THE MACROECONOMIC CONSEQUENCES OF POVERTY AND INEQUALITY

by

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DISSERTATION ABSTRACT

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This dissertation examines the macroeconomic effects of poverty and inequality. The second chapter considers the effect of poverty and subsistence consumption constraints on economic growth in a two-sector occupational choice model. I find that in the presence of risk taking, subsistence consumption constraints result in a dramatic slow down in terms of economic growth. The third chapter (joint with Shankha Chakraborty) proposes a model in which agents face endogenous mortality and direct preferences over inequality. I find that the greater the scale of relative deprivation the worse the mortality outcomes are for individuals. The fourth chapter looks at the relationship between inequality and the demand for redistribution when individuals have social status concerns. I show that under social status concerns an increase in consumption inequality results in higher taxation and lower growth.

This dissertation includes unpublished coauthored material.

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CHAPTER I

INTRODUCTION

The topics of poverty and inequality have been of great interest to economists for many years. This dissertation focuses on the macroeconomic effects of the heterogenous behavior that results from poverty and inequality.

While the microeconomic consequences of poverty have been well documented in both empirical and theoretical studies, the macroeconomic consequences, especially on economic growth, are not as well understood. The fundamental problem is that most growth models are highly aggregated or assume a homogenous population. Also, these same models tend to assume away risk faced by individuals, which is of particular concern when discussing issues faced by the poorest members of society. Therefore, their relevance for developing countries with problems of acute poverty is suspect at best.

In contrast to the notion of poverty, inequality is by definition a macroeconomic outcome. The empirical and theoretical literature, typically looks at broad measures of inequality (e.g. the Gini coefficient) to understand how unequal distributions affect aggregate outcomes like growth, through prices and market access. These studies neglect the impact that inequality has on individual decisions when agents care directly about where they sit in the distribution. I endow individuals with preferences directly over inequality and by doing so I am able to investigate how inequality impacts macroeconomic outcomes like health, growth, and the demand for redistribution.

This dissertation is organized into four chapters. The second chapter deals with the impact poverty has on economic growth while the third and fourth investigate how inequality influences aggregate outcomes.

The second chapter presents a two-sector occupational choice model in which the extent and depth of poverty influence the aggregate outcome of the economy. Agents are bound by a subsistence consumption constraint and must face a risky move to find employment in the modern sector. The modern sector experiences learning-by-doing productivity growth that depends on the number of workers it employs. Agents' risk aversion is negatively related to their distance from the subsistence constraint. While there is no poverty trap and every one eventually ends up employed in the modern sector, the greater the extent of poverty the longer it takes for this equilibrium to be achieved.

The third chapter (joint work with Shankha Chakraborty) investigates a variant of Blanchard-Yaari's model of perpetual youth, in which agents have social aspirations that influence their decisions and an endogenous probability of survival that is determined by their health stock. This model is applied to the empirical literature on health and inequality in an attempt to explain two results: relative deprivation is detrimental to health and that the correlation between life expectancy and inequality has been weakening over time. The aggregate results between inequality and life expectancy show that the weakening correlation between these two variables can be explained by increases in income.

The fourth chapter of this dissertation presents a model that examines the relationship between inequality and the demand for redistribution. Much like the third chapter, agents are endowed with social aspirations that are determined by looking up the distribution of consumption. Each agent lives two periods and has a single offspring. Individuals have preferences over consumption and leisure and earn income from either running a firm as an entrepreneur or working for a wage. The government provides services which are financed through taxation, where the tax rate is determined by a median voter. I show that under social concerns, an increase in consumption inequality results in a higher tax rate on entrepreneurs. This higher tax rate results in lower aggregate growth because it reduces the returns associated with entrepreneurship.

CHAPTER II

SUBSISTENCE CONSUMPTION, OCCUPATIONAL CHOICE, AND THE COST OF POVERTY

Introduction

The consequences of poverty for an individual go far beyond having low levels of consumption. Numerous studies have documented the adverse social, emotional, biological, and intellectual effects of poverty. This paper focuses on one of the behavioral consequences of poverty: increased risk aversion. Although risk is a universal condition of humanity, its effects on an individual's standard of living are far from uniform. Risk and its consequences differ not only from profession to profession, but also from country to country and between levels of income. In this chapter I will examine how individuals' risk preferences influence aggregate outcomes like economic growth.

In developed countries, there are social safety nets or mechanisms that insure individuals against bad shocks (unemployment insurance, social security, etc). These safety nets or mechanisms are often lacking in developing countries. For instance, lower than expected amount of rainfall can usually be dealt with in a developed nation through the use of complex irrigation systems; in developing regions where rainfall is the only source of water for farmers, a shortage of water can be devastating.

Negative income shocks are particularly hard on individuals who are near subsistence. A loss of income will result in a reduction of already low levels of consumption. This could have many consequences, ranging from a loss of productivity due to malnutrition to outright starvation. Therefore, "gambles" taken on by individuals near the subsistence level of consumption are far riskier than for those who are not bound by this constraint. This implies that not only do the poor face more costly risk, but also that their attitudes toward risk will most likely differ from those in developed countries. If growth enhancing activities, like modern production techniques, embody risk, the poor will spend less time taking these actions.

The model presented in this chapter is a dual-sector occupational choice framework in which the agents choose between two technologies to produce a unique final good. The focus will be on whether the depth of poverty has any influence over the rate of structural change out of "traditional" modes of production into "modern" ones. It is important to note that there is no need for a relative price in this framework because there is only a shift in the way goods are produced not the composition of the goods that are produced. Because there is only one good in the model the increased production from the modern sector does not result in any relative price differences. Growth is determined endogenously by the number of workers in the modern sector through learning-by-doing.[1] This model differs from the standard endogenous growth framework because it allows for the agent's risk preferences to influence the aggregate outcomes.[2] The main consequence of this is that the distribution of income plays a role in the evolution of the economy.

This dual-economy framework has a long history in the literature, originating with Lewis' (1954) seminal work on the transition from traditional to modern production processes. This literature, much like this paper, contrasts a low

[1]This is similar to Matsuyama (1992), who depicts a two sector model with agriculture and manufacturing where growth in the manufacturing sector is given by a learning-by-doing externality.

[2]While it is true that agents do not have assets to lose, the consequence of falling below the subsistence level (death) is enough to ensure that agents do not take advantage of limited liability.

productivity, low growth traditional (or subsistence) sector with high productivity, high growth modern sector. More recent examples of this include Temple (2005) and Vollrath (2009). Both papers argue that dual-economies need to feature more prominently in the discussion of developing countries because they can address issues that the standard neoclassical model cannot. Also related to this paper are the models that stem from Harris-Todaro (1970). Like this paper, Harris-Todaro look at a binary occupational choice in terms of a migration decision in which agents chose between rural/informal and urban/formal employment. Recently, Bryan et al (2013) used a partial equilibrium version of the Harris-Todaro model with subsistence requirements to examine the decision to temporarily migrate. Their experimental evidence shows that subsistence requirements and the risks associated with migration significantly lowered an agent's willingness to migrate.

In the model presented below agents have preferences over their own consumption and the size of the financial bequest given to their single offspring. Their decisions are constrained by a subsistence consumption requirement that enters into the utility function. Agents earn income from wages and the return from their assets. The distribution of the work force is determined stochastically and workers in the modern sector of production must be skilled. Therefore, in order to enter the modern sector agents must pay a training cost, at which point they are stochastically matched with a job. If the agent is not matched in the modern sector she returns to production using traditional methods.[3]

This chapter has four main results. First, the presence of the subsistence requirement results in a loss in the generational growth rate of between 4 and 32

[3]Given that this is an OLG framework, the assumption that the individual has to fall back to the traditional sector after one failed attempt to enter the modern sector may seem extreme. However, Banerjee (1983) provides evidence in the case of migration that an agent who takes up employment in urban traditional sector is unlikely to move to the modern sector in the following period.

percentage points. This manifests in a reduction of output of 2-17% over the course of a generation.

Secondly, in this dynamic environment, unconditional cash transfers are strictly dominated by conditional cash transfers in terms of their impact on growth rates. In fact, funding an unconditional transfer through taxation results in a reduction of the generational growth rate by 2 to 9 percentage points, while funding the same transfer through aid dollars results in an increase of between 0.9 and 1.8 percentage points. In contrast, conditional cash transfers have a positive impact on generational growth rates of between 2 and 6 percentage points.

Third, if the modern sector is operating, it will eventually absorb all employment. However, the speed of convergence to this equilibrium depends negatively on the distance between the agents' consumption and the subsistence level. Moving to the modern sector is a risky endeavor, therefore the poorer agents are, the less likely they are to undertake it.

Note that the implication of this result is that there is no poverty trap. This finding is in contrast to a large literature that shows poverty traps can arise in the presence of incomplete borrowing markets, warm-glow bequest motives, and indivisible investments.[4] My model avoids a poverty trap by making the indivisible investment affordable to all agents and allowing for technological change that influences wages in both sectors. This technological progress allows for poor agents to increase their incomes enough so that they find it optimal to pay the fixed cost.

Finally, an increase in the depth of poverty (poverty gap) measured by the average consumption gap increases convergence time to full employment in the

[4]For examples see: Galor and Zeira (1993), Ghatak and Jiang (2002), and Mookherjee and Ray (2003).

modern sector. When there are fewer "rich" individuals, there will be fewer people working in the modern sector, which slows technological advancement.

Overall, the results of the model confirm this paper's premise: if the acquisition of technology (or any growth enhancing activity) is risky, poorer agents will undertake it at a lower rate. Or in a more aggregate sense, the extent and depth of poverty is negatively related to growth outcomes.

This paper is related to four literatures: subsistence consumption, risk-taking, barriers to technological adoption and structural change. Quite a bit of the literature dealing with subsistence consumption deals with what Schultz (1953) referred to as the "food problem." Two papers here are particularly relevant. Donovan (2012) uses subsistence consumption and exogenous idiosyncratic productivity shocks to examine cross-country agricultural productivities. The presence of subsistence consumption results in decreasing relative risk aversion which causes agents to use fewer intermediate inputs in their production process. His model accounts for two-thirds of the difference in intermediate income shares and the presence of risk increases per capita income differences between the richest and poorest countries by almost eighty percent. In contrast to Donovan, this paper looks at growth rates, and not only allows agents to choose their risk exposure, but to avoid it completely if they so desire.

The second paper in the subsistence consumption literature relevant here is Chatterjee and Ravikumar (1999). In their paper the authors evaluate the effect that subsistence consumption has on economic growth and the evolution of the wealth distribution. They show that when a subsistence constraint is included into a CRRA utility function, the inter-temporal elasticity of substitution is no longer constant. Instead, as consumption increases, the inter-temporal elasticity of substitution increases. The results of their paper regarding economic growth line up well with those presented later in this chapter. First, in both models the presence of the subsistence consumption constraint does not influence the steady-state growth rate, but it does cause the economy to converge asymptotically rather than immediately. The second similarity is that larger subsistence constraints result in longer transition paths to the steady-state. Differently from Chatterjee and Ravikumar, this chapter includes risk and shows how it can prolong this asymptotic convergence.

Moving onto the literature on risk aversion, the paper that most closely resembles this one is Sadler (2000) who finds that poverty traps are eliminated in the presence of a risk taking technology. Sadler assumes that there are two production technologies: traditional and modern. The modern production technology requires a large entry cost that is greater than the individual resources of an agent in the traditional sector. Therefore, Sadler introduces an actuarially fair lottery which allows a few agents to win enough so that they can pay the entry cost. Sadler goes on to show that as long as there is an infinitesimally small probability of entering the modern sector, agents will choose to engage in this lottery. My paper builds upon Sadler's model by adding a subsistence consumption constraint and making the cost of entry to the modern sector affordable to all agents.

Several examples in the development economics literature show that the poor engage in costly activities in order to avoid risk. Banerjee and Duflo (2009) and Binswanger and Rosenzweig (1993) both show that the poor engage in activities that limit their exposure to risk at the cost of lowering their incomes.[5] On the macro

[5]There are several experimental papers that show the importance of social networks in the process of technology adoption. These papers find that agents can minimize their exposure to risk by learning from the actions of others. For examples see Bandiera and Rasul (2006), Conley and Udry (2010), and Karlan et al (2013).

side, Acemoglu and Zilibotti (1997) consider how an inability to completely diversify risk affects economic growth. They use indivisible projects that keep agents from diversifying to show that market-incompleteness can hinder capital accumulation and growth.

Several barriers to adoption have been identified in the literature including: education (Nelson and Phelps, 1966, and Caselli, 1999), political resistance (Parente and Prescott, 1994), and inappropriate technologies (Atkinson and Stiglitz, 1969 and Acemoglu and Zilibotti, 2001). This research adds to the literature by including behavioral factors stemming from risk aversion close to subsistence.

The last related literature is that of structural change. Chanda and Dalgaard (2008) show that the relative efficiency between two sectors is determined by constraints on the distribution of resources and the relative level of technology. Both are features of the model in this chapter. This chapter is also related to those papers who consider the transition from the Malthusian growth regime to a modern one.[6] This literature, as well as this chapter, considers the transition from traditional production, low productivity methods to modern production.

This chapter proceeds as follows: section 2 presents the production/occupation side of the economy. Section 3 discusses the agent's preferences, while section 4 presents some analytical results. Computational results are found in section 5 and section 6 concludes.

[6] For examples of this literature see Lagerof (2003) and Galor and Weil (2000).

Production

Production Functions

The economy produces a unique final good using two different production processes. To fix ideas, these processes will be referred to as traditional and modern. The two sectors differ in three distinct ways: labor (endowed with idiosyncratic productivities), technology, and capital intensity. The traditional sector only requires unskilled workers to produce, while the modern sector uses skilled workers who have paid a training cost to enter the production process. Because the two sectors differ in their skill intensity, they also differ in their labor augmenting productivity. Specifically, they differ in the growth of their productivity. In the traditional sector it is assumed that all productivity increases have been realized and the technology level is fixed throughout time. However, in the modern sector, the skilled workers are assumed to be able to improve their productivity through learning-by-doing. Finally, the traditional sector is assumed to be less capital intensive as the modern sector. Explicitly, if θ is the capital share in the traditional sector and α is the capital share in the modern sector under competitive markets, I assume that $\alpha \geq \theta$. Equations (2.1) and (2.2) give the production functions.

$$Y_t^T = \Omega(K_t^T)^\theta (B\Phi_t^T)^{1-\theta} \tag{2.1}$$

$$Y_t^M = \Omega(K_t^M)^\alpha (A_t\Phi_t^M)^{1-\alpha} \tag{2.2}$$

where the superscripts M and T denote the modern and traditional sectors and Φ_t^j for $j \in \{T, M\}$ denotes the aggregate stock of human capital.[7] For simplicity

[7] The parameter Ω is used to calibrate the model to fit the data.

in what follows I will define: $\Phi_t^T = \bar{\phi}_t^T L_t$ and $\Phi_t^M = \bar{\phi}_t^M H_t$ where $\bar{\phi}_t^j$, $j \in \{T, M\}$, denotes the average productivity and L_t and H_t denote the stock of workers in the traditional and modern sector, respectively. Since the focus is on the behavior of individuals who live in developing countries, it is quite possible that the traditional sector requires very little capital. Note that as $\theta \to 0$, the traditional production function collapses to BL_t. Aggregate production is given by the sum of outputs:

$$Y_t = Y_t^M + Y_t^T$$

Labor Markets

Assume that each individual has a single offspring, which implies a fixed population N. The population can be decomposed into skilled labor (H_t) and unskilled labor (L_t).

$$N = L_t + H_t \tag{2.3}$$

In order to simplify computation, I will define λ_t as the proportion of workers who are employed in the modern sector. Solving for λ_t will implicitly provide the allocation of labor between the two sectors.

$$\lambda_t = \frac{H_t}{N}, \; 0 \leq \lambda_t \leq 1$$

Risk is introduced through the labor market: the labor markets for modern and traditional sectors differ in their ability to efficiently match workers to jobs. It is assumed that the labor market for the traditional sector is well developed, which means the matching technology in this sector is efficient and any individual seeking a job will find one. In contrast, the labor market in the modern sector is underdeveloped: not all workers seeking a job find one. Agents who are seeking employment in the modern sector must pay a training cost because the modern sector only employs skilled labor. Once the training cost is paid, agents are stochastically matched in the modern sector. If an agent fails to find a match to a production unit or firm in the modern sector, she returns to the traditional sector. As more individuals enter the modern sector, the labor market becomes more developed and the probability of a successful match will increase. This is given by:

$$p(\lambda_{t-1}) = \max\{\underline{p}, \lambda_{t-1}^{\xi}\}, \;\; \underline{p} > 0 \tag{2.4}$$

This formulation implies that even if there is no one working in the modern sector at $t-1$ there is still some chance that agents will successfully match. The parameter $\xi > 0$ determines the influence that congestion in the labor market and network effects have on the probability of successfully matching in the modern sector, and its value depends upon on beliefs as to when congestion is the biggest problem. If $\xi < 1$ so that the matching technology is concave, the congestion effect will dominate. On the other hand if $\xi > 1$ so that the matching technology is convex, positive network externalities are important. In the simulations that follow ξ will be chosen so that the matching technology is convex. Given the context of a developing country, it is likely that early on (when λ is small) the modern sector will be underdeveloped and therefore it will be much more difficult to find employment in, as opposed to later in the economy's history when the modern sector is running smoothly. It should be noted that the choice of ξ does not have qualitative effects on the results presented later.

Wages, Interest Rates, and Arbitrage

Since there are two sectors of production in this model, it implies that there are two different wages and two different rates of return on capital. As usual, both labor and capital earn their marginal products, given by:

$$w_t^M = (1-\alpha)\Omega(K_t^M)^\alpha A_t^{1-\alpha}(\bar{\phi}_t^M H_t)^{-\alpha} \tag{2.5}$$

$$w_t^T = (1-\theta)\Omega(K_t^T)^\theta B^{1-\theta}(\bar{\phi}_t^T L_t)^{-\theta} \tag{2.6}$$

$$R_t^M = \alpha\Omega(K_t^M)^{\alpha-1}(A_t\bar{\phi}_t^M H_t)^{1-\alpha} \tag{2.7}$$

$$R_t^T = \theta\Omega(K_t^T)^{\theta-1}(B\bar{\phi}_t^T L_t)^{1-\theta} \tag{2.8}$$

Arbitrage in investment in the two sectors pins down a unique rate of return as long as both production sectors are active (if one sector is inactive the rate of return is given by either equation (2.7) or (2.8)). Since capital is fully mobile, $R_t^M = R_t^T$. Setting equation (2.7) equal to (2.8), I can solve for the ratio of the capital allocated to the two sectors.

$$\frac{(K_t^T)^{1-\theta}}{(K_t^M)^{1-\alpha}} = \frac{\theta}{\alpha}\frac{B^{1-\theta}}{A_t^{1-\alpha}}\frac{(\bar{\phi}_t^T)^{1-\theta}}{(\bar{\phi}_t^M)^{1-\alpha}}\frac{(1-\lambda_t)^{1-\theta}}{\lambda_t^{1-\alpha}}N^{\alpha-\theta} \tag{2.9}$$

Defining, $K_t = K_t^M + K_t^T$ and using (2.9), I can write the amount of capital allocated to each sector as:

$$\frac{(K_t - K_t^M)^{1-\theta}}{(K_t^M)^{1-\alpha}} = \frac{\theta}{\alpha}\frac{B^{1-\theta}}{A_t^{1-\alpha}}\frac{(\bar{\phi}_t^T)^{1-\theta}}{(\bar{\phi}_t^M)^{1-\alpha}}\frac{(1-\lambda_t)^{1-\theta}}{\lambda_t^{1-\alpha}}N^{\alpha-\theta} \tag{2.10}$$

which implicitly solves for K_t^T (a closed-form solution does not exist for $\alpha \neq \theta$). It is clear from equation (2.10) that increases to A_t and λ_t result in an increased allocation of capital to the modern sector.

Technology

As mentioned above the two production sectors differ in their labor augmenting technology. The traditional sector has a constant technology of B, while the modern sector experiences technological growth and the time t stock is given by A_t. The learning-by-doing externality is proportional to the percentage of the labor force employed in the modern sector and the average productivity of those workers. Technological growth is given by:

$$\frac{A_{t+1} - A_t}{A_t} = g(\lambda_t, \bar{\phi}_t^M),\ g(\lambda, 0) = 0,\ g(0, \bar{\phi}_t^M) = 0\ g_1(\cdot,\cdot) > 0, g_2(\cdot,\cdot) > 0 \qquad (2.11)$$

In the simulations that are presented in section 5, I assume the following functional form for (2.11):

$$g(\lambda, \bar{\phi}^M) = \eta\lambda^{\omega}(\bar{\phi}^M)^{1-\omega}$$

where η pins down the long-run growth of the economy when $\lambda = 1$ and $0 < \omega \leq 1$ determines the relative importance of the average skill of the workforce in the modern sector.

Households

This economy is populated by a large number of one-period households that transfer financial bequests and occupational skills to their single off-spring. While the transfer of occupational skills in the traditional sector is not controversial because the labor market is perfectly efficient, the ability of parents in the modern sector to do so requires explanation since their labor market is not perfect. The assumption of transferability is made for two reasons. First, skilled parents tend to raise skilled children (meaning that their training cost is lower if not zero) and second because the parent works in the modern sector they have better connections and are able to secure jobs for their children.[8]

Preferences

Altrusitic households have preferences over own consumption and the size of the financial bequest passed on to the next generation. Preferences are given by:

$$U_{it} \equiv (1-\gamma)u(c_{it}-\bar{c}) + \gamma v(a_{it+1}) \tag{2.12}$$

where $\bar{c} > 0$ is the subsistence consumption constraint, c_{it} is stochastic consumption, and a_{it+1} is agent i's bequest level. The subsistence consumption constraint, $\bar{c}$, can be thought of as the expenditures on food, clothing, and housing that are essential for survival. Both $u(\cdot)$ and $v(\cdot)$ are assumed to take the CRRA functional form:

$$\begin{aligned} u(c_{it}-\bar{c}) &= \begin{cases} \frac{(c_{it}-\bar{c})^{1-\sigma}}{1-\sigma} & \text{if } c_{it} \geq \bar{c} \\ -\infty & \text{otherwise} \end{cases} \\ v(a_{it+1}) &= \frac{a_{it+1}^{1-\sigma}}{1-\sigma} \end{aligned} \tag{2.13}$$

Before moving onto the household's optimization problem, I briefly note how the subsistence consumption constraint influences risk aversion and choices. Typical

[8] Banerjee (1983) shows that a good deal of employment in the urban modern sector comes about because of interpersonal connections.

measures of risk aversion include relative (r_R) and absolute (r_A). When using the standard CRRA preference structure, these measures are $r_R = \sigma$ and $r_A = \sigma/c$. However, once a subsistence constraint is included in the preference structure, these measures of risk aversion change to:

$$r_A(c) = \frac{\sigma}{c - \bar{c}}, \; r_R(c) = \frac{\sigma c}{c - \bar{c}}$$

The main difference between these measures of risk aversion and the standard ones is that $r_R(c)$ depends on the level of consumption. In fact, relative risk aversion approaches infinity as consumption goes to the subsistence level. This implies that as agents approach destitution, they will be more conservative with the risks that they take. Decreasing relative risk aversion is consistent with the evidence presented by Ogaki and Zhang (2001).

Budget Constraint

Agents earn income from two sources, wages (w_t^j) $j \in \{T, M\}$ and the return on their parents' financial bequest ($R_t a_{it}$). This income is allocated towards consumption, financial bequests and the training cost. Agents can costlessly remain in the sector that employed their parents. This can be thought of as children inheriting some sort of sector-specific human capital, or as a social network effect. For instance, the children of agents who are already employed in the modern sector may already know the employers, and therefore, do not have to pay a cost to signal their desire to enter. This is similar to Song et al's (2011) assumption that children inherit the entrepreneurial skills of their parents. This assumption has no meaningful effect on both the analytic and computational results presented in this paper. As noted above, moving to the modern sector from the traditional sector requires a training cost that I will denote, $\bar{x}$ (going the opposite direction is costless). This implies that the agent has effectively two choices to make: switching to the other sector and the size of bequest left to her offspring. Therefore, the budget constraint can be written as:

$$c_{it} = \phi_i w_t^j + R_t a_{it} - h_{it}\bar{x} - a_{it+1} \tag{2.14}$$

where

$$h_{it} = \begin{cases} 1 \text{ if the agent attempted a move to the modern sector} \\ 0 \text{ otherwise} \end{cases} \tag{2.15}$$

and ϕ_i is agent i's idiosyncratic productivity.

