One may think that in reality, if individuals live in such small society it would be very unlikely that they would rely the Law of Small Numbers. That is, once an individual knows the total size of the population and she have met all those of her same experience, then the ones that she has not met should belong only to one of the other types. This line of thought should then start the reasoning system which may be able to correct for sampling bias. Nevertheless, becoming aware of the sample bias is hard in big societies. That is,
Table 2 – Example: Real society

<table>
<thead>
<tr>
<th>Income</th>
<th>32</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>16</td>
<td>32</td>
</tr>
</tbody>
</table>

Table 3 – Samples procured by individuals according to their own story when $\psi = 1/2$, $\gamma_e = 1$ and $\gamma_\omega = 2$

(a) $(e^t_i, w^t_i) = (1, \omega_h)$  
(b) $(e^t_i, w^t_i) = (1, \omega_l)$  
(c) $(e^t_i, w^t_i) = (0, \omega_h)$  
(d) $(w^t_i, e^t_i) = (\omega_l, 0)$

<table>
<thead>
<tr>
<th>Income</th>
<th>32</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>16</td>
<td>32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Income</th>
<th>8</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Income</th>
<th>16</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>16</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Income</th>
<th>2</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
<td>32</td>
</tr>
</tbody>
</table>

individual samples are only a very small percentage of the whole population when living in big societies as an individual’s network size is constrained by her ability to meet, and keep track of, other individuals (Killworth et al., 2003).

3.4 Beliefs updating

An agent from generation $t$ of lineage $i$ holds a system of beliefs which she uses to make her effort choice. At the core of her system of beliefs are two objects. On the one hand, there is the belief on the probability of being lucky, i.e. $\hat{P}_t^i(w^t_i = \omega_h | e^t_i = 0)$, denominated by $\hat{\theta}_t^i$.

On the other hand, there is the probability of earning a high income when effort is exerted, i.e. $\hat{P}_t^i(w^t_i = \omega_h | e^t_i = 1)$, denominated by $\hat{\Phi}_t^i$. Notice however that, an individual exerting effort may receive a high income because she was going to be lucky in any case or because she exerted effort. That is, $\hat{\Phi}_t^i = \hat{\theta}_t^i + \hat{\delta}_t^i$.

Based on these two beliefs an agent can solve for other parameters of interest. Specifically, an agent can find the probability of being unlucky, which is $1 - \hat{\Phi}_t^i$, and the believed probability increase of receiving a high income associated with exerting effort $\hat{\delta}_t^i$.
\[ \hat{\delta}_i^t = \hat{\Phi}_i^t - \hat{\theta}_i^t \]  

(6)

Note that what, for an agent who exerted effort, what is not effort is luck:

\[ 1 - \hat{\delta}_i^t = 1 - \hat{\Phi}_i^t + \hat{\theta}_i^t \]

(7)

therefore an estimate on the probabilistic increase associated with exerting a high effort provides an estimate of the relative role of effort in determining higher incomes.\(^{13}\)

The system of beliefs is Bayesian updated every period based on the sample of stories procured. However, agents are bounded in their rationality in that they assume that their samples are random. Bayesian updating states that an agent’s updated beliefs, i.e. the posterior distributions \( p_{i,t}(\theta|y) \), are proportional to her prior belief \( p_{i,t-1}(y|\theta) \) and the likelihood she observes given the sample obtained that period \( p_{i,t}(\theta) \).

\[ p_{i,t}(\theta|y) \propto p_{i,t-1}(y|\theta) \times p_{i,t}(\theta) \]  

(8)

Uncertain about the three parameters, agents do not hold a unique estimation but instead their beliefs are captured by a probability distribution. For this purpose, I assume that an agent’s beliefs regarding these parameters can be captured by beta distributions \( \beta(\alpha, \beta) \), which are commonly used in models of Bayesian learning when the parameter to be estimated is a probability. Two moments of special interest of this distribution are the mean \( \alpha/(\alpha + \beta) \) and the mode \((\alpha - 1)/(\alpha + \beta - 2)\) which could be used when making decisions.\(^{14}\) Additionally, the variance is \( \alpha\beta/(\alpha + \beta)^2(\alpha + \beta + 1) \). Note that the variance is decreasing in the parameters \( \alpha \) and \( \beta \). Therefore, agents that have observed bigger samples

\(^{13}\)Note that in a similar way, agents might form other beliefs. Specifically they might want to have an estimate regarding the proportion of agents who are exerting a high effort \( \hat{P}_i^t(\epsilon_i^t = 1) \), denominated \( \hat{\epsilon}_i^t \). Then, they could use this belief when considering how much redistribution should exist.