Finally note that an agent born at time t first decides whether or not to attempt to a switch into the modern sector, then realizes the outcome of her job search, after which she sets her level of bequest and consumes the remainder of her income.

Optimization

Using the functional form of (2.13) and the budget constraint given in (2.14), I get the following optimization problem for agent i with labor productivity ϕ_i and initial assets a_{it} is:

$$\max_{h_{it},a_{it+1}} E_t(1-\gamma)\frac{(\phi_i w_t^j + R_t a_{it} - h_{it}\bar{x} - a_{it+1} - \bar{c})^{1-\sigma}}{1-\sigma} + \gamma\frac{a_{it+1}^{1-\sigma}}{1-\sigma} \tag{2.16}$$

First consider the bequest decision. There are four different types of households. Defining:

$$\Gamma \equiv \left(\frac{\left(\frac{\gamma}{1-\gamma}\right)^{\frac{1}{\sigma}}}{1 + \left(\frac{\gamma}{1-\gamma}\right)^{\frac{1}{\sigma}}} \right)$$

the first order conditions for a_{it+1} are:

- $a_{it+1}^{M} = \Gamma(\phi_i w_t^M + R_t a_{it} - \bar{c})$ for those households already in the modern sector.
- $a_{it+1}^{MX} = \Gamma(\phi_i w_t^M + R_t a_{it} - \bar{x} - \bar{c})$ for those households who are new to the modern sector.
- $a_{it+1}^{TX} = \Gamma(\phi_i w_t^T + R_t a_{it} - \bar{x} - \bar{c})$ for those households who failed to move to the modern sector.
- $a_{it+1}^{T} = \Gamma(\phi_i w_t^T + R_t a_{it} - \bar{c})$ for those households who did not attempt a move to the modern sector

Moving onto the occupation decision. Note that for an agent to be willing to switch to the modern sector, $\phi_i w_t^M - \bar{x} > \phi_i w_t^T$, therefore any agent whose parent is in the modern sector would have lower income if she moved to the traditional sector. This means that it is never optimal for an agent to switch from the modern sector to the traditional. Therefore, the only choice that needs to be examined is the move from the traditional to the modern sector. Since occupational choice is not a continuous variable, I will solve a linear programing problem to compare the expected utility from changing occupations, U^S, to the expected utility from remaining in the same occupation, U^R. Substituting in the appropriate first order conditions for a_{it+1}, the expected lifetime utility can be written as:

$$
\begin{aligned}
E_t U_{it}^S = &\Big((1-\gamma)u\left((1-\Gamma)(\phi_i w_t^M + R_t a_{it} - \bar{x} - \bar{c})\right) \\
&+\gamma v\left(\Gamma(\phi_i w_t^M + R_t a_{it} - \bar{x} - \bar{c})\right)\Big)\, p(\lambda_{t-1}) \\
&+\Big((1-\gamma)u\left((1-\Gamma)(\phi_i w_t^T + R_t a_{it} - \bar{x} - \bar{c})\right) \\
&+\gamma v\left(\Gamma(\phi_i w_t^T + R_t a_{it} - \bar{x} - \bar{c})\right)\Big)\,(1 - p(\lambda_{t-1}))
\end{aligned} \tag{2.17}
$$

and

$$
U_{it}^R = (1-\gamma)u\left((1-\Gamma)(\phi_i w_t^T + R_t a_{it} - \bar{c})\right) + \gamma v\left(\Gamma(\phi_i w_t^T + R_t a_{it} - \bar{c})\right) \tag{2.18}
$$

Agents will attempt to move from the traditional to the modern sector if $U_{it}^S > U_{it}^R$.

Analytical Results

Since a closed-form solution for the optimal allocation of capital does not exist (except for the special case $\alpha = \theta$), I will rely on computational methods. However, something can be said about the evolution of capital and the output growth rate without special assumptions. The bequests are invested and become the capital used in period t: $K_t = \sum_{i=1}^{N} a_{it}$, which can be split up into financial bequests given by parents in the modern sector and those given by parents in the traditional sector. After making this separation, it is possible to average the bequests across individuals in each sector. Therefore the aggregate capital stock can be written as:

$$
K_t = H_{t-1} a_t^M + L_{t-1} a_t^T
$$

where $a_t^j = \Gamma(\bar{\phi}_t^j w_{t-1}^j + R_{t-1}a_{t-1}^j - \bar{c})$ for $j = T, M$.[9] Because production is given by a constant returns to scale function, K_t can be written as:[10]

$$K_t = \Gamma(Y_{t-1} - \bar{c}N) = \Gamma N(y_{t-1} - \bar{c}) \tag{2.19}$$

where y denotes aggregate output per capita. Using equation (2.19) the growth of the aggregate capital stock is given by:

$$\frac{K_{t+1}}{K_t} = \frac{Y_t - \bar{c}N}{Y_{t-1} - \bar{c}N} = \frac{y_t - \bar{c}}{y_{t-1} - \bar{c}} \tag{2.20}$$

Equation (2.20) implies that the growth of the capital stock is determined by the distance between per capita income and the subsistence level.

Now I consider two potential steady-states: $\lambda^* = 0$ and $\lambda^* = 1$. Starting with $\lambda^* = 0$, aggregate production can be written as:

$$Y_t = (K_t)^\theta (B\bar{\phi}N)^{1-\theta}$$

This implies that the growth factor of output can be given by:

$$\frac{Y_{t+1}}{Y_t} = \left(\frac{K_{t+1}}{K_t}\right)^\theta$$

[9] This formulation requires that no one is attempting a switch. This assumption is inconsequential because the following discussion will only consider steady-states.

[10] This can be seen by recognizing that $H_{t-1}a_{t-1}^M + L_{t-1}a_{t-1}^T = K_{t-1} = K_{t-1}^M + K_{t-1}^T$. Distributing the capital accordingly and noting that $R_{t-1} = R_{t-1}^M = R_{t-1}^T$, we can write the capital equation as:

$$\begin{aligned} K_t &= \Gamma\left[H_{t-1}\phi_{t-1}^M w_{t-1}^M + R_{t-1}^M K_{t-1}^M + L_{t-1}\phi_{t-1}^T w_{t-1}^T + R_{t-1}^T K_{t-1}^T - \bar{c}N\right] \\ &= \Gamma[Y_{t-1}^M + Y_{t-1}^T - \bar{c}N] = \Gamma[Y_{t-1} - \bar{c}N] \end{aligned}$$

Substituting in (2.20) into the above equation yields:

$$\frac{Y_{t+1}}{Y_t} = \left(\frac{Y_t - \bar{c}N}{Y_{t-1} - \bar{c}N}\right)^{\theta}$$

Defining $\chi_{t+1} = \frac{Y_{t+1}}{Y_t}$. Then, the above equation can be written as:

$$\chi_{t+1} = \left(\frac{\chi_t - \frac{\bar{c}N}{Y_{t-1}}}{1 - \frac{\bar{c}N}{Y_{t-1}}}\right)^{\theta}$$

It is clear that $\chi_{t+1} = \chi_t = 1$ solves the above equation. In order for this to be a steady-state in λ the additional constraint that no one desires to switch production technologies at time t must also be imposed. Under this constraint, no one attempts a switch in t and because the growth rate of output is zero (hence the wage and rate of return are constant as well), no one will attempt a switch in $t+1$.

For the other steady-state where $\lambda^* = 1$, aggregate production is given by:

$$Y_t = (K_t)^{\alpha}(A_t \bar{\phi} N)^{1-\alpha}$$

Using the steps outlined above, I can write down the following dynamic system in χ:

$$\chi_{t+1} = \left(\frac{\chi_t - \frac{\bar{c}N}{Y_{t-1}}}{1 - \frac{\bar{c}N}{Y_{t-1}}}\right)^{\alpha}(1 + \eta\bar{\phi}^{1-\omega})^{1-\alpha}$$

where $\eta\bar{\phi}^{1-\omega}$ is the growth rate of technology. In a balanced growth path as $Y_{t-1} \to \infty$, the dynamic system collapses to:

$$\chi_{t+1} = \chi_t^{\alpha}(1 + \eta\bar{\phi}^{1-\omega})^{1-\alpha}$$

This system is solved by the constant value: $\chi = (1+\eta)\bar{\phi}^{1-\omega}$. In order to achieve this steady-state level of growth, output needs to be increasing over time, therefore, outside of the limiting case, χ_t must satisfy:

$$\chi_t > \frac{1 - \frac{\bar{c}N}{Y_{t-1}}}{(1+\eta\bar{\phi}^{1-\omega})^{\frac{1-\alpha}{\alpha}}} + \frac{\bar{c}N}{Y_t - 1}$$

where the RHS is less than 1.[11] This condition will most likely hold, because if an economy with zero technological growth can achieve constant output, it is reasonable to think that an economy with constant technological growth will be able to achieve it as well. It is trivial to show that $\lambda^* = 1$ is a steady-state because, by construction, once a household is in the modern sector, they will not switch back.

Quantitative Results

Computational methods are necessary to understand the dynamics of the model. This section presents some numerical results that center on four questions:

- What role does subsistence consumption play in the movement of agents from the traditional sector to the modern one?
- What role does the distribution of income play in convergence to full employment in the modern sector?
- What are the welfare consequences of the subsistence constraint?
- Which policies bring about the fastest rate of convergence to full employment in the modern sector?

[11]This condition is found by setting the dynamic system for output growth equal to 1.

Parameters

There are seventeen parameters that need to be calibrated. The first set of parameters are the capital shares associated with production in the traditional and modern sectors. For these I rely on parameter estimates from three sources: Caselli and Feyrer (2007), Gollin (2002), and Guerriero (2012).[12] Starting with the Caselli and Feyrer paper, the authors make the argument that the capital share that is normally reported in the literature does not accurately represent the capital share used in theoretical models. Their concern is that the measure of capital used in the theoretical literature is mainly of reproducible capital, while the empirical estimates include both reproducible and non-reproducible capital.[13] Therefore the authors adjust a country's overall capital to include only reproducible capital and report these estimates for 53 countries. Using their method, I adjust the estimates found in Gollin, Guerriero, and the OECD data website so that they only reflect the share of income associated with reproducible capital. The complete data set is available in the appendix. Table 1 shows the averages grouped by the World Bank income classifications.

	Caselli & Feyrer	Gollin	OECD	Guerriero
Low Income	0.029 (1)	—	—	—
Low-Middle Income	0.152 (10)	0.094 (4)	—	0.124 (8)
High-Middle Income	0.193 (15)	0.183 (4)	0.256 (5)	0.176 (25)
High Income Non-OECD	0.219 (4)	0.3 (1)	0.246 (1)	0.172 (6)
OECD	0.196 (23)	0.201 (14)	0.235 (24)	0.175 (21)

The number of countries in each group is in parentheses

TABLE 1. Capital Shares By Income Group

[12]There is a fourth source from the OECD data website. The data available from this source does not include developing countries, therefore it is only used for a robustness check.

[13]This would conceivably result in large estimated capital shares for developing countries whose primary means of income revolve around natural resources.

Given the set-up of the model, the capital shares reported in table 1 are clearly an amalgamation of the shares in the traditional and modern sectors and do not directly correspond to either θ or α. The model does imply that poorer countries have lower capital intensities, therefore using the capital shares on the lower-end of the income distribution for the traditional sector and the OECD estimates for the modern sector should provide a good proxy for reality.

Since only one estimate is available for a county in the lowest income bracket, I set the share of capital in the traditional sector to estimates for low-middle income countries. Likewise the capital share for the modern sector is given by the OECD estimate. Because three of the studies provide capital shares for both the low-middle income countries and OECD countries each pair will be used in the baseline simulations.[14]

Several parameters do not have empirical counter-parts. The population, N, is a scaling parameter and set at 10,000 in order to avoid any small sample problems. $\underline{p}$ is set at 0.2 which allows for a rather large success probability for a nascent modern sector while the matching technology is assumed to be convex with $\xi = 2$.[15] The preference share γ is set so that the bequests are large enough to ensure $c_{it} > \bar{c}$ and the training cost is constant across simulations and is set so that even the poorest agent can afford to pay it and still satisfy her subsistence constraint (the parameterization implies a value of 28 rupees). The labor augmenting technology in the traditional sector is normalized to 1 and the initial technology in the modern sector is set at 1.2. As for the growth rate of technology, η is set so that the long-run

[14] The simulations are also run using a fixed capital share for the modern sector (the estimate from the OECD dataset), the results do not differ qualitatively from those presented in the paper.

[15] Appendix B provides a robustness check for ξ and $\underline{p}$.

generation growth rate annualizes to 2% and ω is set at .75.[16] Finally, Chatterjee and Ravikumar (1999) use estimates from Ogaki and Atkeson (1997) and Rosenzweig and Wolpin (1993) to show that subsistence consumption makes up between 58% and 80% of total consumption.[17] Therefore the subsistence constraint is set using these estimates and the model is calibrated (Ω is set) to match the consumption data presented in Townsend (1994). In the results presented in this paper, I assume $\sigma = 1$ which is close to the value used in Chatterjee and Ravikumar.[18] Finally, the length of a generation is assumed to be 35 years.

The last step is to set the distribution for the idiosyncratic productivities. Because I must ensure that all agents can satisfy their subsistence constraint, a Pareto distribution is used. The minimum productivity is set at 2.65 with the spread parameter set at 7.5. These parameters are chosen because increasing the spread any larger causes the poor agents' incomes to fall below the line in which they are able to afford both their subsistence constraint and the training cost.

Baseline Results

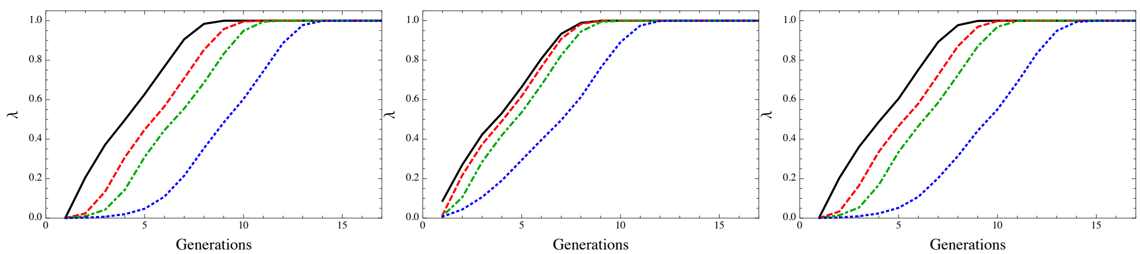
The simulation results presented in this section are calculated using four different values for $\bar{c}$. Two of these values come from the empirical literature and correspond to 58% and 80% of consumption. The third value corresponds to 69% of consumption and is chosen to to determine whether the results are linear in the constraint or if they are more extreme for larger values of $\bar{c}$. Finally, the value $\bar{c} = 0$ is used to

[16]The results are robust to a wide variety of choices for these parameters.

[17]It should be noted that Ogaki and Atkeson (1997) state that the consumption data used to estimate the subsistence parameter do not include housing and transportation.

[18]The qualitative results are robust to different choices for σ.

contrast the effect of subsistence consumption. Figure 1 presents the results for λ in these baseline simulations.



(a) Caselli & Feyrer (b) Gollin (c) Guerriero

FIGURE 1. The evolution of the percentage of the workforce employed in the modern sector across time for the baseline calibration. Each panel represents different capital share estimates for the modern and traditional sectors.
$\bar{c} = 0$: *Solid/Black,* $\bar{c} = 58\%$: *Dashed/Red,* $\bar{c} = 69\%$: *Dashed-Dot/Green,* $\bar{c} = 80\%$: *Dotted/Blue*

Regardless of the values chosen for the capital shares, the closer agents are to their subsistence constraint, the longer it takes for the economy to reach full employment in the modern sector. The time to convergence is increasing with the level of subsistence because those agents whose constraint represents 80% of their total consumption will be significantly more risk adverse than the agents whose constraint is only 58%, which results in less risk taking on average. Before looking at the impact that the subsistence requirement has on growth, I want to further discuss the effect that the capital intensities have on convergence to full employment in the modern sector.[19] The pictures in figures 1a and 1c are quite similar in terms of the path to convergence, and looking back at table 1 this should not be surprising because the estimates found in Caselli/Feyrer and Guerriero are quite similar. Figure 1b, however exhibits a much more direct path to convergence than the other simulations. The only difference between the three simulations is that ratio of capital shares

[19]Note that given the parameter choices and functional forms described above, the economy always converges to a unique stationary equilibrium where only the modern sector is active.

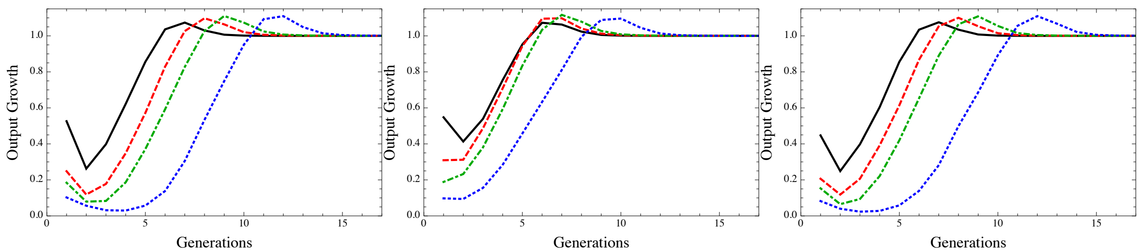
is significantly higher with the Gollin estimates. This affects the transition path because the ratio of capital shares influences the capital allocated to each sector. A larger capital share ratio not only results in more capital being allocated to the modern sector (resulting in higher wages), it also mitigates the effect that capital leaving the traditional sector has on traditional wages. In other words, the capital shares under the Gollin estimates result in higher wages in both the modern and traditional sectors, thus making a switch optimal sooner.

Figure 1 also shows the implications of incomplete markets: that agents carefully diversify their idiosyncratic risk. In a two-sector model without a subsistence constraint and risk, the model would predict a path similar to the black-solid line in the graphs shown in figure 1. This would lead the researcher to conclude that modernization is both imminent and immediate. In contrast, this model implies that there is a prolonged build up towards full fledged industrialization (full employment in the modern sector).

The evolution of λ is not the only variable of interest. Figure 2 shows the growth rates of output for the different estimations of the capital shares and subsistence requirements.[20] There are a couple of noteworthy results. First, during the transition to full employment in the modern sector, output growth overshoots the long-run growth rate. This happens because soon after a complete switch the economy not only gets a boost from the increased technology associated with skilled workers, but also the added increase from the subset of workers who are employed in the modern methods in the current period, but used traditional techniques in the previous period. This is an empirically appealing result of the model, as countries that are rapidly

[20]The initial decline in output growth is a result of the economy adjusting from the initial condition.

developing often have growth rates above what is considered sustainable in the long-run. A prime example of such a pattern may be China.



(a) Caselli & Feyrer (b) Gollin (c) Guerriero

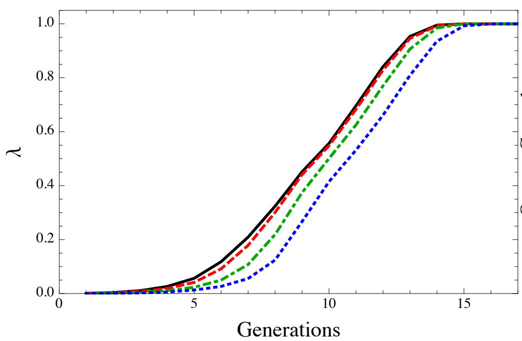
FIGURE 2. The evolution of output growth across time for the baseline calibration. Each panel represents different capital share estimates for the modern and traditional sectors.
$\bar{c} = 0$: *Solid/Black*, $\bar{c} = 58\%$: *Dashed/Red*, $\bar{c} = 69\%$: *Dashed-Dot/Green*, $\bar{c} = 80\%$: *Dotted/Blue*

While these spikes in output growth are an interesting feature of the model, just about any two-sector framework will produce a growth rate that is higher than the long-run during the transition phase. What makes this model different is the delay in this spike. Looking at figure 2, it is clear that the simulation that does not impose a subsistence constraint immediately produces this spike in output growth, while the peak is significantly delayed under the constraint.

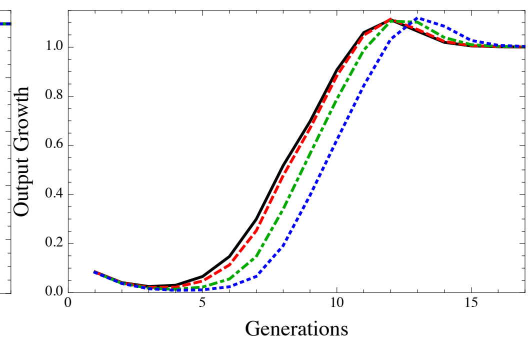
Consequences of Poverty

At this point it is natural to ask: what happens when the extent of poverty increases? In other words, how do the results from the previous section change when the standard deviation of the idiosyncratic productivities decreases? Answering this question will allow me to determine what happens when two economies do not differ in their α, θ, or $\bar{c}$ but in their wealth (income) distributions.

In order to determine the consequences of having a larger proportion of the population in poverty, the productivity will be drawn from a Pareto distribution that maintains the same mean as the baseline simulation, but whose standard deviations represent 85, 70, and 56 percent of the baseline simulation's standard deviation. This will push a higher percentage of the population toward the subsistence constraint. Figure 3 plots the evolutions of λ and the growth rate of output for the Guerriero parameter estimates and $\bar{c} = 80\%$.[21]



(a) λ



(b) Output Growth

FIGURE 3. The Consequences of Poverty. Each line represents a different spread of the underlying idiosyncratic productivity distribution. The reported standard deviations are given as a percentage of the baseline.
Std: 1–Solid/Black, Std: 85%–Dashed/Red, Std: 70%–Dashed-Dot/Green, Std: 56%–Dotted/Blue

Ultimately, the results presented in figure 3 should not be that surprising. It is clear that the result of having a higher density of poverty is a lower proportion of individuals in the modern sector, which drives the low growth outcomes. This is exactly what one would expect from this model. The greater the population density around the poor income level, the fewer the number of agents who are willing to take on the risk of moving to the modern sector. As suggested by the previous results,

[21]These parameters were chosen because they clearly illustrated the effect poverty has on the transition path. The results do not differ qualitatively with other parameterizations.

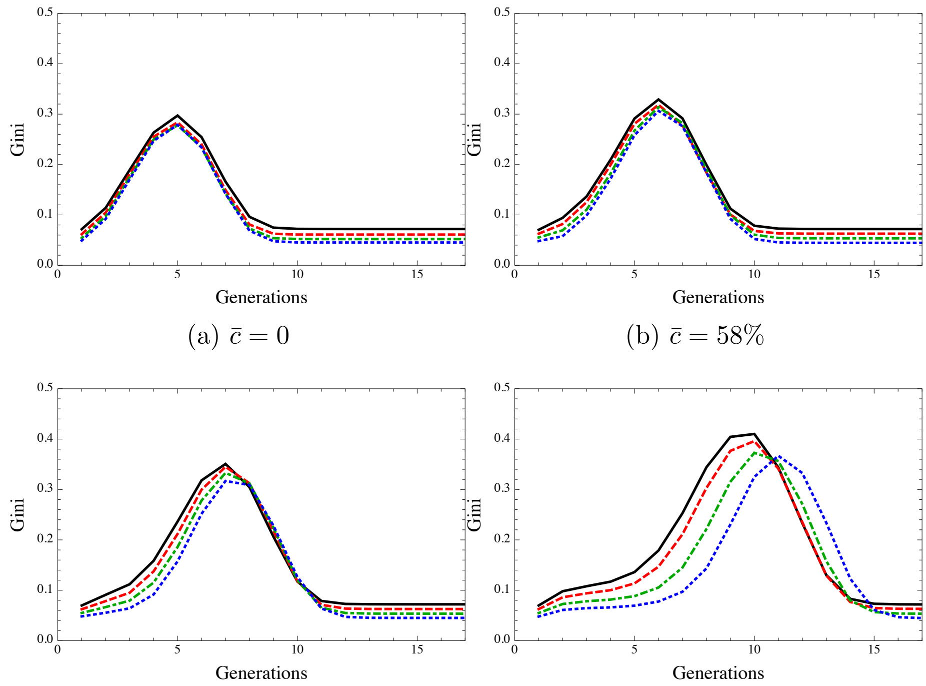
this will result in a prolonged time to convergence to full employment in the modern sector. The results so far imply that the chief determinants for the length of the transition period are: proximity to the subsistence constraint, the capital shares in both sectors, and the distribution of income.