\(^{14}\)Which to choose when deciding depends on a behavioural assumption about agents process of recalling beliefs. Either the agent acts based on the estimate which more frequently comes into her mind, the mode, or she is able to find the mean. For big numbers of \( \alpha \) and \( \beta \) any difference is negligible. In the simulations we will use the mode.
will have a lower variance in their estimates. In this paper I refer to a lower variance in the beliefs each individual holds as “being more confident” about their beliefs.

In this case, the likelihood is based on the proportion of agents observed earning a high income for each level of effort. Given that there are only two possible effort levels and two incomes, the likelihood of receiving a high income conditional in a level of effort can be described by a binomial distribution $B(n, p)$ with parameters $n$ (the number of individuals observed in the given level of effort) and $p$ (the proportion of individuals earning the high income). This means that the procedure resembles an experiment out of which we can separate successes from errors.

An advantage of using a beta distribution as a prior is that a beta distribution is conjugate to a binomial likelihood so the distribution of the posterior is of the same family of the prior. Bayesian updating in this model can be described by:

$$\beta(\alpha + pn, \beta + (1 - p)n) \propto B(n, p) \times \beta(\alpha, \beta)$$ (9)

That is, for every level of effort the number of agents observed in one’s sample who receive a high income are “added” to the alpha parameter while those receiving a low income are added to the beta parameter. Therefore the posterior belief has a mean of $(\alpha + pn)/(\alpha + \beta + n)$, a mode of $(\alpha + pn - 1)/(\alpha + \beta + n - 2)$ and a variance of $(\alpha + pn)(\beta + (1 - p)n)/(\alpha + \beta + n)^2(\alpha + \beta + n + 1)$. Using this procedure, individuals update their beliefs for the two possible levels of effort.\(^\text{15}\)

It is noteworthy that segregation provides samples over-representing the agent’s experience, which implies, for example, that an agent from a lineage with a long history of exerting effort and obtaining high incomes will be less confident about her estimates of the chances that someone exerting low effort has to obtain a high income.

\(^{15}\) Assuming this type of learning implies that, waiting until the sample is complete before updating beliefs is equivalent to updating after every interaction. In fact, updating after every interaction can be thought as if, for every experience an agent observes the agent slightly—the size of the effect actually would depend on how “confident” one is about its prior—increases or reduces the belief regarding the probability of earning a high income for that level of effort. Nonetheless, it can be argued that recognizing sample biases when updating after every interaction is considerably more complicated.
4 Simulation

This section presents the results of simulating various economies that only differ in the level of segregation that they have.

4.1 Simulation parameters

There are $g = 100$ generations of agents from $n = 500$ lineages who live in the following environment:

- Probability of upward luck $\theta = 1/4$ ; Gains from effort $\delta = 1/2$

- Proportion with low cost $\lambda = 1/3$; costs: $\xi_L = 1.5$ and $\xi_H = 2.5$

- Possible incomes $\omega_l = 1$ ; $\omega_h = 5$

- $\psi$ ranges from .2 to .8 ; segregation by effort $\gamma_e = 1$ is lower than segregation by income $\gamma_\omega = 2$.\(^\text{16}\)

- All income is consumed by the parents, i.e. $\eta = 0$.

- Additionally I assume that, by chance, the first generation hold correct beliefs, i.e. $\hat{\delta}_i^0 = \delta$ $\forall i$, but with a minimal level of confidence.\(^\text{17}\)

The simulation is made in Stata where each agent chooses effort optimally given their beliefs. I consider four levels of segregation ($\psi \in \{.2, .4, .6, .8\}$) which I refer to as very high, high, low and very low levels of segregation respectively.
4.2 Simulation findings

Figure 3 presents how agent’s beliefs \( \hat{\theta}_t^i + \delta_t^i \) and \( \hat{\theta}_t^i \) evolve over time under different levels of segregation. Box plots are used to depict the distribution of beliefs in every period.\(^\text{18}\) Living in segregated societies leads to differences in beliefs regarding the probability to be lucky and the probability of receiving a high income when effort is made. Moreover, the variance of beliefs (level of disagreement) is monotonically increasing with the level of segregation of

\(^{16}\)While I do not refer to any specific type of effort choice, the decision to continue studying beyond high school can be considered as an effort choice. The U.S. is more segregated by income than by education levels, therefore this assumption—though admittedly arbitrary—goes in line with what is observed in terms of education.