Inequality

Consider next the implications for inequality. First, in figure 4, I present the results by subsistence level with each line representing a different concentration of poverty. Figure 4 clearly depicts a Kuznets curve with inequality increasing during the transition period only to return to a lower level once everyone is employed in the modern sector. The more important part of these graphs is that inequality is uniformly lower for economies with less heterogeneity. In other words, those economies who have a smaller dispersion of individual productivities, also experience a smaller increase in inequality during the transition from traditional to modern production methods.

Figure 5 looks at the results in a slightly different manner. Rather than looking across subsistence levels, figure 5 looks at the Gini coefficient across concentrations of poverty with each of the lines representing a different subsistence constraint. There is a distinct pattern in figure 5 which shows that inequality is lower for those economies that start further away from their subsistence constraint regardless of the concentration of poverty. This is because economies with lower subsistence requirements do not have as many agents "stuck" with traditional methods because their risk profiles do not allow for an attempted switch. [22]

[22] The results presented in figures 4 and 5 line up well with those found in Atolia et al (2012).



(a) $\bar{c} = 0$ (b) $\bar{c} = 58\%$

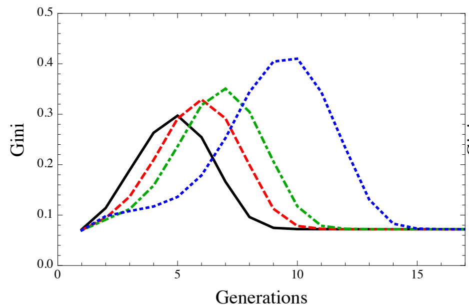
(c) $\bar{c} = 69\%$ (d) $\bar{c} = 80\%$

FIGURE 4. The Gini Coefficient for income plotted across time for different levels of subsistence consumption. Each line represents a different spread of the underlying idiosyncratic productivity distribution. The reported standard deviations are given as a percentage of the baseline.
Std: 1–Solid/Black, Std: 85%–Dashed/Red, Std: 70%–Dashed-Dot/Green, Std: 56%–Dotted/Blue

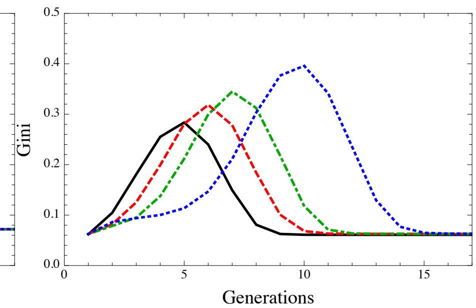
Overall the inequality results help explain how countries can experience rapid economic growth with only a slight increase in the level of inequality. It could be that these countries that are an apparent affront to the Kuznets curve, do not experience the rise in the Gini coefficient because they are either (a) relatively homogenous, (b) further from their subsistence constraints, or (c) some combination of (a) and (b).

Welfare

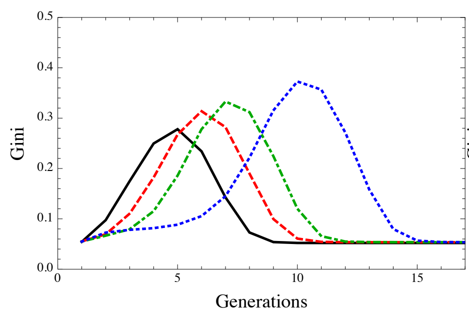
To quantify the welfare implications of subsistence consumption requirements, I will use the metric of loss in average generational growth rates. The case with



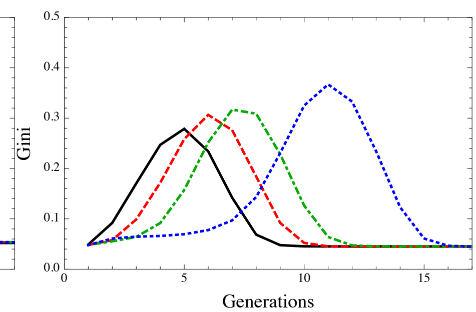
(a) Std : 100%



(b) Std : 85%



(c) Std : 70%



(d) Std : 56%

FIGURE 5. The Gini Coefficient for income plotted across time for different underlying productivity distributions (where the standard deviations are reported as a percentage of the baseline). Each line represents a different subsistence consumption level.
$\bar{c} = 0$: *Solid/Black*, $\bar{c} = 58\%$: *Dashed/Red*, $\bar{c} = 69\%$: *Dashed-Dot/Green*, $\bar{c} = 80\%$: *Dotted/Blue*

$\bar{c} = 0$ is considered the benchmark and table 2 reports the difference between the benchmark and each of the subsistence consumption levels.[23]

The loss in generational growth ranges from 4 to 32 percentage points. This implies that over the course a generation, the existence of a subsistence constraint results in total output being 2-17% lower than the benchmark case. It should be noted that the Caselli/Feyrer and Guerriero estimates for the capital shares are fairly close and looking only at those numbers implies a reduction of total output of between 5-17% over the course of a generation.

[23]The elements in table 2 are calculated using: $g^{\bar{c}=j} - g^{\bar{c}=0}$ for $j \in \{58\%, 69\%, 80\%\}$.

α & θ Values	$\bar{c} = 0$	$\bar{c} = 58\%$	$\bar{c} = 69\%$	$\bar{c} = 80\%$
Caselli & Feyrer	0	-0.1186	-0.1872	-0.3059
Gollin	0	-0.0362	-0.0796	-0.1999
Guerriero	0	-0.0979	-0.1636	-0.3144

TABLE 2. Welfare Analysis–Growth Rate Change (Baseline): This table gives the generational change in the growth rate in comparison to the baseline with $\bar{c} = 0$ using the three sets of estimates for the capital shares and the baseline calibration parameters.

The above discussion of growth rate loss can be applied to the situation in which the income distribution varies across subsistence levels. Table 3 reports the growth loss associated with an increase in poverty (the parameter set is the same as in section 2.5).

Standard Deviation	$\bar{c} = 0\%$	$\bar{c} = 58\%$	$\bar{c} = 69\%$	$\bar{c} = 80\%$
100%	0	0	0	0
85%	0	0	-0.0128	-0.0127
70%	0	-0.0095	-0.0261	-0.0473
56%	0	-0.0115	-0.0406	-0.0885

TABLE 3. Welfare Analysis–Growth Rate Change (Cost of Poverty): This table gives the generational change in the growth rate in comparison to the baseline with $\bar{c} = 0$ using the three sets of estimates for the capital shares and the baseline calibration parameters.

It shows that the growth rate loss ranges from negligible to 9 percentage points. This implies a reduction of total output of between 0-5.6% over the course of a generation. These results are quite intuitive as the consequences of poverty increase as subsistence consumption becomes a larger share of total consumption. Consider the benchmark ($\bar{c} = 0$) case, one would expect the consequences of poverty to be zero when there is no notion of poverty in the model. While the reduction of growth rates for either the benchmark case or the simulations with different income distributions are not exceptionally large, they are economically significant when one considers the the dismal growth rates in many LDCs.

Policy

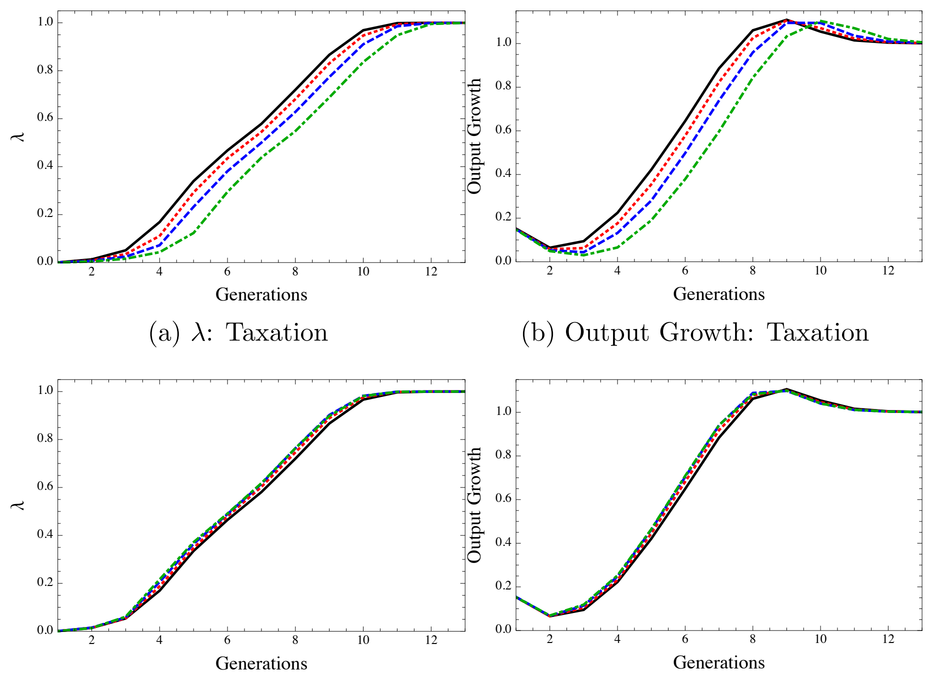
Given the welfare loss associated with delayed structural change, I conclude by discussing the possible policy implications. I show computationally in the appendix that the social planner would prefer to allocate all workers to the modern sector in the first period. It is only the agent's proximity to her subsistence constraint that limits her movement. Therefore if policy can be designed to provide more income to those agents in the traditional sector, it may speed up convergence to full employment in the modern sector.

Before discussing tangible policies, I will frame this problem in terms of an optimal cash transfer. There are two different approaches that can be taken in terms of financing the cash transfer: aid and taxation. The goal of this exercise is to judge the relative effectiveness of conditional (CCT) and unconditional cash transfers (UCT). Starting with the UCT, under this policy every agent will receive the same amount through the transfer and in the case of taxation every agent will be taxed at the same rate. Therefore under taxation, every agent will receive:

$$z_t = \tau(\bar{\phi}_t^M w_t^M \lambda_t + \bar{\phi}_t^T w_t^T (1 - \lambda_t))$$

where τ is the tax rate. If the unconditional cash transfer is financed by aid the agents will receive: $\zeta \times \bar{x}$, where $0 \leq \zeta \leq 1$ and $\bar{x}$ is the cost of switching.

Figure 6 presents the results of the simulations using an unconditional cash transfer. The results for this simulation are quite interesting. First, if the UCT is financed through taxation, this policy actually slows down convergence to full employment in the modern sector. The reason for this result is two fold: first, taxation lowers the return on switching to the modern sector by depressing the take home income. Secondly, the UCT raises the benefit from not attempting a switch because the agent receives the transfer regardless of her occupation decision. When the UCT is financed by aid, the results change so that the policy results in a (slightly) positive impact on both convergence to full employment in the modern sector and economic growth.



(a) λ: Taxation (b) Output Growth: Taxation

(c) λ: Aid (d) Output Growth: Aid

FIGURE 6. The Effects of an Unconditional Cash Transfer: This figure depicts the time paths of λ and output growth under an unconditional cash transfer financed by both taxation and aid.
Taxation–solid/black: $\tau = 0\%$, red/dotted: $\tau = 5\%$, blue/dashed: $\tau = 7.5\%$, green/dashed-dot: $\tau = 10\%$.
Aid–solid/black: $\tau = 0\%$, red/dotted: $\tau = 50\%$, blue/dashed: $\tau = 75\%$, green/dashed-dot: $\tau = 100\%$.

Moving away from the UCT, the conditional cash transfer will only be distributed to those agents who successfully find employment in the modern sector.[24] The advantage of designing the transfer in this way is that occupational location is largely observable and by conditioning on a successful employment I remove the potential for moral hazard problems. Under taxation, this policy is financed by imposing a proportional tax on the wages of those individuals who are already operating in the modern sector. Explicitly this is given by:

$$z_t = \tau w_t^M \bar{\phi}_{t-1}^M \left(\frac{\lambda_{t-1}}{\lambda_t - \lambda_{t-1}} \right)$$

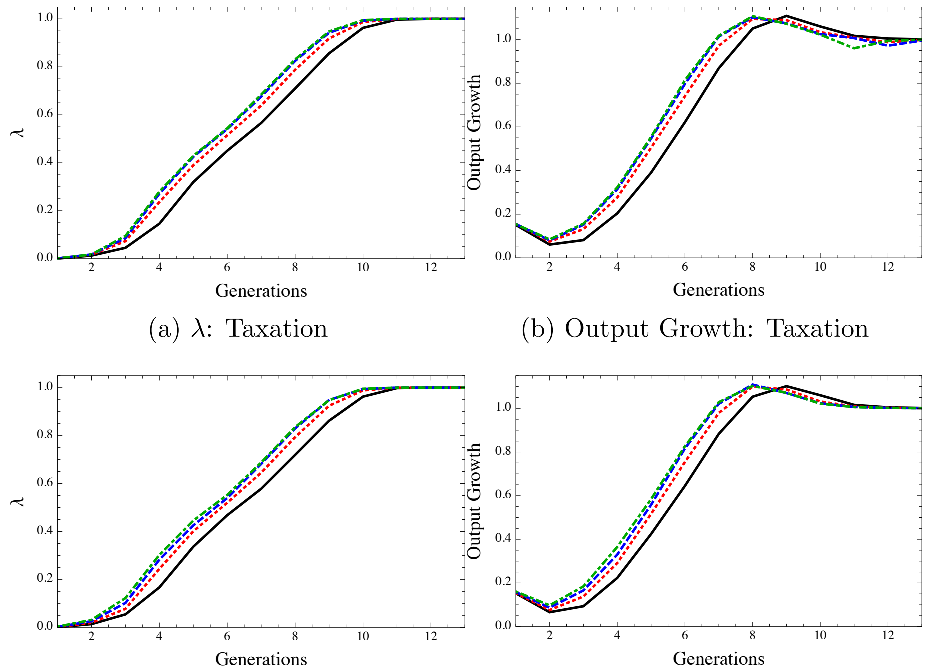
where the variables are as defined above. The CCT financed by aid is distributed in the same manner as the UCT.

Figure 7 presents the results of the CCT financed by both aid and taxation. The results for CCT are less surprising than the UCT, under both taxation and aid, convergence to the modern sector is faster than under the baseline.

The welfare effects of both types of cash transfers can be quantified using the same metric as above. Table 4 shows the change in the growth rates in relation to the baseline results. Clearly the CCT dominates the UCT regardless of the type of financing used. Comparing the two sets of results, the CCT results in growth rates that are at least 2.5 percentage points higher than the UCT.

This discussion on cash transfers shows results that are in-line with Mookherjee and Ray (2008) who compare unconditional cash transfers to conditional cash transfers. They argue that conditional cash transfers not only raise per capita output

[24] A CCT policy that does not depend on successfully finding employment in the modern sector was also analyzed (not reported). Such a policy results in a larger improvement in growth rates, but does open up the issue of moral hazard.



(a) λ: Taxation (b) Output Growth: Taxation

(c) λ: Aid (d) Output Growth: Aid

FIGURE 7. The Effects of a Conditional Cash Transfer: This figure depicts the time paths of λ and output growth under an unconditional cash transfer financed by both taxation and aid.
Taxation–solid/black: $\tau = 0\%$, red/dotted: $\tau = 5\%$, blue/dashed: $\tau = 7.5\%$, green/dashed-dot: $\tau = 10\%$.
Aid–solid/black: $\tau = 0\%$, red/dotted: $\tau = 50\%$, blue/dashed: $\tau = 75\%$, green/dashed-dot: $\tau = 100\%$.

but also have a positive welfare effect. In the unconditional setting, agents get stuck on "welfare" and do not have the incentive to invest in productive activities, the conditional transfer, however, counteracts this underinvestment by providing the right incentives. My paper highlights the need to consider poverty in a dynamic sense, showing that when individual decisions affect aggregate growth outcomes, unconditional transfers result in worse growth outcomes. This is particularly relevant given the on going discussion in the field as to the efficiency of unconditional cash transfers.

Taxation	Baseline	$\tau = 5\%$	$\tau = 10\%$	$\tau = 15\%$
UCT	0	-0.0248	-0.0493	-0.0921
CCT	0	0.0226	0.0347	0.0426
Aid	Baseline	$\zeta = 50\%$	$\zeta = 75\%$	$\zeta = 100\%$
UCT	0	0.0091	0.0166	0.0176
CCT	0	0.0346	0.0570	0.0664

TABLE 4. Welfare Analysis–Change in Growth Rate: Taxation

Conclusion

This chapter has contributed to the literature on dynamic poverty in two ways. First, it has shown that agents behave differently when they are near their subsistence constraint, especially in terms of risk taking. When risky activities are the same ones that are necessary for economic growth, poverty results in a substantial loss in output over the course of a generation.

The second contribution deals with how we interact with the poor in an attempt to lift them out of poverty. Conventional wisdom would suggest that unconditional cash transfers would be enough to move the poor far enough away from their subsistence level so that they would be willing to take on risk. However, this paper has shown that only under a system of conditional transfers does handing out cash to those in poverty actually result in the desired effects.

There are plenty of avenues of research for this topic. The main ones include: endogenizing the probability of a successful match through the entry and exit of firms. This would allow for a more in-depth study of the development of the modern sector. Another interesting possibility is to look at the role of education in greater detail and allowing for the training cost to be more involved than a simple cash payment.

CHAPTER III

INEQUALITY AS A HEALTH HAZARD

This chapter is based on joint work with Shankha Chakraborty. In its current form, I am responsible for the formalization and execution of the model, including both the analytical and computational results. Dr. Chakraborty is responsible for the idea that drives the paper as well as editorial and thematic guidance.

Introduction

Our perception of and tolerance for income inequality are shaped by how it affects our choices, behavior and welfare. While the economics literature in this area is deep, it has generally shied away from the notion that individuals care directly about inequality. They may do so because of social aspirations that are profoundly affected by how they fare relative to others. A body of research that does include such positional concerns is the literature on status seeking (sometimes called aspirations), though often, researchers assume identical decision-makers or behavior contingent on a common level of aspirations, typically the economy-wide average wealth or consumption.

This chapter starts from the premise that socially aware individuals care directly about inequality but departs from the literature in assuming social aspirations differ across individuals. More concretely, we assume that individuals have upward-looking aspirations: they pursue the living standards of those who are economically better off than them and this is as true of the rich as of the poor. We build on the Blanchard-Yaari model of "perpetual youth" (Blanchard, 1985; Yaari, 1965) and Grossman's (1972) work on health production. Individuals earn wage income from labor and annuitized returns on investment and they differ in their intrinsic labor productivity. They also differ in their social aspirations which is based on the reference group consisting of all individuals with consumption levels higher than theirs. An individual's utility depends negatively on how far below this reference group his current consumption falls.

We use this framework to study the main thesis of Wilkinson's (2002) book *The Unequal Society*, that inequality has a first-order effect on personal and population health since it promotes unhealthy behavior. To do so we assume that the production of health capital requires time investment in the form of leisure and consumption of health goods. Hence the decision to supply labor not only influences an individual's wage earnings and utility from leisure but also the evolution of his health stock. This health stock in turn determines the probability of surviving onto the next period.

We establish two main results. First, an individual's health declines as the measure of his relative deprivation (aspirations gap) increases. The further below his aspirations level an individual is, the more effort he exerts on the labor market to increase his relative income and consumption. The increased labor activity directly translates into lower health investment from less leisure – more generally the compounding effects of added stress, longer work-hours and an unhealthy lifestyle. This effect is only partially attenuated by higher consumption of the health good. Hence a higher relative deprivation results in a lower life expectancy for the individual. Secondly we show that despite this relationship at the individual level, in the aggregate, the effect of economic inequality on life expectancy is ambiguous. The somewhat weak negative correlation between the two weakens still when income goes up. An increase in income weakens the relationship because the biological constraints on life expectancy ensure that a one unit increase in income does not translate into a one unit increase in survival probability.

In a series of work, the British epidemiologist Richard G. Wilkinson (Wilkinson 1992, 2002, Wilkinson and Pikett, 2009) argues that income inequality is itself a health hazard. Wilkinson documents this health-inequality connection by relying on evidence on mortality and income inequality in the OECD countries. For his sample, he finds a distinct negative relationship between inequality and life expectancy at the aggregate level. Subsequent studies have cast doubt on the robustness of this relationship.[1]

The disaggregated evidence is, however, clearer and robust. The Whitehall studies on British civil servants have found, for example, a strong inverse correlation between position in the administrative hierarchy and mortality rates. "Men in the lowest grade had a death rate three times higher than that of men in the highest grade" which was related to "higher risk of heart disease ... chronic lung diseases, gastrointestinal disease, depression, suicide, sickness absence from work, back pain and self reported health" (Wilkinson and Pikett, 2009). The direct effect of income on health choices seems to explain only a third of such higher mortality risk, the residual presumably explained by the direct effect inequality has on an individual's health (Smith *et al.*, 1990).

Using panel data on reported health and inequality within the United States, Deaton (2001) shows that, when controlling for ethnic make-up, between-state inequality has no effect on observed health outcomes but within-state inequality does. Using a measure of relative deprivation similar in spirit to this paper's aspirations gap, Deaton shows that an increase in relative deprivation results in worse reported

[1]See Deaton (2003) for an overview of the literature and Judge (1995) for one of the earliest critiques.

health. Eibner and Evans (2005) confirm Deaton's result for a larger range of health outcomes including mortality. They find that relative deprivation has a particularly large impact on deaths linked to smoking and coronary heart diseases, both of which are tied to behaviors brought on by stress and excessive work. The theoretical results that we establish in this paper affirm the generality of Deaton's (2001) and Eibner and Evans (2005)'s empirical findings. They indicate quantitatively how significant the aspirations gap can be: in our model, relative deprivation can account for a gap in conditional life expectancy of at least ten years. At the same time our work shows that what is true at the individual level is not necessarily matched by a similar aggregate picture as the lack of a firm correlation between inequality and life expectancy in industrialized countries indicates.

Our work is also related to the sizable literature on status-seeking and aspirations. While much of that work is not directly related to ours, a few are. We utilize Abel (1990) and Gali's (1994) specification of aspirations in the form of relative consumption levels, though we include income and aspirations heterogeneity. Among more recent works on social aspirations, two are closely connected to our paper. Genicot and Ray (2010) discuss how various forms of aspirations – common (as used in the status-seeking literature), stratified, upward-looking and local aspirations – are shaped by different moments of the income distribution. They embed the first two types of aspirations into a simple two-period growth model to illustrate the possibility of income polarization. Bogliacino and Ortoleva (2011) also use common aspirations in a two-period model to show the existence of multiple equilibria, including polarization. Both these papers use a logistic function to formalize the effect of aspirations failure. We rely, instead, on a concave specification and assume aspirations are defined with respect to consumption levels which are likely more easily observed than income levels in the two aforementioned papers. There is no possibility of polarization in our model.

The paper proceeds as follows. Section 2 presents the dynamic model. The individual's decision problem is formalized and partially analyzed in Section 3. Computational work in Section 4 studies the implication of aspirations and inequality for individual and aggregate health. We conclude in Section 5.

Model

A discrete time infinitely-lived economy is populated by individuals who potentially live forever. Individuals are born with a labor productivity draw θ, initial assets a_0 and health capital H_0. Time is indexed by $t = 0, 1, \ldots \infty$.

Health Production

Much like the Grossman (1972) model, agents accumulate a stock of health by making purposeful investments. Unlike the Grossman model they do not face a deterministic length of life that is dictated by a minimum health stock. Rather, the model incorporates the perpetual youth framework from Yaari (1965) and Blanchard (1985) in assuming that agents face a positive probability of death each period. The Grossman and Blanchard-Yaari frameworks are combined by allowing the agent's health capital H_t at the beginning of time t to positively affect his probability of surviving in that period.