\(^{17}\)Assigning an uninformative prior to the first generation does not have any significant impact on the behaviour here described as a weak prior (not very confident) is quickly overridden by the data.

\(^{18}\)These plots present a box limited by the percentiles 25 and 75 of the distribution. Additionally the median is highlighted, although in this case is indistinguishable. Whiskers are extended up to the maximum and minimum, or 1.5 times the distance between percentiles 25 and 75 (whichever is closer). Any observation beyond the whisker has its own marker.
the society.

We can then use Equation 6 to solve for $\hat{\delta}_i$, which is the variable that affects effort decisions. Figure 4 shows how beliefs regarding the returns to effort evolve as well as the proportion of agents exerting effort—remember that if they had complete information only one out of three should be exerting effort. I also highlight an area of efficient choices. That is, the range of beliefs where agents choose correctly to exert effort according to their cost of effort. Outside this area, agents are excessively over- (under-) estimating the returns to effort so they do (do not) exert effort for any of the possible costs. I refer to these cases as extreme beliefs. Notice that, given the parameters of our simulation, by applying Equation 4 we find that agents holding a belief $\hat{\delta}_i \geq 0.625$ will exert effort regardless of their cost while they will never exert effort if $\hat{\delta}_i \leq 0.375$.

While extreme beliefs are briefly observed in low levels of segregation, i.e. $\psi = .6$ as

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4}
\caption{Evolution of beliefs regarding the returns to effort.}
\end{figure}
shown in Figure 4b, it is only when segregation is very high (when $\psi$ is low) that extreme beliefs are common, can be sustained for a significant amount of time and affect a significant number of decisions to exert effort. In cases, c and d, less than 5 generations are required in order for some beliefs regarding $\tilde{\delta}^i_t$ to reach critical values after which the decision to exert effort becomes independent of the cost of effort. In fact, when segregation is very high the economy is, on average, exerting more effort than what is socially optimum.

It is noteworthy that holding an extreme belief may have implications beyond inefficient selection of effort. Specifically, even though it is not included in the model, extreme beliefs can affect how agents assess the actions of others. For example, an agent holding the belief that effort has a return sufficiently high, so she exerts effort for any of the two possible costs, most probably would question the motives of another agent who is not exerting effort. She may think, for example, that either (i) the other agent has not been able to solve the problem or (ii) there is a cost of effort—still unobserved by her lineage—sufficiently high so it was optimal to choose differently for the other agent. The converse is true for an agent with an extreme underestimation of the returns to effort. Contemplating these possibilities most likely affects individual willingness to redistribute income in the economy.

4.2.1 Beliefs and lineages experiences

Now, the natural question becomes who are the lineages that are positioned in both extremes. Namely, what experiences lead to believing that the returns to effort are either too low or too high? In order to study this question I first focus on the first periods. Figure 5 presents how beliefs evolve according to the experiences that each lineage live during the first four generations when the parameter $\psi = .6$. The first observation is that lineages with the lowest estimates on the returns to effort are those who have been the most lucky, while on the other extreme are those who obtained the “expected” incomes but have also observed both the high and low incomes.

We proceed to study what are the long-term patterns in the typical experiences that lead to different beliefs. Table 4 presents average experiences, after 100 generations, lived
Beliefs and stories when segregation is low

Note: horizontal lines present the thresholds after which the effort decision does not depend on individual costs.

Figure 5 – Beliefs according to the stories lived (the first experience lived is to the left) when segregation is low ($\psi = .6$).

Table 4 – Experiences lived on average, after 100 generations, by groups with different levels of beliefs.

(a) Very low segregation

<table>
<thead>
<tr>
<th></th>
<th>$e_0, \omega_l$</th>
<th>$e_0, w_h$</th>
<th>$e_1, w_l$</th>
<th>$e_1, w_h$</th>
<th>$\hat{\delta}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low belief</td>
<td>50.91</td>
<td>20.32</td>
<td>7.59</td>
<td>21.18</td>
<td>0.470</td>
</tr>
<tr>
<td>Low belief</td>
<td>50.67</td>
<td>18.13</td>
<td>7.55</td>
<td>23.65</td>
<td>0.473</td>
</tr>
<tr>
<td>Average belief</td>
<td>49.98</td>
<td>16.7</td>
<td>8</td>
<td>25.32</td>
<td>0.475</td>
</tr>
<tr>
<td>High belief</td>
<td>49.78</td>
<td>15.25</td>
<td>8.36</td>
<td>26.61</td>
<td>0.477</td>
</tr>
<tr>
<td>Very high belief</td>
<td>49.32</td>
<td>12.94</td>
<td>8.99</td>
<td>28.75</td>
<td>0.479</td>
</tr>
<tr>
<td>Total</td>
<td>50.132</td>
<td>16.668</td>
<td>8.098</td>
<td>25.102</td>
<td>0.475</td>
</tr>
</tbody>
</table>

(b) Very high segregation

<table>
<thead>
<tr>
<th></th>
<th>$e_0, \omega_l$</th>
<th>$e_0, w_h$</th>
<th>$e_1, w_l$</th>
<th>$e_1, w_h$</th>
<th>$\hat{\delta}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low belief</td>
<td>55.92</td>
<td>19.65</td>
<td>7.1</td>
<td>17.33</td>
<td>0.506</td>
</tr>
<tr>
<td>Low belief</td>
<td>23.31</td>
<td>8.77</td>
<td>17.79</td>
<td>50.13</td>
<td>0.615</td>
</tr>
<tr>
<td>Average belief</td>
<td>20.01</td>
<td>6.45</td>
<td>17.38</td>
<td>56.16</td>
<td>0.626</td>
</tr>
<tr>
<td>High belief</td>
<td>22.05</td>
<td>6.97</td>
<td>18.08</td>
<td>52.9</td>
<td>0.636</td>
</tr>
<tr>
<td>Very high belief</td>
<td>28.12</td>
<td>8.98</td>
<td>14.64</td>
<td>48.26</td>
<td>0.674</td>
</tr>
<tr>
<td>Total</td>
<td>29.882</td>
<td>10.164</td>
<td>14.998</td>
<td>44.956</td>
<td>0.611</td>
</tr>
</tbody>
</table>
by groups of lineages holding different levels of belief on the returns to effort. I focus in the cases with very low or very high levels of segregation. In every case, agents in the lowest quintile of the distribution of beliefs are classified as holding a very low belief, the next quintile as a low belief, and so on. The table also presents the average for the population as a whole.

Let’s start by analyzing the case of low segregation in Panel 4a. In this case there are almost no extreme beliefs. This table tell us, for example, that a lineage holding a very low belief on the returns to effort typically had 51 generations not exerting effort and obtaining a low income, 20 generations not exerting effort but obtaining a high income, eight exerting effort but obtaining a low income, and 21 exerting effort and obtaining a high income. As expected, on average only one third exerted high effort. In such case, it is luck (in the sense of obtaining a low cost of effort) the main driver of beliefs. Individuals holding the lowest beliefs only exerted effort 29% of the times while those with the highest beliefs exerted effort 38% of the times. That is, exerting effort more times allowed the latter to observe more cases when, by exerting a high effort they obtained a high income. Moreover, a comparison of contiguous levels of beliefs shows that higher beliefs result from living through more generations obtaining expected incomes, i.e. a low income when effort is not exerted and a high income when exerting effort.

When segregation is very high, Panel 4b, on average more than one third of individuals were exerting a high effort. This is the effect of holding extreme beliefs—typical in this environment. Additionally, there are no longer monotonic relationships between beliefs and the histories that lineages have. Interestingly enough, those holding the highest and the lowest beliefs regarding the returns to effort have experienced more periods exerting low effort when compared with those in the middle of the distribution. What separates them is the proportion of expected results. Individuals holding very low beliefs obtained on average a low income 74% of times when they exerted low effort and a high income 71% of times when they exerted effort. Individuals holding very high beliefs received a low income 76% of times when they exerted low effort and a high income 77% of times when exerting a
high effort. Notice that only by having enough experience exerting low and high effort is that individuals will form a very high belief on the returns to effort. A lineage frequently affected by extreme beliefs, so its members exert effort more times than optimal (as the group of average beliefs) will have insufficient experience with low effort so they won’t be able to hold a very high estimate on the returns to effort.