Health capital depreciates at the rate $\delta \in (0, 1)$. For individual i the stock of health at time $t + 1$ depends on the stock of undepreciated capital and health investment at time t. In other words, health evolves much like physical capital in the standard neoclassical model:

$$H_{it+1} = (1-\delta)H_{it} + I_{it}. \tag{3.1}$$

Health investment at time t depends upon the amount of leisure, $1 - l_{it}$, l_{it} being agent i's labor supply out of a unit time endowment, and consumption of a market-provided health good, q_{it}, such as visits to the doctor, drugs, vitamins, etc.. The relative price of this good is taken to be one and we do not explicitly model its production.[2] Given these two inputs, the amount of health invested is given by:

$$I_{it} = I(l_{it}, q_{it}),$$

an increasing and concave function of leisure and the health good, that is, $I_1(\cdot,\cdot) < 0$, $I_{11}(\cdot,\cdot) < 0$, $I_2(\cdot,\cdot) > 0$, and $I_{22}(\cdot,\cdot) < 0$. Using (1) the health stock in period $t+1$ can be expressed in terms of initial health and past investments:

$$H_{it+1} = (1-\delta)^{t+1} H_{i0} + \sum_{s=0}^{t} (1-\delta)^s I(l_{it-s}, q_{it-s}). \tag{3.2}$$

The next step is to relate this health stock to agent's i decision problem. Individual i's survival probability, ϕ_{it}, depends upon agent i's stock of health in time t through an increasing concave function

$$\phi_{it} = \phi(H_{it}), \tag{3.3}$$

[2]This is easily done by assuming q is produced solely from labor with labor productivity of χ normalized to unity.

where $\phi'(\cdot) > 0$, $\phi''(\cdot) \leq 0$, $\phi(0) = 0$ and $\lim_{H\to\infty} \phi(H) = 1$. To ensure that the agent is alive in the initial period we also assume that $\phi_{i0} = 1$. Given this formulation, ϕ_{it+1} is the probability of being alive in $t+1$ conditional on being alive in period t. Finally note that the cumulative probability of being alive until period t is

$$\Phi_{it} = \prod_{n=0}^{t} \phi_{in}. \tag{3.4}$$

Health capital has no other effect on i's decision problem except through the survival rate. In particular, it does not directly affect his labor productivity.

Budget Constraint

Agent i's labor productivity θ_i is time invariant, drawn at the beginning of his life from the distribution $\Gamma(\theta)$ with finite support. We assume that the wage rate per efficiency unit of labor w is constant and exogenous. The return on investment $\tilde{R}_{it}$, on the other hand, is endogenous and individual-specific. Since individuals die over time, we need to ensure their assets are accounted for, and following Yaari (1965) we assume a perfect annuities market in the form of an insurance company. Under a perfectly competitive insurance market, the zero profit condition implies equilibrium annuitized return on investment is $\tilde{R}_{it} = R/\phi_{it}$, R being the constant market return on investment. This brings us to agent i's period t budget constraint:

$$c_{it} + q_{it} + a_{it+1} = w\theta_i l_{it} + \tilde{R}_t a_{it}, \tag{3.5}$$

where a denotes assets and c the consumption good. Figure 8 shows the ordering of events for each period.

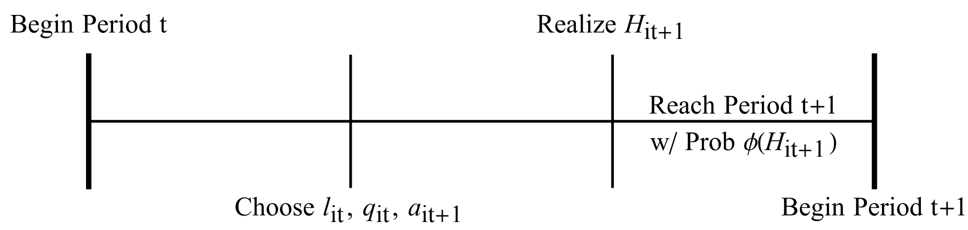


FIGURE 8. Agent i's Decision Timeline

Preferences

These health and mortality behavior are embedded in an economy where individuals are "socially minded". Specifically we assume preferences are defined over both consumption and leisure. Where we depart from the standard neoclassical paradigm is in the formulation of utility from consumption which depends on an individual's relative position in the consumption distribution. While it may seem reasonable to have agents care about inequality measures like the Gini coefficient or the Kuznet's ratio, these capture the whole distribution when it is not clear that people care about those who are worse off then themselves in the same way they care about those who are doing better than themselves. The former is usually labeled "pride" in the literature, the latter variously as "envy", "status seeking" and "upward-looking aspirations" (see Hopkins 2008 for an excellent discussion of these alternatives). The macro literature in this area commonly assumes mean dependence, that is, individuals care about their status relative to the economy-wide average consumption, income or wealth.

We assume upward-looking aspirations in that agents care only about how worse-off they are relative to those who are better off than themselves. More precisely agents form their aspirations by taking the average of the consumption of every agent who consumes *at least* as much as they do. This ensures that the highest-consumption agent remains an aspirant, using his own consumption level to form that aspiration.

Hence, individual i's aspirations level is set according to

$$\bar{C}_{it} = \frac{\sum_{j=1}^{N} \mathbb{1}(c_{jt} \geq c_{it}) c_{jt}}{\sum_{j=1}^{N} \mathbb{1}(c_{jt} \geq c_{it})} \tag{3.6}$$

where $\mathbb{1}(c_{jt} \geq c_{it})$ is an indicator function that takes on the value 1 if true and 0 otherwise.

The exact formulation of how this influences the individual's overall utility is borrowed from the status-seeking and Keeping-up-with-the-Joneses (henceforth KUWJ) literature, particularly Gali (1994):

$$u_{it} \equiv U(c_{it}, \bar{C}_{it}, l_{it}) = \frac{c_{it}^{1-\sigma}}{1-\sigma} \bar{C}_{it}^{\psi\sigma} + \gamma \frac{(1-l_{it})^{1-\sigma}}{1-\sigma} \tag{3.7}$$

where $\sigma > 0$ and $0 < \psi < 1$. This specification is also motivated by Alpizar *et al.*'s (2005) survey-experimental evidence that relative consumption of non-positional goods matter as much as positional goods; we do not distinguish between the two types of consumption. The parameter restrictions are such that for a given level of consumption, c_{it} an increase in the aspirations will result in strictly lower utility.

A final point about the period utility function. Note that when $\sigma > 1$, $U(c_{it}, \bar{C}_{it}, l_{it}) < 0$. To ensure that utility from being alive always exceeds that from death, we normalize utility from dying to $\underline{U}$ such that

$$\underline{U} < \inf \left\{ U(c_{it}, \bar{C}_{it}, l_{it}) \right\}_{t=0, i=1}^{\infty, N}$$

which means a complete specification of the period utility function is given by

$$U(c_{it}, \bar{C}_{it}, l_{it}) = \begin{cases} \frac{c_{it}^{1-\sigma}}{1-\sigma}\bar{C}_{it}^{\psi\sigma} + \gamma\frac{(1-l_{it})^{1-\sigma}}{1-\sigma} & \text{if agent } i \text{ is alive} \\ \underline{U} & \text{if agent } i \text{ is dead} \end{cases}$$

Decision Problem

With the economic environment described above, individual i faces the decision problem of maximizing his expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\Phi_{it} \left\{ \frac{c_{it}^{1-\sigma}}{1-\sigma}\bar{C}_{it}^{\psi\sigma} + \gamma\frac{(1-l_{it})^{1-\sigma}}{1-\sigma} \right\} + (1-\Phi_{it})\underline{U} \right], \tag{3.8}$$

$\beta \in (0,1)$ being the subjective discount rate, subject to the health transition equation (3.1), budget constraint (3.5) and initial conditions (a_{i0}, H_{i0}).

We reformulate this decision problem as a dynamic programming problem. First, we assume that the individual takes into account how its health choices affect the annuity return $\tilde{R}$ that it receives. The rationale for this is that people often base their insurance decisions on actuarial tables. This assumption has the advantage of reducing the state space since the annuity return does not have to be considered part of it, cutting down on computation time. In addition, results are very similar for price taking behavior. Thus individual i faces four state variables $(\theta_i, a_{it}, H_{it}, \bar{C}_{it})$ and three controls $(a_{it+1}, l_{it}, q_{it})$ and his optimization decision is specified by the Bellman equation

$$\begin{aligned} V(\theta_{it}, a_{it}, H_{it}, \bar{C}_{it}) = \max_{l_{it}, a_{it+1}, q_{it+1}} u\left(c_{it}, \bar{C}_{it}, l_{it}\right) + \{&\beta\phi(H_{it+1})V(\theta_{it+1}, a_{it+1}, H_{it+1}, \bar{C}_{it+1}) \\ &+(1-\phi(H_{it+1}))\underline{U}\} \end{aligned} \tag{3.9}$$

subject to

$$c_{it} = w_t \theta_{it} l_{it} + \frac{R_t}{\phi(H_{it})} a_{it} - q_{it} - a_{it+1}.$$

Optimization

The optimal choices of a_{it+1}, l_{it}, and q_{it} can be solved for by maximizing (3.9) subject to (3.5), and (3.1). Starting with a_{it+1}, taking the derivative and using the envelope condition yields the Euler equation:

$$\frac{c_{it+1}}{c_{it}} = (\beta R_t)^{\frac{1}{\sigma}} \left(\frac{\bar{C}_{it+1}}{\bar{C}_{it}} \right)^{\psi}. \tag{3.10}$$

Since prices are exogenous in this environment, to ensure a stable invariant distribution we impose the restriction that $R = 1/\beta$ under which the Euler equation simplifies to:

$$\frac{c_{it+1}}{c_{it}} = \left(\frac{\bar{C}_{it+1}}{\bar{C}_{it}} \right)^{\psi}. \tag{3.11}$$

Equation (3.11) will provide useful information regarding the distribution of consumption. Before looking at the distribution in general, we will make the following assumption (A1):

A1: When agents die they are replaced by identical agents.

This assumption removes aggregate uncertainty for all agents. Aggregate uncertainty is problematic because a single agent's decision will be conditioned on her aspirations which are determined by the distribution of consumption. Therefore, because this model has agents exiting through mortality, it is extremely difficult to pin down steady-state dynamics. Assumption A1 solves this problem because it constrains the consumption of the new agents to be the same as the recently deceased and because the new agents' decisions are governed by the same Euler equation the aggregate system will evolve as if there is no mortality. Using A1 it is possible to derive Lemma 1.

<u>Lemma 1</u>

Suppose that A1 holds. Order agents in terms of increasing levels of consumption such that for individuals $i-1$ and i, $c_{i-1t} < c_{it}$. If for $i > j$

$$\frac{c_{it+1}}{c_{it}} = 1 \text{ then } \frac{c_{jt+1}}{c_{jt}} = 1.$$

For proof, see the appendix. Lemma 1 says that if all agents with consumption greater than agent j are enjoying their stationary consumption level, then so will agent j. This is a rather intuitive result. Because all agents $i > j$ are experiencing a constant consumption level, it implies that their upward-looking aspirations are constant as well. This in turn means agent j's aspiration is unchanging, causing her to settle into her relative position in the consumption distribution. It follows then that

<u>Proposition 2</u>

If A1 holds, the distribution of consumption is stable.

The proof is simply an application of Lemma 1 after showing that the agent with the highest level of consumption necessarily has zero consumption growth. However, proposition 2 can be established analytically only under A1, so the question becomes: how restrictive is this assumption?

Suppose we relax assumption A1 so that entering agents can have any consumption level (specifically they are allowed to draw their own productivity but start with $a_{i0} = 0$ and $H_{i0} = 35$) in the distribution. How does this influence the distribution of consumption, or more importantly, how does this change the aspirations of the surviving agents? The answer is not much when the model is calibrated to empirically plausible mortality rates and a large population. Consider the gross mortality rate in 2010 for the United States: 0.8%[3]. For a large $N \geq 500$ this will clearly have very little effect on the aspirations of agents because the role of new agents will be quite small. Therefore the following relationship is approximately true:

$$\bar{C}_{it} \approx \bar{C}_{it+1} \tag{3.12}$$

and will prove useful when we solve the model computationally. Specifically, the recursive form that (3.12) provides will allow for the use of aspirations as a state variable.

Next turn to optimal choices of the other two control variables. Equations (3.13) and (3.14) show the first order conditions for l_{it} and q_{it} respectively.

$$\begin{aligned} w\theta_i c_{it}^{-\sigma}\bar{C}_{it}^{\psi\sigma} - \gamma(1-l_{it})^{-\sigma} + \beta\frac{\partial H_{it+1}}{\partial l_{it}}[\phi'(H_{it+1})[V(\theta_{it+1}, a_{it+1}, H_{it+1}, \bar{C}_{it+1}) - \underline{U}] \\ + \phi(H_{it+1})V_2(\theta_{it+1}, a_{it+1}, H_{it+1}, \bar{C}_{it+1})] \leq 0 \end{aligned} \tag{3.13}$$

$$\begin{aligned} -c_{it}^{-\sigma}\bar{C}_{it}^{\psi\sigma} + \beta\frac{\partial H_{it+1}}{\partial q_{it}}[\phi'(H_{it+1})[V(\theta_{it+1}, a_{it+1}, H_{it+1}, \bar{C}_{it+1}) - \underline{U}] \\ +\phi(H_{it+1})V_2(\theta_{it+1}, a_{it+1}, H_{it+1}, \bar{C}_{it+1})] \leq 0 \end{aligned} \tag{3.14}$$

[3]Source: The Centers for Disease Control–http://www.cdc.gov/nchs/fastats/deaths.htm

Define

$$\Omega_{it+1} \equiv \phi'(H_{it+1})[V(\theta_{it+1}, a_{it+1}, H_{it+1}, \bar{C}_{it+1}) - \underline{U}] + \phi(H_{it+1})V_2(\theta_{it+1}, a_{it+1}, H_{it+1}, \bar{C}_{it+1}),$$

the common term on the left hand side of equations (3.13) and (3.14). Using this, from (3.14) it follows that

$$\Omega_{it+1} = \frac{c_{it}^{-\sigma}\bar{C}_{it}^{\psi\sigma}}{\beta\left[\partial H_{it+1}/\partial q_{it}\right]}. \tag{3.15}$$

Substituting (3.15) into (3.13) yields:

$$\left(\frac{\bar{C}_{it}^{\psi}}{c_{it}}\right)^{\sigma}\left(w\theta_i + \frac{\partial H_{it+1}/\partial l_{it}}{\partial H_{it+1}/\partial q_{it}}\right) = \gamma(1 - l_{it})^{-\sigma}. \tag{3.16}$$

To make further progress, we assume a functional form for investment in health capital. We assume that leisure time in health production and consumption of health goods are complementary inputs according to a Cobb-Douglas technology:

$$I(l_{it}, q_{it}) = Q(1 - l_{it})^{\alpha}q_{it}^{\rho},$$

where $Q > 0$ is the productivity of health investment and $0 < \alpha + \rho \leq 1$. Equation (3.16) can now be written as:

$$\left(\frac{\bar{C}_{it}^{\psi}}{c_{it}}\right)^{\sigma}(1 - l_{it})^{\sigma-1}\left(w\theta_i(1 - l_{it}) - \frac{\alpha}{\rho}q_{it}\right) = \gamma. \tag{3.17}$$

Since $\left(\bar{C}_{it}^{\psi}/c_{it}\right)^{\sigma}$ is necessarily positive, in order for this equality to hold it must be that

$$w\theta_i(1 - l_{it}) > \frac{\alpha q_{it}}{\rho}.$$

Our goal is to understand how aspirations failure, more precisely relative deprivation, affects an individual's mortality. So consider the following comparative statics exercise. Suppose (3.17) holds with equality and agent i experiences an increase in her aspirations level, that is, $\bar{C}_{it}$. Since there is an increase in the first term on the left hand side of (3.17) and the right hand side is constant, this means individual i will have to adjust his labor supply or consumption of the health good. In the case of the labor supply, (3.17) shows that an increase in labor supply (holding all else constant) will unambiguously push the equation toward equality.

Consumption of the health good, however, has an ambiguous effect on (3.17). An increase in q_{it} will cause the second term on the left hand side to decline, but it will also cause consumption to fall leading to a further increase in the aspirations gap. For little more insight, consider the special case of $\gamma = 0$ for which $w\theta_i(1 - l_{it}) = \alpha q_{it}/\rho$. In this case, labor supply and the consumption of the health good have a negative relationship suggesting that the increase in the labor supply in the previous example (with $\gamma > 0$) would lead to a decline in q_{it}. The negative relationship between l_{it} and q_{it} would necessarily be true in the general case if the increase in labor supply due to the increase in the aspirations gap caused the following to be true: $w\theta_i(1 - l_{it}) < \alpha q_{it}/\rho$, which would necessitate a drop in the consumption of the health good in order for (3.17) to hold with equality. From this reasoning it is clear that an increase in aspirations level will raise labor supply and, quite likely, lower consumption of the health good.

Simulations

Differently from the Ramsey model with KUWJ preferences, the entire consumption and wealth distributions, not just their means, matter for households' choices in this economy. Hence we rely on numerical methods to identify the individual and aggregate consequences of upward-looking aspirations. We make the parametric assumption that

$$\phi(H_{it}) = \left(1 - \frac{1}{H_{it}}\right)^{\tau}$$

whose curvature is determined by $\tau \in (0, 1)$.

In order to solve this problem, we will use dynamic programming. The agent enters period t with an idiosyncratic labor productivity, financial assets, health capital, and an aspirations level. These variables constitute the state-vector for any individual and for ease, the Bellman system is rewritten as

$$\begin{aligned} V(\theta, a, H, \bar{C}) = \max_{l,a',q} & \left\{u + \beta[\phi(H')V(\theta', a', H', \bar{C}') + (1 - \phi(H'))\underline{U}]\right\} \\ c + a' + q &= \theta w l + \tilde{R} a \\ H' &= (1-\delta)H + Q(1-l)^{\alpha} q^{\rho} \\ \bar{C}' &= \bar{C} \\ \theta' &= \theta \\ \tilde{R}' &= \frac{R}{\phi(H')} \end{aligned} \tag{3.18}$$

Baseline Results

Table 5 presents the parameters used in these simulations. The length of a period is chosen to be a year, so the discount rate is set at 0.96 similar to the business cycles literature. The shares of leisure and the health good in the health production process are set at 0.85 and 0.15, respectively.

Parameter	Value	Description	Source
α	0.85	Leisure Parameter in Health Accumulation Equation	Match Health Investment-GDP ratio. He, Huang, Hung (2014)
β	0.96	Discount Rate	
σ	2	Elasticity of Substitution	Carroll, Overland, Weil (1997)
Q	0.0602	Health Investment Parameter	Match Health Investment-GDP ratio. He, Huang, Hung (2014)
τ	0.1	Shape Parameter for Probability of Survival	Match Health Investment-GDP ratio. He, Huang, Hung (2014)
w	20	Wages	
H_{i0}	35	Initial Stock of Health Capital	
ρ	0.15	Health good Parameter in Health Accumulation Equation	Match Health Investment-GDP ratio. He, Huang, Hung (2014)
γ	0.5	Weight of Leisure	Match Labor Supply. He, Huang, Hung (2014)
ψ	0.5	Strength of Reference Level of Consumption	Free
δ	0.03	Depreciation of Health Capital	He, Huang, Hung (2014)
N	200	Size of the Population	Scale
R	$\frac{1}{\beta}$	Rate of Return on Savings	

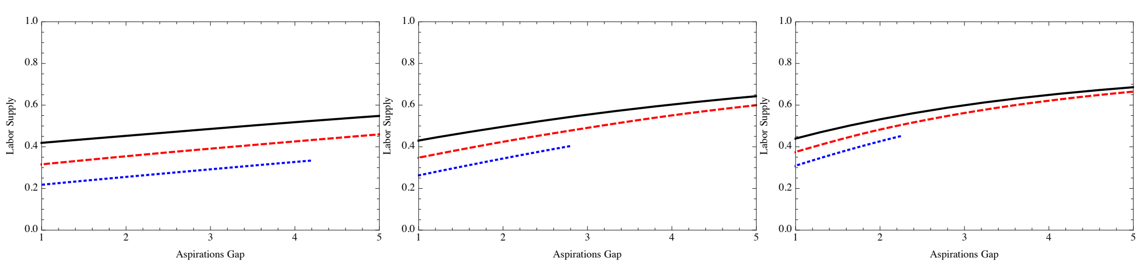
TABLE 5. Parameter Values

For the aggregate simulations we will need to draw from different idiosyncratic productivities. The state space for θ is discretized and agents are endowed with productivities from the set $\Theta = \{1, 20 : 0.01\}$. The weights are truncated Pareto where the probability associated with observations greater than 20 is redistributed over each point on the range 1 to 20 using the geometric formula $G(\Theta)$. The mean and the functional form for $G(\cdot)$ were chosen to maximize inequality.

Before a detailed presentation of the computational results it will be helpful to keep in mind the main result from the analytical section that agents with larger aspirations gaps $\bar{C}_{it}/c_{it}$ will unambiguously supply more labor and most likely consume less of the health good.

The existence of four state variables makes it difficult to present the policy rule for all possible realizations.[4] Because our primary goal is to understand the effect of inequality, all of the choice variables are plotted against the individual's aspirations gap. Each choice variable will be presented in three graphs that correspond to health stocks of 5, 10, and 15 and, unless otherwise noted, the individual's savings level will be zero. This choice does not have qualitative effects on the results shown in this section, but it does allow for the clearest picture of how choices differ across productivity levels.

Starting with the choice variables that influence the health stock, we see in figure 9 that, as indicated by our analytical results, the labor supply of an individual is increasing in her aspirations gap. This confirms the basic intuition of the model: as the gap between actual and desired consumption increases, agents will supply more labor. The main issue with this outcome is that, *ceteris paribus*, an increase in the labor supply results in lower health. However, before we can say anything definitive about the evolution of the health stock we need to examine how consumption of the health good varies. These are shown in figure 10.

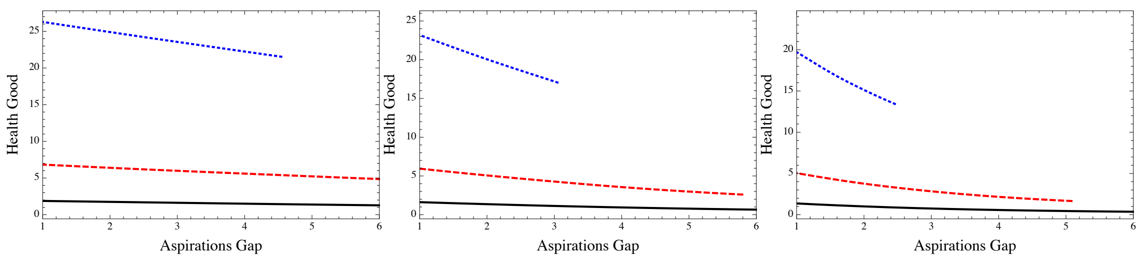


(a) Health Stock: 5 (b) Health Stock: 10 (c) Health Stock: 15

FIGURE 9. Labor Choice vs Aspirations Gap by Health Stock
Solid: $\theta = 1$, Dashed: $\theta = 3$, Dotted: $\theta = 12$

[4]The policy rules are plotted by calculating the aspirations gap, labor supply, health good, and savings for a given exogenous level of aspired consumption, health stock, and savings.

Much like figure 9, figure 10 confirms the basic premise of the model. Those agents with the largest aspiration gaps forgo consumption of the health good in order to make up the difference. It is clear from these figures that an increase in the aspirations gap results in fewer inputs into the health production function, resulting in a higher probability of mortality. While the existence of the gradient between the health inputs and the aspirations gap is independent of the agent's health stock, the level of investment is not. Both figures 9 and 10 show that as the agent's health stock deteriorates, she invests more in health production at the expense of consumption.

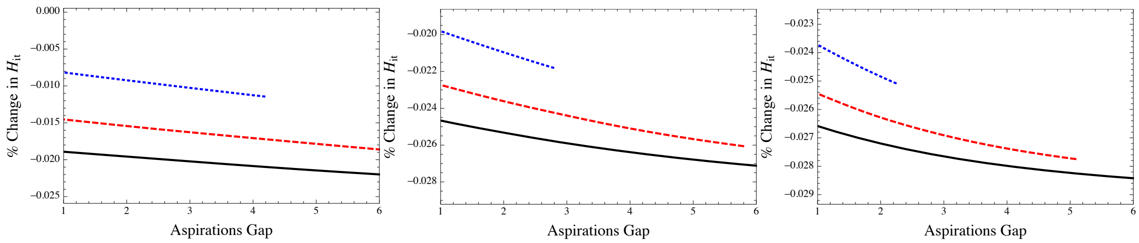


(a) Health Stock: 5 (b) Health Stock: 10 (c) Health Stock: 15

FIGURE 10. Health Good vs Aspirations Gap by Health Stock
Solid: $\theta = 1$, Dashed: $\theta = 3$, Dotted: $\theta = 12$

Figure 11 shows the relationship between the change in the health stock and the aspirations gap. As the results seen in figure 9 and 10 indicated, the health stock is declining in the aspirations gap. Figure 11 also confirms the level effect shown in figures 9 and 10: agents invest more in their health as their health stock falls.

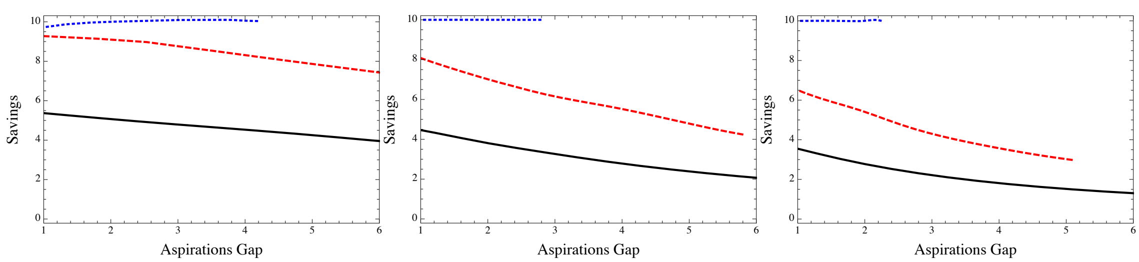
The agent's savings decision looks very similar to the that of the health good. Figure 12 shows that as the aspirations gap increases, the agent chooses to hold less in savings. Beyond that, the savings decision exhibits two interesting patterns. As the health stock declines, first, the gradient between the aspirations gap and the level of savings gets flatter and second, the absolute amount of savings increases. This seems a little counter intuitive, because a declining health stock would seemingly



(a) Health Stock: 5 (b) Health Stock: 10 (c) Health Stock: 15

FIGURE 11. Percent Change in Health Stock vs Aspirations Gap by Health Stock
Solid: $\theta = 1$, Dashed: $\theta = 3$, Dotted: $\theta = 12$

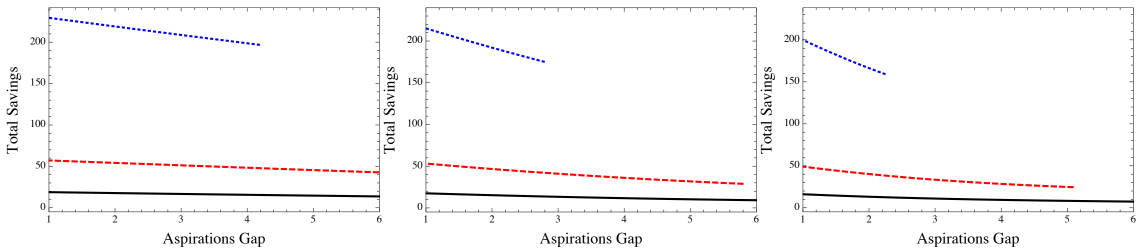
cause agents to substitute away from savings towards the health good and leisure. However, in this case savings acts as a way to increase health in the future. By transferring wealth from today to tomorrow, agents can not only increase the amount of the health good purchased but also their consumption. In this way, savings allows an agent who is below her aspirations today to move closer in the future.



(a) Health Stock: 5 (b) Health Stock: 10 (c) Health Stock: 15

FIGURE 12. Savings vs Aspirations Gap by Health Stock
Solid: $\theta = 1$, Dashed: $\theta = 3$, Dotted: $\theta = 12$

In this model, savings goes beyond the accumulation of financial assets, agents can also save through investment in health. Therefore figure 13 plots the relationship between total savings and the aspirations gap. Total savings is monetized by adding the time value of leisure $w(1-l_i)$ to the consumption of the health good and financial assets.[5]



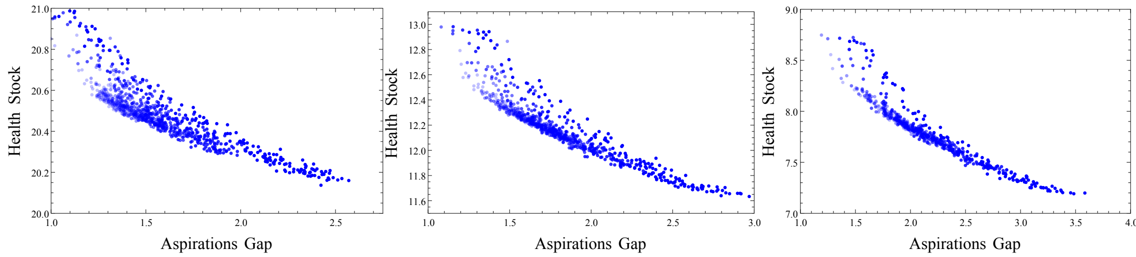
(a) Health Stock: 5 (b) Health Stock: 10 (c) Health Stock: 15

FIGURE 13. Total Savings vs Aspirations Gap by Health Stock
Solid: $\theta = 1$, Dashed: $\theta = 3$, Dotted: $\theta = 12$

Figure 13 clearly shows a negative relationship between total savings and the aspirations gap. Again this follows the logic that those with greater aspirations will focus more on closing the gap and less on future consumption. The other striking result from this figure is that a large proportion of savings is in the form of health. Apparently, the return agents get on financial investment is not nearly as high as the return on health which prompts them to invest more in health than conventional savings instruments.

Next consider the evolution of an agent's health stock. In the preceding paragraphs it was made clear those agents that suffered from the greatest amounts of relative depravation, invested the smallest amount in health. If agents are relatively deprived for long periods of time, one would expect this lack of investment to manifest in lower health stocks and shorter life expectancy. Figure 14 plots the health stock against the aspirations gap for an aggregate simulation.

[5]This definition of total savings is not unlike Becker *et. al* 's (2005) approach of valuing longevity gains into their definition of a "full income".



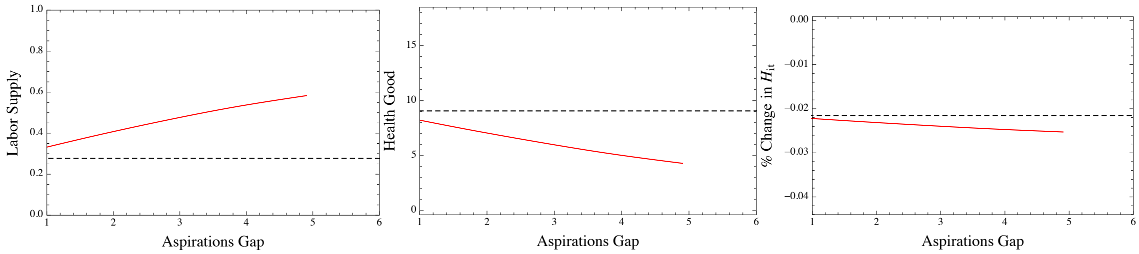
(a) Age 20 (b) Age 40 (c) Age 60

FIGURE 14. Health Stock vs Aspirations Gap by Age. Lighter dots indicate simulations with lower inequality.

The relationship depicted in figure 14 is easy to understand and, importantly, confirms one of the empirical results reported in Deaton (2001). Clearly mortality depends upon relative deprivation through upward-looking aspirations. What is interesting about this result is that the gap between the "healthiest" and least healthy individual increases with age (that is, it is higher in older cohorts), which means that being exposed to inequality over long periods has a compounding effect on an individual's health. A back-of-the-envelope calculation for conditional life expectancy suggests that the gap increases from 8 years at age 20 to 13 years at age 60 for the parameter values reported in table 5.

What does upward-looking aspirations add to the model? Figure 15 presents results of labor supply, consumption of the health good and the change in the health stock plotted against the aspirations gap for the baseline model and a version of the model without aspirations (equivalent to setting $\psi = 0$).

The inclusion of aspirations has two main effects. First, labor supply and consumption of the health good strongly respond to the consumption gap when individuals care about their relative position. Secondly, aspirations seriously impacts the accumulation of health capital. Figure 15 also informs us about the effect of aspirations on individual welfare. It can result in a significant loss of health,



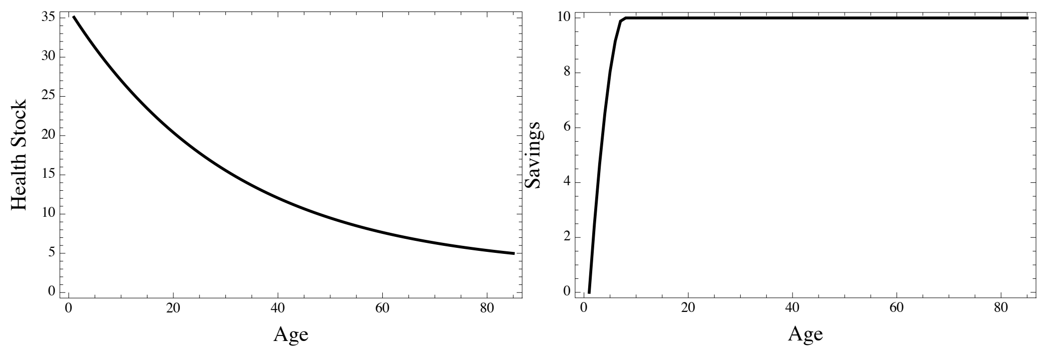
(a) Labor Supply (b) Health Good (c) Percent Change in Health Stock

FIGURE 15. The influence of Aspirations on Labor Supply, Health Good and the Change in the Health Stock.
Solid: Baseline, Dashed: No Aspirations

significantly increase labor supply that directly reduces utility through reduced leisure and, of course, directly impact welfare through the aspirations gap.

Aggregate Effects

Now that we have characterized the individual's problem, we can look at the aggregate impact of aspirations on mortality. Given that we are looking at aggregate simulations in this section we need to deal with the replacement of dead agents. We assume that all incoming agents draw their own productivity level and start with initial conditions: $a_{i0} = 0$ and $H_{i0} = 35$. The zero assets assumption is in keeping with the perfect annuities market, where the assets of dead agents are the property of the risk neutral firm. In addition to the replacement of dead agents it is important to address the issue of convergence. We check the issue of convergence by looking at the time paths of average consumption, labor, and the Gini coefficient. Typically simulations imply that these three variables reach stability after 100 periods. In what follows each of the simulations were run for 125 periods with a "burn-in" period of 125 (these observations were dropped from the sample). In this section we will presenting several aggregate results that depict the relationship between inequality and life expectancy, but first we would like to show the time paths of the health stock and asset holdings of the typical agent. Figure 16 shows these results.



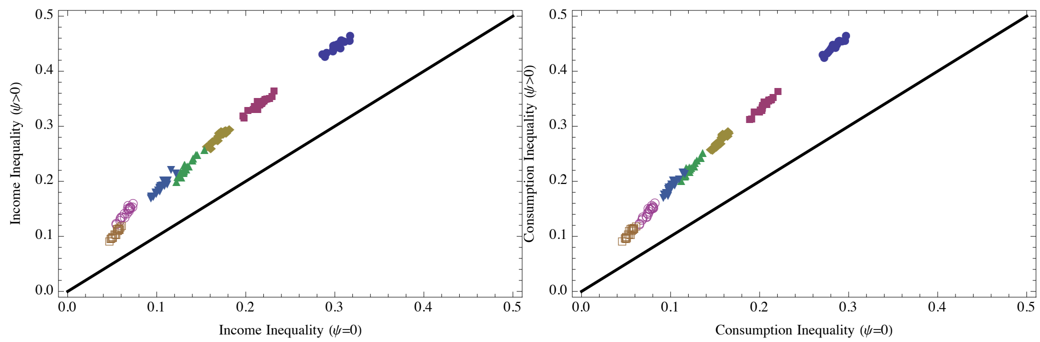
(a) Health Stock (b) Savings

FIGURE 16. The Evolution of Individual Asset and Health Stocks

As can be seen in figure 16 the agent's stock of health is monotonically decreasing over time, while the asset stock monotonically increases until settling around the maximum asset holdings. Not surprisingly, figure 16 implies that as agents get older they are more likely to die in any given period.

The first step in looking at how aspirations effect mortality is to understand how aspirations influence the inequality outcomes of the model. In other words, how does the consumption and income inequality that result from the model relate to the fundamental inequality (the inequality present in ability)? Milton Friedman posited in *Capitalism and Freedom* (1962) that inequality is motivating for individuals as it compels them to strive for something better, thus attenuating the effects of inequality. In order to test this prediction, we remove health from the model and look at the relationship between consumption/income inequality for the model with aspirations against the model without aspirations. The results are in figure 17.

As seen in figure 17, social aspirations do not result in lower amounts of inequality, which is contradictory to Friedman's conjecture. The next question is:



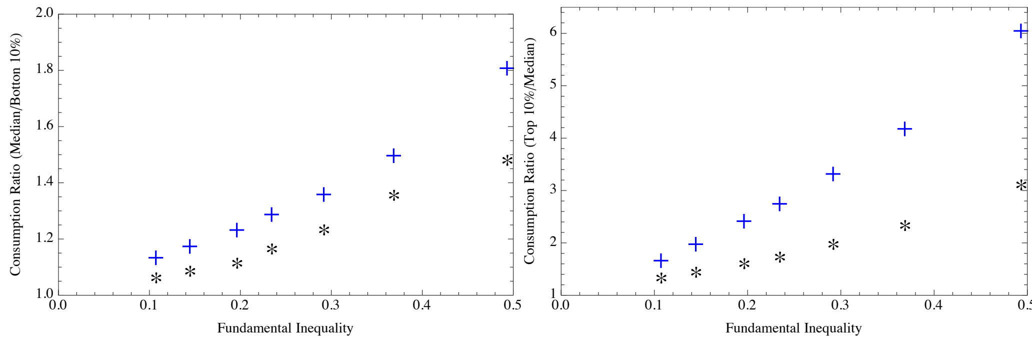
(a) Income Inequality (b) Consumption Inequality

FIGURE 17. Fundamental Inequality Plotted Against Income Inequality.
Solid: 45° Line, Markers: Simulations

why do social aspirations cause greater amounts of inequality? The reason could be that social aspirations do not have a uniform impact on the distribution. In particular, if aspirations cause higher productivity individuals to work relatively harder than poorer individuals, it would be possible to see a spreading of the consumption/income distribution, resulting in greater inequality. Figure 18 looks at this possibility by plotting two ratios: median consumption/consumption by the bottom 10% and consumption by the top 10%/median consumption.

Figure 18 shows that aspirations do have a differential effect on the distribution. It is clear that the increase in the consumption ratio due to social aspirations is greater for the top decile. The other result that can be ascertained from figure 18 is that consumption is higher under aspirations, but it is important to note that this increase in consumption come at the cost of lower health.

The next step in fully understanding the aggregate cost of social aspirations is to look at how health production depends on income (sum of wage and rental income). Because agents live for multiple periods, the relationship between income and health production is not a static object that can be plotted. However, we can look at the relationship between income and the health stock at various ages. In

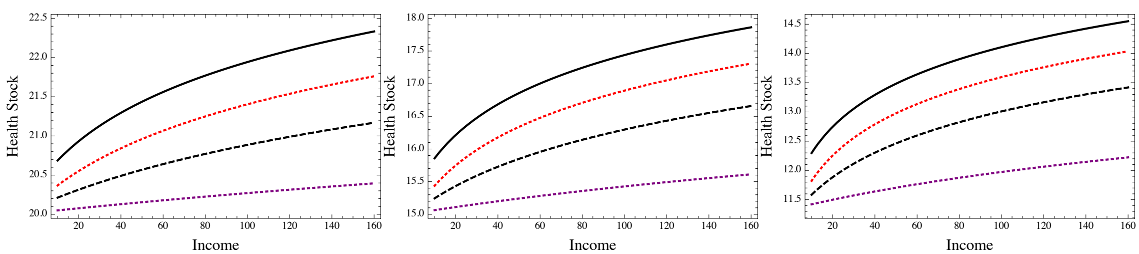


(a) Median/Bottom 10%

(b) Top 10%/Median

FIGURE 18. Consumption Ratios plotted against Fundamental Inequality.
This figure shows the consumption ratio of the median and the bottom decile and the top decile and median plotted against inequality for both the model without aspirations and the one with.
Blue/Plusses: Aspirations
Black/Stars: No Aspirations

figure 19, we fit a nonlinear model to the data produced by four different social aspirations preferences ($\psi \in \{0, 0.25, 0.5, 0.75\}$).



(a) Age: 20

(b) Age: 30

(c) Age: 40

FIGURE 19. Health Stock as a Function of Income.
Solid/Black: $\psi = 0$, Red/Dotted: $\psi = 0.4$,Dashed/Black: $\psi = 0.5$, Purple/Dotted: $\psi = 0.6$

In figure 19, regardless of the magnitude of the social concerns, aspirations significantly lowers health production. The effect is clearly non-linear, as social aspirations increases (going from ψ values of 0 to 0.4 versus 0.50 to 0.6) the impact on health production worsens. One interesting aspect of this figure is that social aspirations results in a greater loss of health production for richer individuals than poorer ones. This result is most likely driven by the fact that richer individuals have more to give up in terms of health expenditures. No matter how poor an agent is, her health can only deteriorate by the depreciation rate every period. Therefore even if aspirational concerns are so high that no one invests in health production there is still a floor on what health can be for any age. Intuitively, richer individuals are further away from this floor, which implies that an increase in aspirational concerns will cause them to move more than their poorer counterparts.

Now that the inequality effects and the health costs of social status have been characterized, it is important to examine the empirical results found in the literature regarding inequality and health. As noted in the introduction, Wilkinson (1992) originally found a significantly negative relationship between inequality and life expectancy while Deaton (2001) found no such significant relationship.[6] In what follows we attempt to identify one potential reason why the empirical evidence is mixed. First, we report a few empirical correlations between inequality and life expectancy in table 6.[7]

The most significant result presented in table 6 is that the correlation weakens over time.[8] It is not obvious why this would be so. We explore two possibilities: increase in income and change in the health production function. Looking again at table 6, the split sample shows that after 2000 income growth had a significant effect on life expectancy, so it could be that increases income are causing the weakening

[6]Subramanian and Kawachi (2004) survey the empirical literature on income inequality and health and find mixed evidence.

[7]The data set was constructed using Gini data from the OECD, CIA World Fact Book, Deininger and Squire Dataset. The life expectancy and income data are from the OECD website. The data covers the period 1974-2010.

[8]This result is robust to splitting the sample at 1985, 1990,1995, 2000, and 2005.

	Full Sample	Before 2000	After 2000
Gini	-9.386^{**}	-13.167^{***}	-8.831^{**}
	(-2.486)	(-2.853)	(-1.993)

	Full Sample	Before 2000	After 2000
Gini	-9.234^{**}	-13.791^{***}	-7.302^{*}
	(-2.477)	(-3.0179)	(-1.735)
GDP Growth	-0.167	0.055	-0.391^{***}
	(-1.637)	(0.425)	(-3.555)

	Full Sample	Before 2000	After 2000
Gini	-7.370^{**}	-12.928^{***}	-8.393^{**}
	(-2.058)	(-2.862)	(-8.393)
Mean GDP Growth	-0.308^{*}	0.135	-0.662^{***}
	(-1.932)	(0.573)	(-4.012)

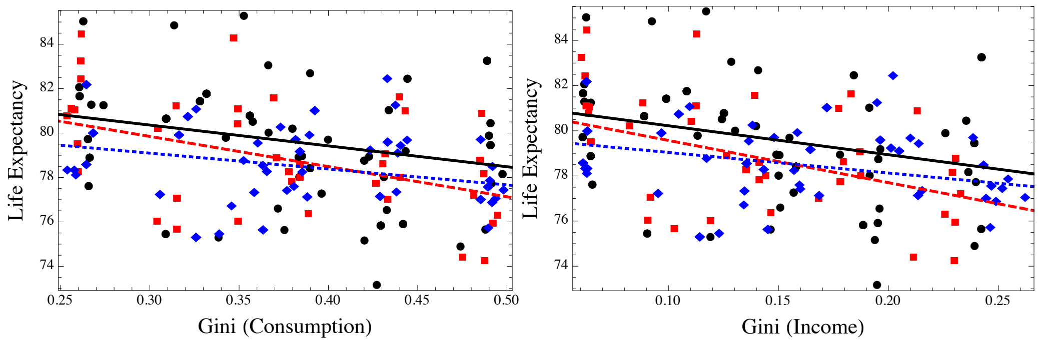
t-stat in Parentheses. Significance: ***: 1%, **:5%, *:10%

TABLE 6. Data: Life Expectancy and Inequality

relationship. Figure 20 plots the relationship between life expectancy and inequality with wages of 15, 20, and 25.[9]

Figure 20 shows that increasing incomes decreases the gradient between life expectancy and inequality. This result is not immediately obvious, however one would expect that an increase in income would result in increased health expenditure (in absolute terms). Due to biological constraints, life expectancy can only increase so much as a result of an increase in income, the reason for this stems from the concavity of the survival function. Therefore the impact of a uniform increase income will be lower for those economies with already high life expectancy/low inequality than those economies with low life expectancy/high inequality. The empirical estimates of the simulations in table 7 show the magnitude of this effect.

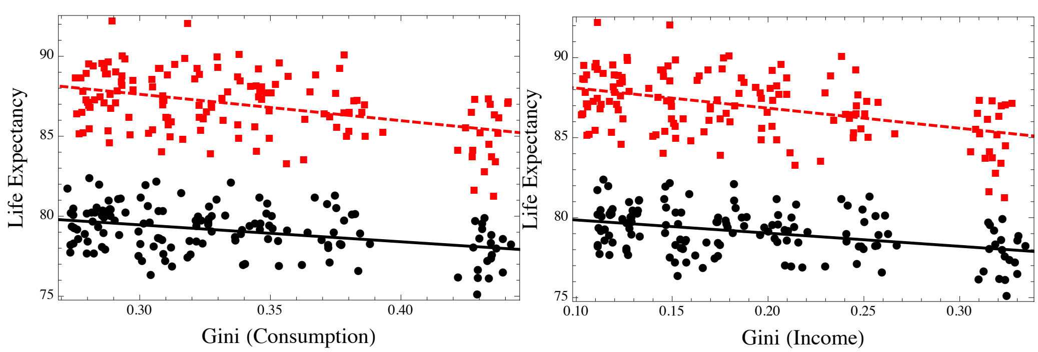
[9] In comparison to the baseline, the wage of 25 represents an 8-10% increase in GDP, while the wage of 15 represents a 1-3% reduction.



(a) Consumption Inequality (b) Income Inequality

FIGURE 20. Life Expectancy versus Inequality: Rising Income.
Solid/Black/Circles: $w = 20$, Dashed/Red/Squares: $w = 15$, Dotted/Blue/Diamonds: $w = 25$

Table 7 confirms what was shown in figure 20, an increase in income results in smaller gradient between life expectancy and inequality. The second option for the weakening correlations was a change in the health production function. For instance, improvements in medical science could result in greater health production for a given set of inputs. Figure 21 depicts the relationship between inequality and life expectancy for the baseline parameters ($Q = 0.08$) and the comparison parameters ($Q = 0.12$).



(a) Consumption Inequality (b) Income Inequality

FIGURE 21. Life Expectancy versus Inequality: Changing Medical Technology.
Solid/Black/Circles: Baseline, Dashed/Red/Squares: $\alpha = 0.7,\ \rho = 0.3$

	Inequality	Regression 1 Gini	Regression 2 Gini	GDP Per Capita
$w = 15$	Income	-18.72^{***}	-22.439^{***}	-0.303
		(-5.214)	(-5.073)	(-1.4278)
	Consumption	-13.579^{***}	-15.867^{***}	-0.264
		(-5.182)	(-4.987)	(-1.262)
$w = 20$	Income	-12.831^{***}	-12.534^{***}	0.151
		(-3.558)	(-3.448)	(0.739)
	Consumption	-9.380^{***}	-9.151^{***}	0.166
		(-3.234)	(-3.136)	(0.807)
$w = 25$	Income	-9.113^{***}	-9.75678^{***}	-0.212^{**}
		(-3.568)	(-3.872)	(-2.377)
	Consumption	-7.146^{***}	-7.973^{***}	-0.227^{**}
		(-3.318)	(-3.740)	(-2.517)

t-stat in Parentheses. Significance: ***: 1%, **:5%, *:10%

TABLE 7. Model: Life Expectancy and Inequality

Figure 21 shows that improvements in the medical technology result in greater life expectancy, but do not explain why the correlation between life expectancy and inequality is weakening over time. This result is rather intuitive. First, improvements in health care would undoubtably result in better life expectancy. However, this improvement in medical science does not change the marginal cost of leisure (increased distance from aspired consumption), therefore we would expect to see same gradient between life expectancy and inequality.