4.2.2 The long run

In a closer analysis we observe how the level of disagreement decreases with time. For example, in Figure 4d we can observe how after 100 generations, even though we keep observing a considerable number of lineages holding extremely low $\hat{\delta}^i$’s, beliefs are becoming increasingly concentrated. Figure 6 presents the distribution of beliefs after more than 900 generations when segregation is very high. Notice that in this case agent’s beliefs gravitate, around an incorrect estimation of $\delta$ and the economy can be considered as overheated—in the sense that more agents than the social optimum are exerting effort.\footnote{This does not implies that segregation will always generate a higher level of income per capita. Analyses not presented here show that the result could have been other in a different economy.}
4.2.3 Partial inherited confidence

That the level of disagreement decreases in time is a consequence of our approach to beliefs updating. The parameters $\alpha$ and $\beta$ in the beta distributions, a reflection of a lineage’s accounting of high and low incomes for each level of effort, are always increasing so the variance is always decreasing.\(^{20}\) Nevertheless, while individuals take seriously the beliefs their parents pass to them, they are not necessarily as confident as their parents with respect to those estimates. In that regard, Dohmen et al. (2012) conclude that “attitude transmission [from parents to their children] is unlikely to be the sole driver of any specific behaviour [of the children].” Therefore we consider a case where the inherited beliefs take the following form:

\[
\beta \left( \rho \alpha + pm, \rho \beta + (1-p)n \right) \propto B(n, p) \times \beta(\rho \alpha, \rho \beta) \tag{10}
\]

where $\rho$ is a confidence discounting factor. Even with a $\rho$ of .95, then we should no

\(^{20}\)It is noteworthy, nonetheless, that Bayesian learning eliminates the need of perfectly recalling all the observations made by an individual’s predecessors as all this information is summarized in the prior bequeathed to individuals.
longer expect convergence in beliefs and disagreements can be forever present. Figure 7 shows the distribution of beliefs after 900 generations in this case. If individuals are less confident than their parents with respect to the beliefs bequeathed to them, disagreements can be held in perpetuity.

4.2.4 What happens if the cost of effort depends on the experiences lived by their ancestors?

So far, it seems that it is another type of luck what is driving agents’ beliefs. Namely, the percentage of times a lineage draws a low cost is one of the main determinants of the position in the beliefs spectrum. Here we relax the assumption of independently and identically distributed probabilities of receiving a low cost to capture the time dependence of effort choices. That is, I introduce—in a very simplified way—effects of being raised by someone who exerted effort and the resources one had when young (their parents’ income) in the likelihood of receiving a low cost.\(^{21}\)

Let’s assume that \(\theta^t_i\) vary between 1/6 and .5 with \(\theta^0_i = 1/3\) for all agents. Further, assume that \(\delta\) does not change with the parent’s experience. The probability of receiving a low cost evolves for every lineage as presented in Table 5. That is, we are assuming that what matters the most when determining the chances of receiving a low cost is the level of effort made by the parents. In fact, if the parents exerted effort then the chances at having a low cost of effort increase, regardless of the income they receive. Agents whose parents

\(^{21}\)An alternative would be to allow the agents to invest part of their income in changing their children’s probability of receiving a low cost. To keep matters simple, as this is not our focus, I assume rather the expected dynamics resulting from optimal behaviour.
Table 6 – Experiences lived on average, after 100 generations, by groups with different levels of beliefs when the probability of a low cost depends on the parents’ experience.