One final aspect of the model to look at is the role of the survival function's curvature. In order to examine the impact of changing the curvature, we will look at health inequality in terms of the life expectancy gap. Specifically, we will look at the difference in life expectancy for the top and bottom deciles of the distribution. Figure 22 plots the life expectancy plotted against inequality for $\tau = 0.1$ and $\tau = 0.25$.

Figure 22 shows that an increase in the curvature of the survival function (decrease in τ) results in a steeper gradient between the life expectancy gap and

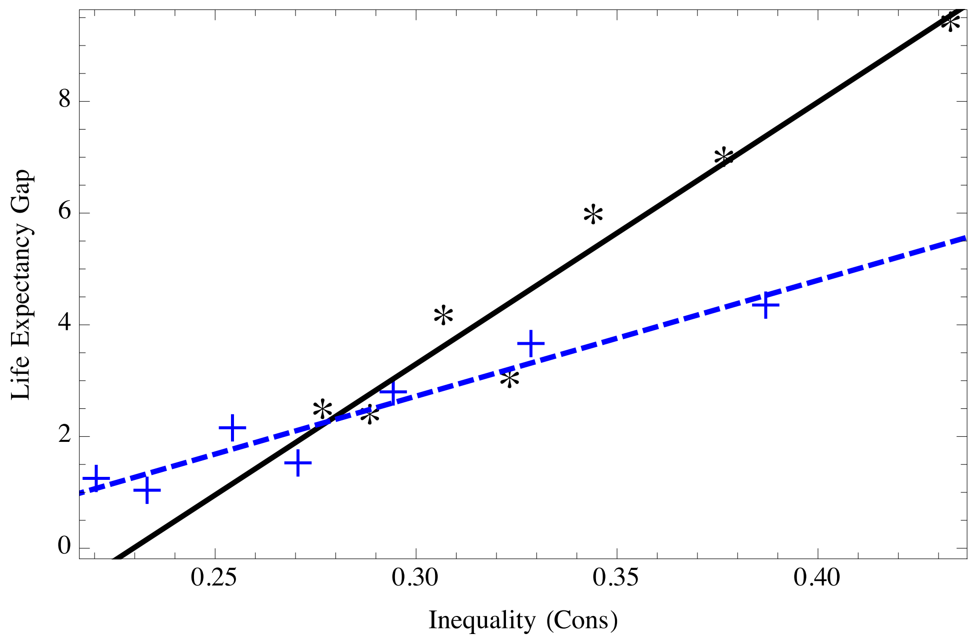


FIGURE 22. Life Expectancy Gap vs. Inequality.
Black-Solid Line/Black Stars: Baseline, Blue-Dashed Line/Blue Plusses: $\tau = 0.25$

inequality. Intuitively this due to the fact that for lower values of τ there is a steeper drop-off in survival probability for those individuals with low health stocks. Given that figure 19 showed low incomes were also associated with low health stocks, an increase in the curvature of the survival function will lower life expectancy of those in the bottom decile faster than those individuals in the top decile.

Conclusion

This chapter has used a model of upward-looking aspirations and endogenous health to study the effect of inequality when social aspirations matter. The model shows that relative deprivation within a reference group is an important determinant for mortality outcomes. In addition, we showed that social aspirations act as a motivating force which causes income and consumption inequality to be lower than fundamental inequality. However, this motivation comes at a cost as social aspirations drastically shift down the health production function, resulting in worse health outcomes. Finally, we provided an explanation for why the correlation between inequality and life expectancy has been declining over time. Clearly, increases in income result in better health outcomes, however these improvements in health are not equally shared across levels of inequality. Due to biological constraints those individuals who live in low inequality societies with already high life expectancy do not receive the same improvements in health that their counterparts in high inequality/low life expectancy economies do.

A helpful extension to this work would be to explore the role of government. Redistributive taxation may be able to improve health outcome by making individuals feel relatively less deprived. The provision of public health may also explain the weakening correlation between inequality and life expectancy because health decisions would then be partially outside of the control of individuals, less responsive to an individual's inequality aversion.

CHAPTER IV

ASPIRATIONS AND REDISTRIBUTION

Introduction

The notion that individuals have social status concerns or care about their relative standing has long been around in economics. Both Veblen (1898) and Duesenberry (1949) stressed the importance of status concerns in examining the individual's decision problem. Recently, experimental evidence has shown that most people do in fact care about relative income.[1] [2]

Hopkins (2008) identifies three reasons why people could care about their relative position within society. First, there could be rivalry: when others do better an individual may worry that their success will elevate them to a position of power. Secondly, it may reveal information—for example, witnessing others have success may indicate that a change in an individual's behavior is needed. The third reason has to do with perception—the only way to know if an individual is doing well is to compare herself to the success of others.

In this chapter, I take it as given that people exhibit these behavioral patterns and assume people are status conscious. Status seeking is then used to address the relationship between inequality and growth. The premise is that when individuals feel deprived relative to the rest of the society, they may undertake actions that are not necessarily in the best interest of the economy as a whole. In the case of this chapter, these actions take the form of demanding higher redistribution, which reduces entrepreneurship and innovation.

[1] See Johansson-Stenman et al. (2002), Solnick and Hemenway (1998), and Alpizar et al (2005).

[2] For an overview of the literature regarding social status see Weiss and Fershtman (1998).

Socially oriented preferences are formalized through the use of individual-specific consumption benchmarks, referred henceforth as aspirations. Each agent forms aspirations by taking the average of consumption by those agents above them in the distribution. Therefore agents are upward-looking and, in terms of the Hopkins (2008) classifications, motivated by feelings of rivalry.[3]

Agents inhabit a two-period OLG model and have preferences over two types of goods, referred to broadly as consumption and leisure. Consumption is subject to social status concerns while leisure is not.[4] I assume that enjoyment of leisure time requires requires certain marketed goods. Individuals are endowed with market time and leisure time, which are both supplied inelastically to their respective activities.

Agents become workers or entrepreneurs based upon their endowed entrepreneurial ability. Workers earn a wage determined in the market for labor, while entrepreneurs produce a market good and earn profits net of taxation. The tax rate is determined by a median voter and the proceeds are used to finance government services, which act as a redistributive force that mitigates the negative effects of social concerns. This can be thought of as the government providing services that could otherwise not be afforded by an agent, making them feel relatively less deprived.

I present three main results. First, an economy with upward-looking aspirations desires higher redistribution than one without. The intuition behind this result lies in the relationship between government services and aspirations. Upward-looking aspirations make the median agent feel relatively deprived, therefore in order to mitigate these feelings of relative deprivation the median agent sets a higher tax rate and hence higher government services.

[3]For a discussion of aspiration formation see Genicot and Ray (2010).

[4]See Hirsh (1976) and Frank (1985a, 1985b, 1999) for a discussion of the varying positionality of goods.

Second, the tax rate is increasing in consumption inequality. The intuition here again relies on the counteracting effects of government services on aspirations. An increase in consumption inequality results in greater relative deprivation, thus the median agent demands more of the government service.

Finally, the effect of an increase in ability (fundamental) inequality on the equilibrium tax rate depends upon the occupation of the median agent. If the median agent is a worker, an increase in ability inequality results in higher taxes, for reasons similar to the first two results. However, if the median agent is an entrepreneur, an increase in ability inequality results in a lower equilibrium tax rate, as the erosive power of taxation is strong for an entrepreneur. This suggests the effect of inequality on growth is not unambiguously negative.

This chapter is related to the vast literature on social status. Most relevant are papers which deal with growth, taxation, and inequality. Two papers on the linkage between inequality and growth have been influential. Persson and Tabellini (1994) and Alesina and Rodrik (1994) both present theoretical and empirical evidence depicting the negative relationship between inequality and growth. Their mechanism by which this relationship arises is redistributive taxation, which lowers capital accumulation and thus economic growth.

Within the social status literature the topics of growth and optimal taxation have garnered significant attention. Theoretical support has been mixed regarding the impact that social status concerns have on growth. Several papers show that growth is higher under social status concerns, for example Corneo and Jeanne, henceforth CJ, (1997, 1999a, 2001) use asset holdings to determine social status. The measure of social status is slightly different in each of these paper, one uses asset held relative to the average (1997), another uses total assets held (1999a), and the last paper uses position within the wealth distribution (2001). In each of these papers the authors use Arrow-Romer production externalities and showed that growth is higher under social status. Peng (2008) builds a model similar to CJ (2001) but instead of relative position, the author uses relative deprivation and confirms the result found in CJ (2001). The interesting thing about these results is that just because social status results in higher growth, the same is not necessarily true for increases in the level of inequality. Corneo and Jeanne (2001) and Peng (2008) show that when individuals care about relative position within the asset distribution, an increase in inequality lowers the marginal benefit of increasing their position, thus they invest less in productive activities. Fershtman *et al.* (1996) show that if social status is attached to growth enhancing occupations, low-ability/high-wealth individuals will acquire enough schooling to obtain these jobs. This in turn lowers the average ability in these occupations thus lowering the growth rate.

The social status literature as it relates to taxation has largely focused on optimal tax policies as set by a welfare optimizing government. Aronsson and Johansson-Stenman (2008) construct a model where consumption is positional and leisure is not. They show that taxation can result in better outcomes as it corrects for overspending on the positional good. Ireland (2001) uses non-linear taxation on labor in order to show that positive impact that taxation has on the economy. Much like Aronsson and Johnasson-Stenman the reason for the corrective impact of taxation is that it lowers the incentive to consume positional goods that have no beneficial purpose. Other examples of taxation and social status that follow the same pattern include Dodds (2012), Ljungqvist and Uhlig (2000), and Aronsson and Johansson-Stenman (2010). One paper that studies social status concerns in a median voter model is Alesina and Angeletos (2005), where multiple equilibria can arise based upon a society's view of fairness and how much of individual income is attributed to luck rather than effort and ability.

My contribution to this literature is two-fold. First, I show that, in contrast to the literature on social status and growth, social concerns (regardless of inequality) do not necessarily result in better growth outcomes. The difference between this paper and prevailing literature is that in my paper the agents do not have social concerns over those goods which are necessarily growth enhancing. In the papers discussed above, agents were given an incentive to hold more capital through social status concerns, which given the Arrow-Romer externalities in the production function results mechanically in a higher growth rate. In contrast, social concerns in this paper are over consumption and the steps taken to satisfy these concerns actually lower the growth rate. It should be noted however, that while social status concerns result in higher taxation and lower growth, they do not necessarily result in lower welfare. I show that the tax rate has a Laffer curve effect on welfare.

The second contribution of this paper is theoretical. It uses a dynamic median voter economy compared to static models with an optimizing government commonly used in the literature. Moreover, rather than peg aspirations to a common economy-wide average, I use individual specific benchmarks.

This paper proceeds as follows. Section 2 discusses the model set-up, section 3 presents some analytical results, section 4 discusses the computational results, and section 5 concludes.

Model

Household's Problem

The economy is populated with a continuum of two-period OLG households which consist of a parent and a single offspring on the unit measure. Each household is endowed with an entrepreneurial ability drawn from an invariant distribution $G(a)$, which is bounded below by $a_{min} > 0$. A subset of households use their entrepreneurial ability to start a monopolistically competitive firm and earn profits. The rest find employment in the firms of the entrepreneurial agents. A household's income is allocated toward consumption of the goods produced by the firms and production of leisure. In this model leisure enjoyment requires the purchase of non-market goods. The reason for this distinction between what the literature refers to as positional (consumption) and non-positional (leisure) goods is that agents need face a trade-off in order to respond to changes in the consumption distribution, otherwise the entirety of income would be allocated to consumption. Lifetime utility is given generally by equation (4.1).

$$U_{it} = u(c_{it}, \bar{C}_{it}, g_t) + v(X_{it}) \tag{4.1}$$

where c is a consumption of the composite good, $\bar{C}$ is the agent's aspired consumption, g government spending, and X is the amount of leisure consumed. Aspirations are upward-looking and are formed using the average level of consumption of the composite good by those agents who consume more than individual i. The partials for the above preferences are given by:

$$\frac{\partial U}{\partial c} > 0, \frac{\partial^2 U}{\partial c^2} < 0, \frac{\partial U}{\partial g} > 0, \frac{\partial U}{\partial X} > 0, \frac{\partial^2 U}{\partial X^2} < 0, \frac{\partial^2 U}{\partial c \partial \bar{C}} > 0, \frac{\partial^2 U}{\partial c \partial g} < 0$$

The first five partials follow the standard assumptions within the literature. It should be noted that the partial $\frac{\partial U}{\partial \bar{C}}$ is left unrestricted because it is not clear what impact an increase in aspired consumption would have on overall utility. An argument can be made that an increase in aspired consumption makes an individual better off because their prospects are better, while on the other hand an increase in aspired consumption may make an individual worse off because she is farther away from her goals.

Before looking at the budget constraint, I want to draw attention to how the marginal utility of consumption depends on the level of aspirations and government services. First, the cross-partial with respect to aspirations is positive: an increase in aspirations makes consumption more valuable, thus inducing the household to consume more. Second, the cross-partial with respect to government services is negative. The effect of this is to attenuate the impact that aspirations has on the level of consumption. In other words, when an increase in aspirations pushes the agent further below her desired consumption, an increase in government spending allows her to feel less relatively deprived.

Households are endowed with a unit of work time which they supply inelastically and a unit of leisure time. If the agent is an entrepreneur, she produces a unique final good in a monopolistically competitive market. Entrepreneurs must also pay taxes on their profits which are used to provide the government service. Agents also have a unit leisure time whose enjoyment requires the market inputs through the production function:

$$H(x) = x.$$

The budget constraint is given by equation (4.2).

$$\begin{aligned} &\int_{j\in\Upsilon_t} p_t^j c_{it}^j dj + p_t^x x_{it} = y_{it} \\ &y_{it} = \begin{cases} w_t & \text{if } i\text{'s a worker} \\ (1-\tau_t)\pi_{it} & \text{if } i\text{'s an entrepreneur} \end{cases} \end{aligned} \tag{4.2}$$

where at time t, Υ_t is the set of goods available for purchase, c_t^j is the consumption variety j, p_t^j is the price of consumption variety j, w_t is the wage paid to workers, x_t is the amount of leisure inputs purchased, p^x is the price of the leisure input, π_t is profits, and τ_t is the economy-wide tax rate.

The composite consumption good is given by

$$c_t = \left(\int_{j\in\Upsilon_t} (c_t^j)^{\frac{\epsilon-1}{\epsilon}} dj\right)^{\frac{\epsilon}{\epsilon-1}} \tag{4.3}$$

where $\epsilon \in [1, \infty)$ is the elasticity of substitution between varieties. Individual i's aspired consumption level is:

$$\bar{C}_t = \frac{\int_{c_t}^{\infty} x dF_t(x)}{1 - F_t(c_t)}. \tag{4.4}$$

$F_t(\cdot)$ is the time t distribution of consumption.

It is important to note that this aspirations level is defined as the average of all consumption greater than or equal to their own. This implies that the level of aspirations for the agent with the highest of consumption will be her own consumption.

From the utility maximization problem, the demand for variety j by individual i is

$$c_t^j = \left(\frac{p_t}{p_t^j}\right)^{\epsilon} c$$

where the price index is defined by

$$p_t = \left(\int_{j\in\Upsilon_t} \left(p_t^j\right)^{1-\epsilon} dj\right)^{\frac{1}{1-\epsilon}}.$$

I normalize the budget constraint by the price level, which yields:

$$c_{it} + P_t x_{it} = y_{it} \tag{4.5}$$

where $P_t = \frac{p_t^x}{p_t}$.

Entrepreneur's Problem

As stated above, those agents who become entrepreneurs use their ability endowment to produce a unique variety of consumption good in a monopolistically competitive environment. Using the individual's demand for good j from above, I can write down the total demand faced by a firm as a function of their price and total consumption. This expression is given by equation (4.6).

$$C_t^j = \left(\frac{1}{p_t^j}\right)^{\epsilon} \left(\int_0^1 c_{it} di\right) \equiv \left(\frac{p_t}{p^j}\right)^{\epsilon} C_t \tag{4.6}$$

where C is aggregate demand. I assume that this is a closed economy so that total production equals total demand.

$$Y_t^j = C_t^j \tag{4.7}$$

Production technology is AK and it depends on the entrepreneurial ability of the individual (a), the aggregate level of technology (A), and the amount of labor employed (l). The expression for the production function is given by equation (4.8).

$$Y_t^j = A_t a_t^j l_t^j \tag{4.8}$$

Given the expression for total demand and the production function, I can solve for the optimal price for each good j. The price is given by equation (4.9).

$$p_t^j = \frac{\epsilon}{\epsilon - 1}\left(\frac{w_t}{a_t^j A_t}\right) \tag{4.9}$$

which is the standard result that price is simply a constant mark-up over marginal cost.

Using the expression for the optimal price, I can write down the expressions for profits (equation 4.10) and labor demand (equation 4.11) as a function total consumption, aggregate productivity, entrepreneurial ability, and wages.

$$\pi_t^j = C_t \left(\frac{a_t^j A_t}{w_t}\right)^{\epsilon-1} \left(\frac{\epsilon - 1}{\epsilon}\right)^{\epsilon} \left(\frac{1}{\epsilon - 1}\right) \tag{4.10}$$

$$l_t^j = C_t (a_t^j A_t)^{\epsilon-1} \left(\frac{\epsilon - 1}{\epsilon w_t}\right)^{\epsilon} \tag{4.11}$$

The next step in solving this model is to examine the occupational decision. Note that $\partial \pi_t^j / \partial a_t^j > 0$. Hence, I anticipate that there is a threshold ability level $\underline{a}$ such that agents with $a \geq \underline{a}$ become entrepreneurs and the rest enter the workforce.

In order to solve for $\underline{a}$, I need to determine the value of a for which the after tax profits from being an entrepreneur are equal to the wage received from working. Explicitly this is given as:

$$(1-\tau_t)\pi(\underline{a}_t) = w_t$$

Solving the above expression gives:

$$\underline{a}_t \equiv \frac{(w_t^{\epsilon}\epsilon^{\epsilon})^{\frac{1}{\epsilon-1}}}{A_t(\epsilon-1)C_t^{\frac{1}{\epsilon-1}}(1-\tau_t)^{\frac{1}{\epsilon-1}}} \tag{4.12}$$

It is assumed that the aggregate technology evolves according to a learning-by-doing externality. This externality is determined by the share of the population that are entrepreneurs. That means I can write down the evolution of the aggregate technology stock as a function of the entrepreneurial cut-off value (given in equation 4.13).

$$A_{t+1} = (1+\nu(1-G(\underline{a}_t)))A_t \tag{4.13}$$

Equation (4.13) shows the implicit dependency of aggregate technology growth on taxation. This relationship poses a problem for growth outcomes if the tax rate is positively related to the cut-off. In this case, an increase in the rate of taxation actually has a negative impact on aggregate output.

When taking the derivative of $\underline{a}$ with respect to τ it is important to recognize the implicit relationship between wages and taxes. If a change in taxation does influence the cut-off value, this will effect wages because they are determined endogenously through labor demand which is set by $\underline{a}$. The derivative given by equation (4.14) takes this implicit relationship into account.

$$\frac{\partial \underline{a}_t}{\partial \tau_t} = \frac{C_t^{\frac{1}{1-\epsilon}} (1-\tau_t)^{-\frac{\epsilon}{\epsilon-1}} \left(\epsilon^\epsilon w(\tau_t)^\epsilon\right)^{\frac{1}{\epsilon-1}} \left(w(\tau_t) + (1-\tau_t)\epsilon w'(\tau_t)\right)}{A_t(\epsilon-1)^2 w(\tau_t)} \tag{4.14}$$

The sign of this derivative is not immediately apparent, it depends on:

$$\epsilon(1-\tau_t)\frac{w'(\tau_t)}{w(\tau_t)} \gtreqless -1 \tag{4.15}$$

To make further progress, I adopt specific functional forms.

Analytical Results

The analytical results will require placing structure on the agent's utility and the distribution from which entrepreneurial ability is drawn. Equation (4.16) gives the assumed functional form.

$$U_{it} = \frac{c_{it}^{1-\sigma}}{1-\sigma}\bar{C}_{it}^{\psi\sigma} g_t^{\gamma\sigma} + \eta^\sigma \frac{x_{it}^{1-\sigma}}{1-\sigma} \tag{4.16}$$

In order to satisfy the derivative given above the following parameter restrictions are imposed:

$$0 < \psi < 1, \gamma < 0, \sigma > 1.$$

For convenience, I set the distribution of entrepreneurial ability to be Pareto with location parameter $a_{min} = 1$ and the shape parameter equal to α. I make the additional assumption that $\epsilon < 1 + \alpha$ in order to ensure that the demand for labor is positive.

Production

On the production side of the economy I am interested in obtaining closed form solutions for two variables: wages and the entrepreneurial cut-off ability.

The first step in determining the equilibrium wage is to write down the expression for aggregate labor supply and labor demand. Starting with aggregate labor supply, note that because there is a continuum of agents I can write the integral over the distribution of productivities rather than agents. The expression for aggregate labor supply is given by equation (4.17).

$$L_t^S \equiv \int_0^{\underline{a}_t} 1 dG(x) = G(\underline{a}_t) = 1 - (\epsilon - 1)^{\alpha} \epsilon^{\frac{\alpha\epsilon}{1-\epsilon}} A_t^{\alpha} (1 - \tau_t)^{\frac{\alpha}{\epsilon - 1}} C_t^{\frac{\alpha}{\epsilon-1}} w_t^{\frac{\alpha\epsilon}{1-\epsilon}} \tag{4.17}$$

from this alone, the effect of the tax rate on labor supply is unclear because wages also depend on τ. However, equation (4.17) shows that an increase in wages, holding everything else constant, does result in an increase in labor supply. In the same manner, I can write down the aggregate labor demand by integrating over the firm level demand. The equation for aggregate labor demand is given by (4.18).

$$L_t^D \equiv \int_{\underline{a}_t}^{\infty} C_t \left(\frac{\epsilon - 1}{\epsilon w_t}\right)^{\epsilon} A_t^{\epsilon-1} x^{\epsilon-1} dG(x) = \frac{\alpha(\epsilon - 1)^{\alpha+1} \epsilon^{\frac{\alpha\epsilon}{1-\epsilon}} A_t^{\alpha} (1 - \tau_t)^{\frac{\alpha-\epsilon+1}{\epsilon-1}} C_t^{\frac{\alpha}{\epsilon-1}} w_t^{\frac{\alpha\epsilon}{1-\epsilon}}}{\alpha - \epsilon + 1} \tag{4.18}$$

Much like labor supply, I cannot determine the impact that an increase in the tax rate has on the labor demand, but it is clear that an increase in wages results in a lower demand for labor. Equations (4.17) and (4.18) can be combined in order to determine the equilibrium wage rate (given by equation 4.19).

$$w_t = \frac{(\epsilon-1)^{\frac{\epsilon-1}{\epsilon}} A_t^{\frac{\epsilon-1}{\epsilon}} C_t^{\frac{1}{\epsilon}} \left(\frac{\alpha(\epsilon-\tau_t)+(1-\tau_t)(1-\epsilon)}{\alpha-\epsilon+1}\right)^{\frac{\epsilon-1}{\alpha\epsilon}} (1-\tau_t)^{\frac{\alpha-\epsilon+1}{\alpha\epsilon}}}{\epsilon} \tag{4.19}$$

Taking the derivative of the wage rate with respect to the tax rate yields:

$$\frac{\partial w_t}{\partial \tau_t} = -\frac{(\epsilon-1)^{\frac{\epsilon-1}{\epsilon}} A_t^{\frac{\epsilon-1}{\epsilon}} C_t^{\frac{1}{\epsilon}} (\epsilon-\tau_t)(1-\tau_t)^{-\frac{(\alpha+1)(\epsilon-1)}{\alpha\epsilon}} \left(\frac{\alpha\epsilon-\epsilon+1}{\alpha-\epsilon+1}-\tau_t\right)^{\frac{\epsilon-1}{\alpha\epsilon}-1}}{\epsilon^2} < 0, \tag{4.20}$$

which is unambiguously negative. In order to understand why this is the case let's look at the expression for the ability cut-off for entrepreneurs. When equation (4.19) is substituted in equation (4.12) simplifies to:

$$\underline{a}_t = \left(\frac{-\tau_t(\alpha-\epsilon+1)+(\alpha-1)\epsilon+1}{(1-\tau_t)(\alpha-\epsilon+1)}\right)^{\frac{1}{\alpha}} \tag{4.21}$$

whose derivative with respect to the tax rate is given by:

$$\frac{\partial \underline{a}_t}{\partial \tau_t} = -\frac{(\epsilon-1)\left(1-\frac{\alpha(\epsilon-1)}{(\tau_t-1)(\alpha-\epsilon+1)}\right)^{\frac{1}{\alpha}}}{(\tau_t-1)(-(\alpha+1)\tau_t+\epsilon(\alpha+\tau_t-1)+1)}.$$

This is positive if:

$$1 > -\frac{\alpha(\epsilon-1)}{(1+\alpha-\epsilon)(1-\tau_t)}.$$

This is unambiguously true based on the assumption that $1+\alpha > \epsilon$. This means that an increase in the tax rate results in fewer entrepreneurs, which explains why the wage rate falls. As the tax rate increases, the entrepreneurial cut-off value increases which decreases labor demand while simultaneously increasing labor supply, thus decreasing the wage rate.