(a) Very low segregation

<table>
<thead>
<tr>
<th></th>
<th>$\epsilon_0$, $\omega_1$</th>
<th>$\epsilon_0$, $\omega_1$</th>
<th>$\epsilon_1$, $\gamma$</th>
<th>$\epsilon_1$, $\gamma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low belief</td>
<td>57.71</td>
<td>22.08</td>
<td>5.52</td>
<td>14.69</td>
</tr>
<tr>
<td>Low belief</td>
<td>57.46</td>
<td>20.59</td>
<td>5.24</td>
<td>16.71</td>
</tr>
<tr>
<td>Average belief</td>
<td>58.37</td>
<td>18.66</td>
<td>6.06</td>
<td>16.91</td>
</tr>
<tr>
<td>High belief</td>
<td>56.93</td>
<td>18.36</td>
<td>6.1</td>
<td>18.61</td>
</tr>
<tr>
<td>Very high belief</td>
<td>57.32</td>
<td>16.09</td>
<td>6.14</td>
<td>20.45</td>
</tr>
<tr>
<td>Total</td>
<td>57.558</td>
<td>19.156</td>
<td>5.812</td>
<td>17.474</td>
</tr>
</tbody>
</table>

(b) Very high segregation

<table>
<thead>
<tr>
<th></th>
<th>$\epsilon_0$, $\omega_1$</th>
<th>$\epsilon_0$, $\omega_1$</th>
<th>$\epsilon_1$, $\gamma$</th>
<th>$\epsilon_1$, $\gamma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low belief</td>
<td>38.4</td>
<td>14.05</td>
<td>13.2</td>
<td>34.35</td>
</tr>
<tr>
<td>Low belief</td>
<td>23.8</td>
<td>8.31</td>
<td>17.6</td>
<td>50.29</td>
</tr>
<tr>
<td>Average belief</td>
<td>22.51</td>
<td>7.36</td>
<td>17.42</td>
<td>52.71</td>
</tr>
<tr>
<td>High belief</td>
<td>22.09</td>
<td>6.66</td>
<td>17.74</td>
<td>53.51</td>
</tr>
<tr>
<td>Very high belief</td>
<td>31.34</td>
<td>10.22</td>
<td>13.26</td>
<td>45.18</td>
</tr>
<tr>
<td>Total</td>
<td>27.628</td>
<td>9.32</td>
<td>15.844</td>
<td>47.208</td>
</tr>
</tbody>
</table>

did not exerted effort will see their chances lowered, regardless of the income their parents received. This would be the case of an effort task where a subset of skills can be transmitted from generation to generation.

Table 6 presents the typical experiences of agents holding different degrees of beliefs regarding the returns to effort. When segregation is very low it is again the number of times a lineage exerted effort what determines beliefs. However, in all cases lineages exerted effort less than one third of times. The reason being that agents obtain the low cost less than half of times in average so the average probability of obtaining the low cost should gravitate towards 1/6. Those holding the lowest beliefs exerted effort only 20% of times, while those with the highest beliefs exerted effort 27% of times. The dynamics become more interesting when segregation is very high. In this case the effect of beliefs goes in the opposite direction of the probability of having a low cost. Extreme beliefs increase the number of times a lineage exerts effort so the probability of a low cost is more likely to approach 0.5. Note that, overall they are exerting more effort when compared to the iid case.

In an economy where the chances of having a low cost of effort are partially determined by the experiences of predecessors, path dependence can be higher. For example, when segregation is high, beliefs are self-reinforcing as having a high belief implies a higher propensity to exert effort, which in turn increase the chances on the next period of having a low cost.
5 Concluding remarks

In this paper I present a model where boundedly Bayesian learners, that is people who rely on the Law of Small Numbers, learn in segregated societies about the role of effort in determining a high income. In the model agents form significantly different beliefs regarding the returns to effort. The reason for such a level of disagreement is the bias in the “world” they observe resulting from living in a society segregated by income and effort.

Through a simulation exercise, where it was more likely to obtain a high income when exerting effort and a low income when not (the expected incomes), I find that the level of disagreement (variance in beliefs) is monotonically related to the level of segregation in the society. Moreover, I find that, when segregation is high enough, individuals may start making inefficient choices due to extreme beliefs. Furthermore, while convergence in beliefs may be expected when there is perfect intergenerational transmission of beliefs, a common assumption when modelling learning, convergence in the long run may be towards an incorrect estimation of the returns to effort when segregation is very high. Nevertheless, I argue that under imperfect intergenerational transmission of beliefs, i.e. when the young are not as confident as the old with regard to the beliefs they are bequeathed with, then disagreements can be hold in perpetuity.