The next step is to determine if the median agent is a worker or an entrepreneur. This is straightforward to determine, because the median agent will be endowed with the median ability draw from the assumed Pareto distribution, which is given by:

$$a^M = 2^{\frac{1}{\alpha}}$$

Therefore if $\underline{a} > (<) a^M$ then the median agent is a worker (entrepreneur) and the tax rate will be determined accordingly. Under what conditions is the median agent a worker?

$$\left(\frac{-\tau_t(\alpha - \epsilon + 1) + (\alpha - 1)\epsilon + 1}{(1 - \tau_t)(\alpha - \epsilon + 1)} \right)^{\frac{1}{\alpha}} > 2^{\frac{1}{\alpha}}$$

Simplifying yields:

$$\frac{1 + \alpha\epsilon - \epsilon}{1 + \alpha - \epsilon} > 2 - \tau_t$$

Note that the right hand side of the above expression is at its maximum when $\tau_t = 0$. Hence, sufficient conditions (by setting $\tau = 0$) for the median agent to be a worker are:

$$\begin{array}{ll} \alpha > \frac{1-\epsilon}{\epsilon-2} & \text{if } \epsilon > 2 \\ \alpha < \frac{1-\epsilon}{\epsilon-2} & \text{if } \epsilon < 2 \end{array} .$$

Given the conditions above, if $\epsilon > 2$ then the median agent has to be a worker because $\alpha > 1$ (under the conditions for a Pareto Distribution).

If either of the conditions are violated, then the median agent is a worker only if the tax rate is sufficiently high. The condition on the tax rate is given by:

$$\tau_t > 2 - \frac{1 + \alpha\epsilon - \epsilon}{1 + \alpha - \epsilon}$$

The economy-wide tax rate is set through a median voter, therefore I need to determine the desired tax rate for each individual. It is important to note that because all the workers earn the same wage they will desire the same tax rate, hence if the median voter is a worker the economy-wide tax rate will be given by an arbitrary worker's first order condition. In contrast, if the median agent is an entrepreneur, the economy-wide tax rate will be given by the agent with ability a^M.

Each household has effectively two choice variables: enjoyment of leisure and their desired tax rate. While the choice of leisure is straightforward, the agent's desired tax rate is not. In choosing the desired tax rate, every agent acts as if she was the median voter, thereby internalizing the effect of her desired tax rate on aggregate variables like wages and government spending. The first order condition for leisure is given by equation (4.22).

$$x_{it} = \frac{\eta}{\bar{C}_{it}^{\psi} P_t^{\frac{1}{\sigma}} g_t^{\gamma} + \eta P_t} y_{it} \tag{4.22}$$

Given the parameter assumptions at the start of this section, it is clear that an increase in the level of aspirations results in a decline in the consumption of leisure. This makes sense because the increase in aspirations results in an increase in the marginal value of the composite good. In contrast, an increase in the provision of government services increases the consumption of leisure because g lowers the marginal value of consumption.

The desired tax rate on the other hand implicitly sows the first order condition given by equation (4.23).

$$\gamma\sigma\left(\frac{P_t^{\frac{1}{\sigma}}\bar{C}_{it}^{\psi}g(\tau_t)^{\gamma}}{P_t^{\frac{1}{\sigma}}\bar{C_{it}}^{\psi}g(\tau_t)^{\gamma}+P\eta}\right)\frac{g'(\tau_t)}{g(\tau_t)}=(\sigma-1)\frac{y'(\tau_t)}{y(\tau_t)} \tag{4.23}$$

where $g(\cdot)$ is the level of government services and $y(\cdot)$ is the household income. The government is assumed to run a balanced budget:

$$g(\tau)=\tau\int_{\underline{a}}^{\infty}\pi(x)dG(x),$$

which implies that $g(0)=0$ and $g(1)=0$, the latter a direct result of the expression for $\underline{a}$. Also, because τ and $\pi(x)$ are necessarily non-negative: $g(x)>0$ for $0<x<1$. This means that the derivative of $g'(\tau)$ is ambiguous over the range of possible tax rates.

Because the relationship between taxation and government services is non-monotonic, it stands to reason that the relationship between the tax rate and life utility is non-monotonic as well. In figure 23 I look at the relationship between social welfare (as measured by the Benthamite social welfare function, that is, a weighted sum of the individual lifetime utilities) and the tax rate.

Figure 23 shows that despite the fact an increase in the tax rate lowers the growth rate of the economy it is not necessarily welfare reducing. The Laffer curve presented in figure 23 presents an interesting relationship between the tax rate and total social welfare. For a large range of tax rates, the marginal impact of increasing taxation on welfare is quite small. This suggests that within this range of tax rates the decline in wages from increased taxes is almost completely balanced by the increase in government services. At the extremes of the possible tax rates, the Laffer curve shows that the marginal impact of changing taxation is quite high.

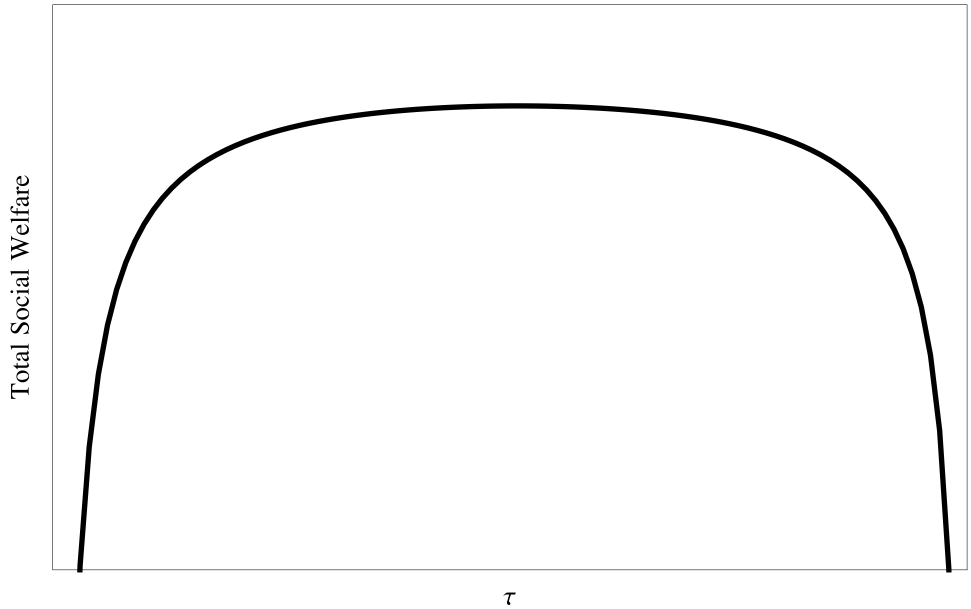


FIGURE 23. Lifetime Utility Plotted Against the Tax Rate

To make further progress I use computational methods to understand the relationship between desired taxation and aspirations.

Computational Results

The first step is to look at the relationship between the level of aspirations and desired taxation. In this section, I will not be looking at dynamics but rather the static relationship between inequality and taxation. Figure (24) shows this relationship for both workers and entrepreneurs.[5]

Two things are to be noted in this figure. First an increase in the level of aspirations results in a greater demand for taxation by both workers and

[5]In the figures presented in this section, the following parameters are used: technology and aggregate demand are scaling parameters and are set at 1 and 100, respectively. The preferences parameters are set: $\sigma = 2$, $\eta = 4$, $\gamma = -0.5$, and $\psi = 0.5$. The distribution parameters are $a_{min} = 1$ and $\alpha = 3.25$. The elasticity of substitution is set at 1.75 or 2.1 depending on the figure. Finally, the price of the leisure good is set at 1.5. The results presented in this section are robust to a wide range of parameter values.

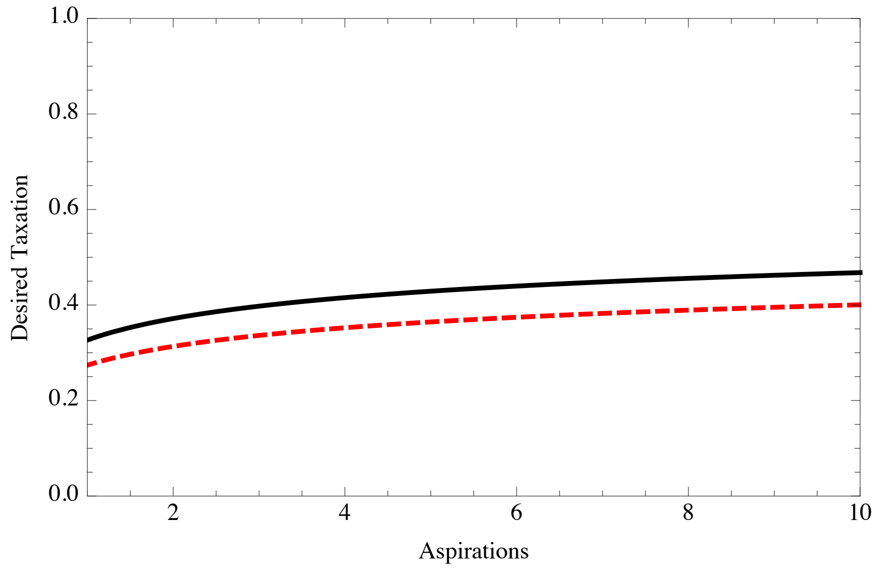


FIGURE 24. Relationship between the level of aspirations and desired taxation for workers and entrepreneurs.
Workers: Black/Solid, Entrepreneurs: Red/Dashed

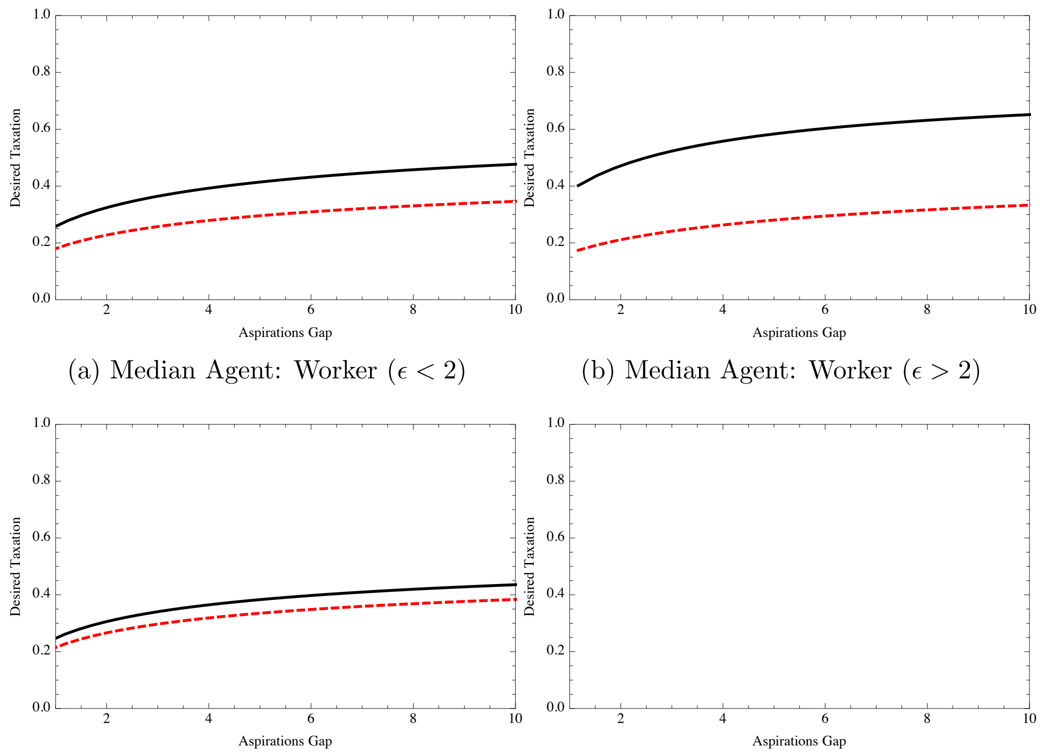
entrepreneurs. This make sense, as agents would desire to reduce the impact of higher aspirations by demanding more government services. The parameter choices of γ and ψ determine the level and shape of the curves in figure (24). As $\gamma \to 0$, the level of desired taxation converges to zero because the effect of government services on utility diminishes. Likewise, as $\psi \to 0$, the demand of redistribution flattens out with respect to the level of aspirations because they play less of role in determining the agent's overall level of utility.

Figure (24) does not reveal how inequality influences the agent's choice. One could have an extremely rich but relatively equal economy with a high level of aspirations. Therefore, I need a notion of an aspirations gap, the ratio of an individual's aspired consumption to their actual consumption. This measure captures how relatively deprived agents are in comparison to their reference group.

The first order condition for leisure implies that this aspirations gap is:

$$\frac{\bar{C}_{it}}{c_{it}} = \frac{\bar{C}_{it}^{1-\psi}\left(P_t^{\frac{1}{\sigma}}\bar{C}_{it}^{\psi}g_t^{\gamma} + P_t\eta\right)}{P_t^{\frac{1}{\sigma}}g_t^{\gamma}y_{it}}$$

This expression is used in figure (25) to plot the relationship between the aspirations gap and the desired rate of taxation for four possible situations: Median Agent (MA) is a worker and $\epsilon < 2$, MA: Worker and $\epsilon > 2$, MA: Entrepreneur and $\epsilon < 2$ and MA: Entrepreneur and $\epsilon > 2$.



(a) Median Agent: Worker ($\epsilon < 2$)

(b) Median Agent: Worker ($\epsilon > 2$)

(c) Median Agent: Entrepreneur ($\epsilon < 2$)

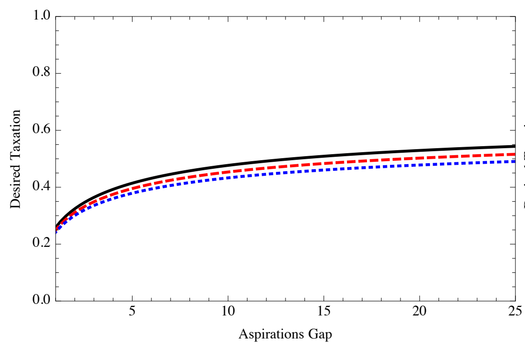
(d) Median Agent: Entrepreneur ($\epsilon > 2$)

FIGURE 25. Aspirations Gap vs the Desired Rate of Taxation for workers and entrepreneurs. If the median agent is a worker, the ability of the shown entrepreneur is $\underline{a}$. If the median agent is an entrepreneur, her ability is a^M.
Black/Solid: Worker, Red/Dashed: Entrepreneur

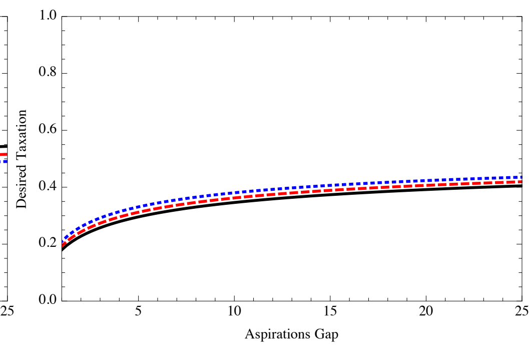
The first thing to note is that figure (25d) is blank because, as discussed above, the median agent will never be an entrepreneur if $\epsilon > 2$ so the results pertaining to this case are irrelevant. Figures (25a) and (25b) show the desired tax rates for the workers and the entrepreneur with ability $\underline{a}$. In both of these figures, the economy-wide tax rate will be given by the solid-black line. In figure (25c) the median tax rate will be given by the entrepreneur with ability $a = 2^{\frac{1}{\alpha}}$ (depicted by the red/dashed-line). There are a couple of things to note from this figure. First, regardless of the type of worker the desired tax rate is increasing in the agent's aspirations gap. This implies that an increase in consumption inequality results in an increase in the demand for redistribution. This is means an increase in taxation will shrink the pool of entrepreneurs, resulting in lower growth of output per capita.

It is clear that the elasticity of substitution between varieties of consumption goods has a rather meaningful impact on the desired tax rate. As can be seen in figures (25a) and (25b) as ϵ increases the gap between entrepreneurs and workers increases and the tax rate as determined by the median voter increases. This happens because an increase in the elasticity of substitution makes various goods closer substitutes, which erodes profits and increases the entrepreneurial cut-off ability, thus lowering wages. Workers optimally deal with the loss of wages by substituting towards government services, while entrepreneurs attempt to stave off further losses by demanding lower taxation.

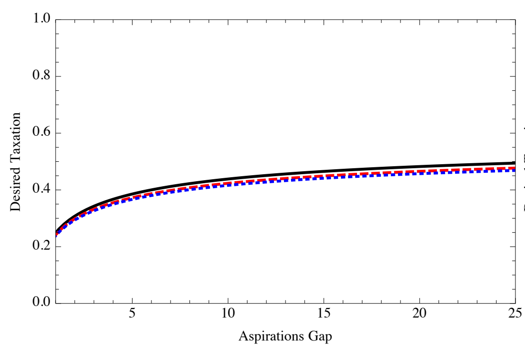
The next question that needs to be addressed is the relationship between inequality and the desired tax rate. Figure (25) shows that for an invariant distribution of entrepreneurial ability an increase in consumption inequality will increase the desired tax rate. To see this consider the situation where the median agent is a worker. Because the workforce is homogenous and an agent's aspirations are inclusive of her own consumption, her aspirations will simply be average consumption, $\hat{c}$. Therefore, her aspirations gap is simply $\hat{c}/c^M$. As this measure increases, so does inequality, which implies an increase in consumption inequality results in greater taxation. However, it does not explain what happens when the inequality in the underlying distribution of ability increases. Figure (26) plots the relationship between the aspirations gap and the desired tax rate for three different distributions of ability (the parameter α is varied).



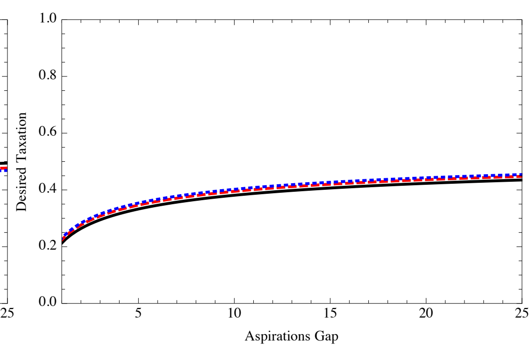
(a) MA: Worker/ DT:Worker



(b) MA: Worker/ Entrepreneur



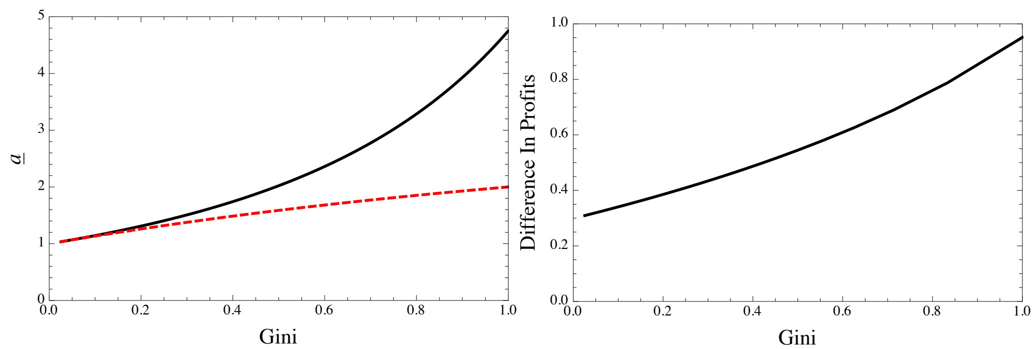
(c) MA: Entrepreneur/ DT:Worker



(d) MA: Entrepreneur/ DT:Entrepreneur

FIGURE 26. Aspirations Gap vs the Desired Rate of Taxation for workers and the lowest ability entrepreneur. The median voter is a worker and there are three different underlying distributions of ability.
MA: Worker—Black/Solid: Gini=0.5, Red/Dashed: Gini=0.35, Blue/Dotted: Gini=0.2
MA: Entrepreneur—Black/Solid: Gini=0.2, Red/Dashed: Gini=0.1, Blue/Dotted: Gini=0.05

Figure (26) presents an interesting set of results. The effect that increases in inequality have on the desired tax rate depends upon which type of agent is being examined. If the agent under examination is a worker, an increase in ability inequality results in a greater demand for redistribution. However, if the agent is an entrepreneur the increase in inequality results in a lower demand for taxation. To gain further understanding of this behavior, I want to examine two variables: (1) the entrepreneurial cut-off level and (2) the difference in income accruing to entrepreneurs and workers.



(a) Entrepreneurial Cut-Off Value

(b) Profits vs. Wages

FIGURE 27. The entrepreneurial cut-off and total income differential plotted against ability inequality.
$\underline{a}$: Black/Solid, a^M: Red/Dashed

The first thing to note is that in both the case of the cut-off value and the difference in accrued income are both increasing in the level of inequality. Figure (27a) implies that both the profits of the marginal entrepreneur and wages are increasing inequality—in order for the cut-off value to increase the costs faced by the entrepreneur (wages) must increase as well. The results presented in figure (26) make more sense when interpreted in the light of figure (27b). As inequality increases, workers face a larger gap between their income and the income of those above them in the distribution, thus in order attenuate this impact they demand greater amounts of redistribution. Entrepreneurs, on the other hand, face a greater loss of profits to taxation as inequality increases thus they demand a lower amount of redistribution.

Therefore the impact that increases in inequality on the rate of taxation depends upon the occupational location of the median voter. That being said, figure (27a) shows that, except in the case of extremely low levels of inequality, the marginal entrepreneur is above the median agent in the distribution, therefore it is likely that the tax rate will be determined by a worker.

The next thing to look at in regards to ability inequality is how it affects the growth rate. Figure (28) plots the growth rate of technology against ability inequality for a given tax rate ($\nu = 1$).