When the chances of receiving a low cost does not depend on the effort and the income of the predecessors, I find that over- or under-estimating the returns to effort depends on the times a lineage obtained the expected or unexpected incomes respectively. Individuals who hold the highest beliefs are those coming from lineages who observed expected outcomes more times than expected and also have sufficient experience exerting both high and low effort. Interestingly, it is being upwardly lucky which decreases estimates about the returns to effort the most. This might become a reinforcing behaviour for some lineages as by holding a low belief on the returns to effort they are more likely to not exert it, thus more likely to being upwardly lucky.

If we further consider that the cost of effort depends on the effort and income of the
parents, the reinforcing effect of beliefs is potentially higher. This results from the positive correlation between the cost of effort and the effort choices by predecessors. If an individual with a high cost decides to exert effort due to holding an extremely high belief then the chances of their descendants to have a low cost is higher.

On the assumption that widespread political disagreement is not beneficial to the economy then our findings suggest that we should be concerned about an increasing segregation. That is because an increasing segregation is expected to lead to accruing disagreements over variables which are fundamental to policy questions. We should expect higher disagreements with respect to the relative roles of effort and luck in determining incomes and this in turn has the potential of affecting debates about the optimal degree of redistribution in a society and how governments behave. Therefore policies that incentivize the formation of more diverse networks to all individuals are highly encouraged.

For example, our findings suggest, on the one hand, the promotion of volunteering and community service for high income individuals. On the other hand, it supports interventions that allow low income individuals to get to know the rich. In that regard, Rao (2013) presents evidence for India where privileged students studying in more diverse schools reveal a higher willingness to support redistribution policies. Therefore, one way could be by increasing socioeconomic integration in our learning environments (from kindergarten to universities) and other environments related to publicly provided services.
References


A Empirical analysis

In this appendix I provide detail on how we can study the relationship between segregation by income and responses that individuals give to questions related to the role of effort in determining economic success. The data about economic segregation comes from the American Communities Project, which includes several measures of segregation by family income made every decade from the 1970’s to 2011, and the Trends in Political Values and Core Attitudes 1987-2009 database by the Pew Research Center.

Measures about beliefs come from the Trends in Political Values and Core Attitudes–1987-2009 database by the Pew Research Center. This database consolidates multiple surveys made between 1987 and 2009 that aim to “understand the nature of American politics by tracking a broad range of beliefs and values that shape public opinion and ultimately influence voting behavior.” The database provides an array of statements and survey respondents are asked to state their level of agreement (or disagreement) in a four level likert scale that ranges from completely agree to completely disagree.

Statements include two questions of our interest. First, “[h]ard work offers little guarantee of success.” Second, “[m]any people today think that they can get ahead without working hard and making sacrifices.” However, the second statement was only read to a portion of the respondents. Additionally it includes statements related to the role of the government in helping people in need and beliefs of why people may remain being poor.

Before going into the analysis, one last issue has to be addressed. That is, how can one measure the level of disagreement when the variables are ordinal and not continuous. For this purpose I currently use the Dissimilarity index. This index captures how dissimilar are the answers between individuals. Figure A.1 presents the relationship between the level of income segregation and the level of disagreement for 18 metropolitan areas with 20 or more survey respondents.

The data suggests a positive relationship between the level of segregation and how much people disagree about the importance of effort in guaranteeing success.
Hard work offers little guarantee of success.

Figure A.1 – Relationship between the level of disagreement about the returns to effort and income segregation (20 or more respondents).

Nevertheless, given that the sample sizes for different metro areas vary, there might be a mechanical relationship between the sample size and the potential level of disagreement we can find. Therefore, I use bootstrapping to find what is the average effect of segregation once we keep the sample size equal. I estimate 500 regressions with randomly selected samples of 5, 10 and 20 respondents. The p-values reported correspond to the percentile in the distribution of estimates where zero, or the first negative estimate, is found. There is also the possibility that zero is not found, i.e. all estimates are positive, in which case I define as having a p-value < .01.

The analysis of the bootstrapped regressions find a positive and significant relationship when the sample is restricted to metro areas with 5 (n=107, p < .1), 10 (n=58, p < .1) and 20 (n=18, p < .01) respondents.