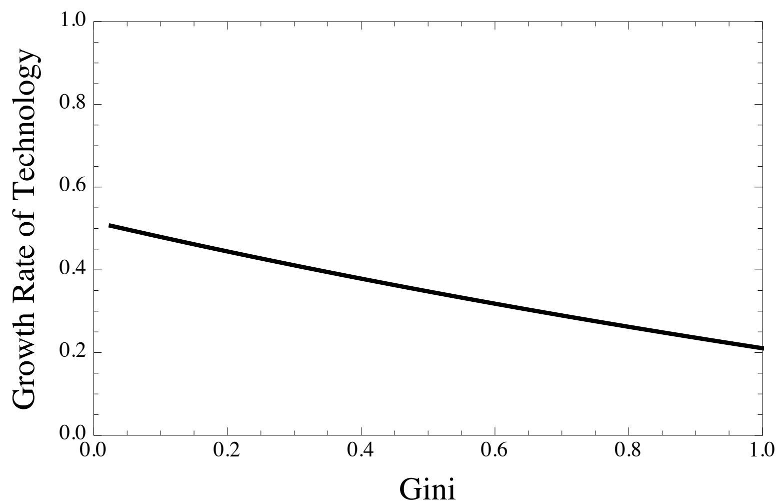
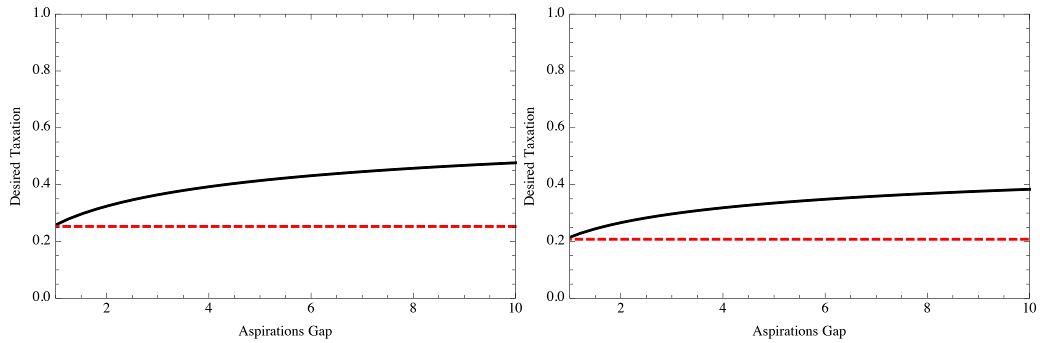


FIGURE 28. The Growth Rate of Technology plotted against Ability Inequality for a given tax rate.

Not surprisingly the increase in ability inequality results in lower growth. The reason for this is that an increase in ability inequality raises the entrepreneurial cut-off ability, which limits the amount of learning-by-doing within an economy.

Finally, I want to look at the impact that aspirations has on the economy-wide tax rate, or in other words, how do the outcomes this model differ from a model with no aspirational considerations. Figure (29) plots the economy-wide tax rate for both the aspirations and no aspirations case.



(a) Median Agent: Worker (b) Median Agent: Entrepreneur

FIGURE 29. Aspirations Gap vs the Desired Rate of Taxation for when the median voter is a worker and when the median voter is an entrepreneur.
Aspirations: Black/Solid, No Aspirations: Red/Dashed

Figure (29), shows two results. First, the presence of aspirations causes a gradient between the economy-wide tax rate and where the median agent sits in the consumption distribution. This is rather intuitive, in the case where the agent does not have preferences over where she sits in the distribution, her desired tax rate does not depend upon her location. The second result is that aspirations result in uniformly higher rates of taxation. This is of concern if entrepreneurship is directly related to taxation and growth. In this case, societies with strong aspirational concerns would experience lower growth rates due to their higher rates of taxation, which is in direct contrast to past studies of social status and growth. The reason for this contrast is that in past studies, social status either directly or indirectly induces agents to do things that are growth enhancing. While in this paper agents seek out actions that are growth reducing in an effort to satisfy their relative concerns.

Conclusion

In this chapter, I present a dynamic model of social status and growth. I show that, in contrast to the existing literature, social status results in an unambiguously lower growth rate. Second, an increase in consumption inequality results in greater redistribution and lower economic growth. And finally, an increase in ability inequality has an ambiguous impact on redistribution and economic growth.

Future work on this chapter will include five avenues. First, a better motivation for the trade-off between positional and non-positional goods is necessary. Second, I will simulate the model in order to examine the evolution of inequality over time and the relationship between fundamental inequality and consumption inequality. Third, I will study the empirical implications regarding inequality and taxation. Fourth, it would be helpful to look at the possibility that entrepreneurs may use their wealth to capture *de jure* political power and influence tax policy. Finally, it will be interesting to look at the situation where entrepreneurship depends on wealth, for example due to credit constraints, besides ability.

A further extension of the work presented here would be to apply it to a developing country in order to understand how social concerns and redistributive taxation effect the decision to move from the informal sector to the formal sector. In this context agents would have to choose between producing/working in the low productivity informal sector with no taxation or the higher productive formal sector with taxation.

APPENDIX A

SUBSISTENCE CONSUMPTION

Capital Shares

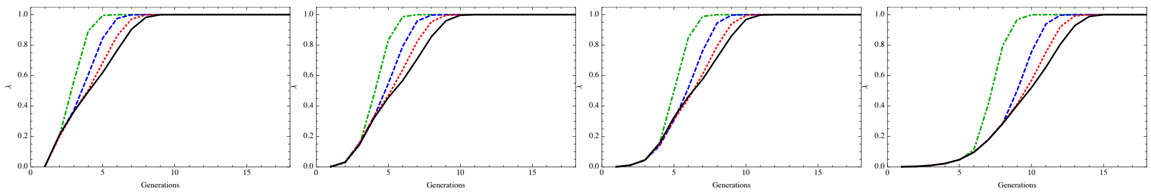
Country	Caselli & Feyrer	Gollin	OECD	Guerriero LS6	Country	Caselli & Feyrer	Gollin	OECD	Guerriero LS6
Algeria	0.125			0.122	Japan	0.256	0.246	0.298	0.168
Argentina				0.267	Jordan	0.251			
Australia	0.182	0.189	0.232	0.131	Latvia		0.300	0.247	0.164
Austria	0.220		0.227	0.169	Malaysia	0.162			0.238
Barbados				0.142	Mauritius	0.329	0.254		0.359
Belgium	0.200	0.197	0.239	0.223	Mexico	0.251		0.318	0.240
Bolivia	0.081	0.092		0.062	Morocco	0.231			0.137
Botswana	0.327			0.303	Namibia				0.130
Brazil				0.109	Netherlands	0.240	0.233	0.230	0.218
Bulgaria			0.223	0.235	New Zealand	0.121		0.190	0.118
Burundi	0.029				Nicaragua				0.080
Canada	0.157		0.189		Norway	0.216	0.197	0.240	0.177
Chile	0.163			0.135	Panama	0.149			0.160
Colombia	0.120			0.131	Paraguay	0.187			0.077
Congo	0.173				Peru	0.216			0.167
Costa Rica	0.108			0.120	Philippines	0.209	0.173		0.199
Cote d'Ivoire	0.062	0.061			Portugal	0.202	0.182	0.237	0.079
Denmark	0.204		0.218		Korea	0.265	0.230	0.170	0.174
Dominican Rep.				0.176	Moldova				0.120
Ecuador	0.079	0.062			Romania			0.192	0.163
Egypt	0.101			0.264	Russia				0.153
El Salvador	0.277				Singapore	0.379			0.307
Estonia		0.257	0.249	0.199	South Africa	0.209			0.214
Fiji				0.095	Spain	0.240		0.254	0.211
Finland	0.197	0.181	0.243	0.190	Sri Lanka	0.136			0.056
France	0.189	0.206	0.233	0.196	Sweden	0.163	0.160	0.239	0.170
Gabon				0.093	Switzerland	0.183		0.264	0.099
Germany	0.235		0.231	0.197	Thailand				0.096
Greece	0.146		0.240	0.237	Trin. and Tob.	0.080			0.087
Hungary		0.139	0.230	0.208	Tunisia	0.188			0.238
India		0.052			Turkey			0.318	0.292
Iran				0.083	UK	0.178	0.156	0.220	
Ireland	0.178		0.270	0.191	United States	0.177	0.175	0.231	
Israel	0.222		0.260	0.170	Uruguay	0.182			0.178
Italy	0.215	0.209	0.239	0.222	Venezuela	0.126			0.100
Jamaica	0.256	0.278		0.077	Zambia	0.063			

TABLE 8. Capital Shares by Country

Robustness Check

As discussed above, the form of the matching technology depends upon the nature of the externalities associated with the labor market. In this appendix I will show that the results above hold regardless of the value chosen for ξ. The matching technology I will consider can be described generally in three ways: convex, linear, and concave. I will check the impact that the shape has on the baseline results using different values for ξ (which are taken from $\{0.5, 1.0, 1.5, 2.0\}$, where 2.0 is the baseline number). Figure 30 shows the evolution of λ for each of the matching technologies.[1]

[1]The capital shares used in figure 30 are from Guerriero.



(a) $\bar{c} = 0$ (b) $\bar{c} = 58\%$ (c) $\bar{c} = 69\%$ (d) $\bar{c} = 80\%$

FIGURE 30. The evolution of the percentage of the workforce employed in the modern sector across time for the baseline calibration. Each panel represents different subsistence estimate.
$\xi = 2.0$: *Solid/Black*, $\xi = 1.5$: *Dashed/Red*, $\xi = 1.0$: *Dotted/Blue*, $\xi = 0.5$: Dashed-Dot/Green

In the figure above it is clear that regardless of the level of subsistence, the concave matching technology results in the fastest rate of convergence to full employment in the modern sector. This result is to be expected, given that the concave technology results in higher probabilities of successfully matching into the modern sector. That being said, even under the concave matching technology it can take up to six generations of relative stagnation before there is a rapid transition out of the traditional sector. The last thing to consider is the welfare effect of subsistence under each of these technologies. Table 9 presents the loss in generational growth rates.

Despite the fact that concavity causes a faster transition to full employment in the modern sector, Table 9 shows that under eight of the nine parameter combinations $\xi = 0.5$ results in the greatest reduction in growth rates when compared to the zero subsistence baseline. The reason for this is that the head start the economy is given under $\bar{c} = 0$ is amplified with a concave technology. In other words, because $\lambda^{\xi} > \underline{p}$ happens fastest under $\bar{c} = 0$, this parameterization results in relatively faster convergence when compared to other subsistence levels.

The final robustness check is to examine the impact that $\underline{p}$ has on the results above. Using the baseline calibration (with $\xi = 2.0$), figure 31 shows the evolution of λ for five different values of $\underline{p}$.

Figure 31 shows that as $\underline{p}$ increases, the rate of convergence to full employment in the modern sector increases as well. This is driven by the increased probability of successfully matching when the modern sector is underdeveloped. Even though the speed of convergence increases, the basic pattern remains: the existence of subsistence constraints results in slower growth. Table 10 shows the loss in generational growth rates across the different values of $\underline{p}$.

As is expected the growth rate effect is muted for larger $\underline{p}$. But subsistence still has a non-zero effect on the generational growth rate. While the reduction of output growth by 0.0126 may not seem like a large number, it manifests itself as a reduction

	Caselli & Feyrer			Gollin		
	$\bar{c} = 58\%$	$\bar{c} = 69\%$	$\bar{c} = 80\%$	$\bar{c} = 58\%$	$\bar{c} = 69\%$	$\bar{c} = 80\%$
$\xi = 0.5$	0.1395	0.2299	0.3729	0.0805	0.1190	0.2182
$\xi = 1.0$	0.1343	0.2050	0.3160	0.0506	0.0942	0.2244
$\xi = 1.5$	0.1275	0.1911	0.3024	0.0430	0.0918	0.2124
$\xi = 2.0$	0.1149	0.1840	0.2883	0.0360	0.0746	0.2041

	Guerriero		
	$\bar{c} = 58\%$	$\bar{c} = 69\%$	$\bar{c} = 80\%$
$\xi = 0.5$	0.1531	0.2038	0.3567
$\xi = 1.0$	0.1208	0.1948	0.3319
$\xi = 1.5$	0.1054	0.1818	0.3271
$\xi = 2.0$	0.1025	0.1669	0.3121

TABLE 9. Welfare Analysis–Loss in Growth Rates: This table gives the annualized growth rate loss (positive number denotes a reduction in the growth rate) in comparison to the baseline with $\bar{c} = 0$ using the three sets of estimates for the capital shares. This table provides a robustness check for the matching technology, checking different values for ξ.

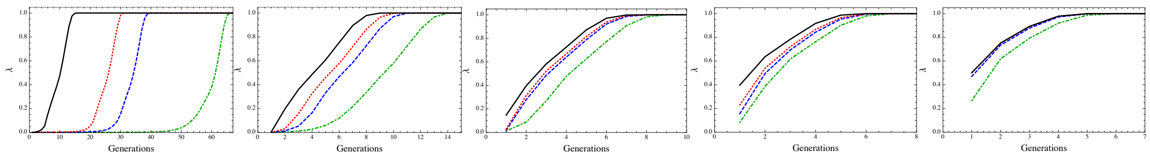
in output of 4% over the course of the transition path to full employment in the modern sector.

Social Planner

In order to solve the social planner's problem I will need to move away from idiosyncratic productivities. The reason for this is that the presence of heterogeneity makes it impossible to determine the transition equation for the aggregate capital stock, therefore homogeneity is needed to solve the dynamic programming problem.[2] In this set-up, the social planner's goal is to maximize the total utility of all agents over an infinite horizon by choosing the agent's bequests and λ_t $\forall t$, taking into account the evolution of technology. Explicitly, the social planner solves:

$$\begin{aligned} &\sum_{t=0}^{\infty}\sum_{i=1}^{N}\beta^t[(1-\gamma)\log(c_{it}-\bar{c})+\gamma\log(a_{it+1})] \\ &\text{s.t. } c_{it}+a_{it+1}+h_{it}\bar{x}=\bar{\phi}w_t^j+R_t a_{it} \\ &\quad A_{t+1}=(1+\eta\lambda_t)A_t \end{aligned} \tag{A.1}$$

[2]It is assumed that every individual is endowed with the mean of the distribution from the baseline simulations.



(a) $\underline{p} = .1$ (b) $\underline{p} = .2$ (c) $\underline{p} = .3$ (d) $\underline{p} = .4$ (e) $\underline{p} = .5$

FIGURE 31. The evolution of the percentage of the workforce employed in the modern sector across time for the robustness check for $\underline{p}$. Each panel represents different $\underline{p}$.
$\bar{c} = 0\%$: *Solid/Black*, $\bar{c} = 58\%$: *Dashed/Red*, $\bar{c} = 69\%$: *Dotted/Blue*, $\bar{c} = 80\%$: Dashed-Dot/Green

	$\bar{c} = 58\%$	$\bar{c} = 69\%$	$\bar{c} = 80\%$
$\underline{p} = .1$	0.4780	0.5808	0.7293
$\underline{p} = .2$	0.1018	0.1639	0.3012
$\underline{p} = .3$	0.0556	0.0637	0.1417
$\underline{p} = .4$	0.0543	0.0765	0.1077
$\underline{p} = .5$	0.0126	0.0215	0.0671

TABLE 10. Welfare Analysis–Loss in Growth Rates: This table gives the annualized growth rate loss (positive number denotes a reduction in the growth rate) in comparison to the baseline with $\bar{c} = 0$ using the three sets of estimates for the capital shares. This table provides a robustness check for the matching technology, checking different values for $\underline{p}$.

where β is the social discount rate. Unfortunately, solving for an analytical solution to this problem is not possible because there does not exist a closed form solution for the allocation of capital. However, it is possible to determine the solution to the social planner's problem using computational methods. The computational methods described in this section will require a bit of finesse. I will use dynamic programming to solve this problem, though doing so is not completely straightforward. The reason for this is that the discrete choice between the two sectors does not lend itself to a recursive formulation. That being said, the decentralized solution shows that all agents will eventually switch to the modern sector, and it stands to reason that this will be the goal of the social planner as well. I can rely on the fact that there are no idiosyncratic differences between agents, which implies that in the long-run all agents will bequeath the same amount to their offspring. This is the starting point for the social planner solution. Using the associative property, the objective function can be written as:

$$\max_{\{a_{it},\lambda_t\}_{t=0}^{\infty}} \sum_{i=1}^{N}\sum_{t=0}^{\infty} \beta^t[(1-\gamma)\log(c_{it}-\bar{c})+\gamma\log(a_{it+1})]$$

Consider period τ, for which all $t > \tau$ the following is true:

$$\lambda_t = 1,\ A_{t+1} = (1+\eta\bar{\phi}^{1-\omega})A_t,\ a_{it} = a_t$$

The objective function can be written as:

$$\max_{\{a_{it},\lambda_t\}_{t=0}^{\tau}} \sum_{i=1}^{N}\sum_{t=0}^{\tau} \beta^t[(1-\gamma)\log(c_{it}-\bar{c})+\gamma\log(a_{it+1})] + \sum_{i=1}^{N} \max_{\{a_t\}_{t=\tau+1}^{\infty}} \sum_{t=\tau+1}^{\infty} \beta^t[(1-\gamma)\log(c_{it}-\bar{c})+\gamma\log(a_{t+1})]$$

Let

$$V(a_t) = \max_{a_{t+1}}\{(1-\gamma)\log(c_{it}-\bar{c})+\gamma\log(a_{t+1})+\beta V(a_{t+1})\}$$

Using the $V(\cdot)$ function above, I can write the objective function as:

$$\max_{\{a_{it},\lambda_t\}_{t=0}^{\tau}} \sum_{i=1}^{N}\left[\sum_{t=0}^{\tau} \beta^t[(1-\gamma)\log(c_{it}-\bar{c})+\gamma\log(a_{it+1})]\right] + \beta^{\tau+1}V(a_t) \tag{A.2}$$

The $V(\cdot)$ is in the form necessary for dynamic programming and satisfies the necessary recursive properties, while the first term of (A.2) is a straightforward finite horizon problem that can be solved using the standard numerical techniques. There is one problem that needs to be dealt with prior to solving for the optimal solution: a_t is not stationary because A_t is growing over time. To solve this problem it will be necessary to normalize the variables in the model. The obvious choice for doing so is to divide by A_t. This is straightforward for $t > \tau$. Starting with the budget constraint we get:

$$\frac{c_{it}}{A_t} + \frac{a_{t+1}}{A_t} = \frac{\bar{\phi}w_t^M}{A_t} + R_t\frac{a_t}{A_t}$$

Letting tilde denote normalized variables, I can the write the above expression as:

$$\tilde{c}_{it} + \frac{A_{t+1}}{A_t}\tilde{a}_{t+1} = \bar{\phi}\tilde{w}_t^M + R_t\tilde{a}_t$$

Because I am considering period $t > \tau$, I can substitute $1 + \eta\bar{\phi}^{1-\omega}$ in for the growth of technology, which yields the following budget constraint:

$$\tilde{c}_{it} + (1 + \eta\bar{\phi}^{1-\omega})\tilde{a}_{t+1} = \bar{\phi}\tilde{w}_t^M + R_t\tilde{a}_t \tag{A.3}$$

where

$$\begin{aligned} \tilde{w}_t^M &= \frac{w_t^M}{A_t} = \frac{(1-\alpha)K_t^\alpha A_t^{1-\alpha}(\bar{\phi}N)^{-\alpha}}{A_t} = (1-\alpha)k_t^\alpha(\bar{\phi}N)^{-\alpha} \\ R_t &= \alpha k_t^{\alpha-1}(\bar{\phi}N)^{1-\alpha} \end{aligned} \tag{A.4}$$

$$k_t = \frac{K_t}{A_t} = \sum_{i=1}^{N}\tilde{a}_{it} = N\tilde{a}_t$$

Notice that substituting the expression for normalized capital into the expression for wages and the rate of return, yields:

$$\tilde{w}_t^M = (1-\alpha)(N\tilde{a}_t)^\alpha(\bar{\phi}N)^{-\alpha} = (1-\alpha)\bar{\phi}^{-\alpha}\tilde{a}_t^\alpha$$

$$R_t = \alpha(N\tilde{a}_t)^{\alpha-1}(\bar{\phi}N)^{1-\alpha} = \alpha\bar{\phi}^{1-\alpha}\tilde{a}_t^{\alpha-1}$$

Substituting in these expressions for income into the budget constraint and simplifying yields:

$$\tilde{c}_{it} + (1 + \eta\bar{\phi}^{1-\omega})\tilde{a}_{t+1} = \bar{\phi}^{1-\alpha}\tilde{a}_t^\alpha \tag{A.5}$$

The next step is to normalize the utility function. This can be done by adding the following term: $\log(A_t) - \log(A_t) + \log(A_{t+1}) - \log(A_{t+1})$. Simplifying the objective function yields:

$$\max_{a_t} \sum_{i=1}^{N}\sum_{t=0}^{\infty}\beta^t[(1-\gamma)\log(\tilde{c}_{it} - \hat{c}_t) + \gamma\log(\tilde{a}_{t+1})] + Q_t \tag{A.6}$$

where Q_t is a time determined constant that does not depend on the individual's choice. The variable $\hat{c}_t$ is normalized subsistence consumption and it follows the recursion:

$$\hat{c}_t = \frac{\hat{c}_{t-1}}{1 + \eta\bar{\phi}^{1-\omega}}, \ \hat{c}_0 = \frac{\bar{c}}{A_0}$$

Using (A.5) and (A.6) it is fairly straightforward to set-up the dynamic programming problem with two states ($\tilde{a}_t$, $\hat{c}_t$) and one control ($\tilde{a}_{t+1}$). Figure 32 shows the policy rule for $\hat{c}_t = 0$. The next step is to solve the finite horizon problem in which the terminal value of the utility function is given by $V(a_{\tau+1})$. In order to solve this problem, I need to write down the associated budget constraint. Taking the original constraint given in (A.1) and normalized by A_t yields (using the same notation as

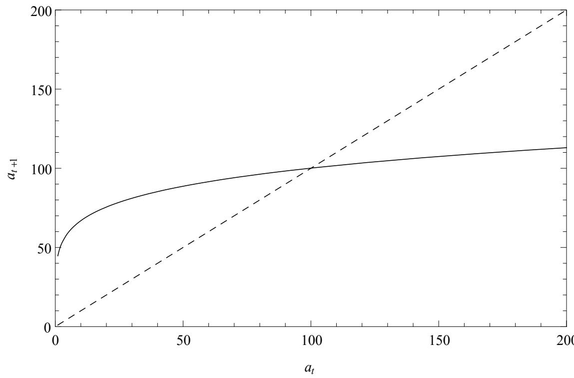


FIGURE 32. Policy Function: $\tilde{a}_{it+1}$

before):

$$\tilde{c}_{it} + (1 + \eta\lambda_t^{\omega}\bar{\phi}^{1-\omega})\tilde{a}_{t+1} + h_{it}\hat{x}_t = \bar{\phi}\tilde{w}_t^j + R_t\tilde{a}_t \tag{A.7}$$

where $\hat{x}_t$ is the normalized cost of switching and the growth of technology includes λ because it is no longer 1 for all t. Normalized wages and rates of return are given by:

$$\tilde{w}_t^M = \frac{w_t^M}{A_t} = \frac{(1-\alpha)(K_t^M)^{\alpha} A_t^{1-\alpha}(\lambda_t\bar{\phi}N)^{-\alpha}}{A_t} = (1-\alpha)\left(k_t^M\right)^{\alpha}(\lambda_t\bar{\phi}N)^{-\alpha}$$

$$\tilde{w}_t^T = \frac{w_t^T}{A_t} = \frac{(1-\theta)(K_t^T)^{\theta} B^{1-\theta}((1-\lambda_t)\bar{\phi}N)^{-\theta}}{A_t} = (1-\alpha)\left(k_t^T\right)^{\alpha}\hat{B}_t^{1-\theta}((1-\lambda_t)\bar{\phi}N)^{-\theta}$$

$$R_t^M = \alpha\left(K_t^M\right)^{\alpha-1} A_t^{1-\alpha}(\lambda_t\bar{\phi}N)^{1-\alpha} = \alpha\left(k_t^M\right)^{\alpha-1}(\lambda_t\bar{\phi}N)^{1-\alpha}$$

$$R_t^T = \theta\left(K_t^T\right)^{\theta-1} B^{1-\theta}((1-\lambda_t)\bar{\phi}N)^{1-\theta}\left(\frac{A_t}{A_t}\right)^{1-\theta} = \alpha\left(k_t^T\right)^{\theta-1}\hat{B}_t^{1-\theta}((1-\lambda_t)\bar{\phi}N)^{1-\alpha}$$

where k_t^j for $j \in \{M, T\}$ and $\hat{B}_t$ are the normalized values of capital in each sector and traditional technology, respectively. Arbitrage implies that the rates of return must be equal in both sectors. This allows me to solve for the capital allocated to each sector for a given λ and $\hat{B}$.

$$\frac{k_t^T}{k_t^M} = \frac{\theta\hat{B}_t^{1-\theta}((1-\lambda_t)\bar{\phi}N)^{1-\theta}}{\alpha(\lambda_t\bar{\phi}N)^{1-\alpha}} \tag{A.8}$$

The next step is the objective function, which is quite similar to (A.2) but instead of a single a the social planner chooses a bequest for each agent.

$$\sum_{i=1}^{N}\sum_{t=0}^{\tau}\beta^t[(1-\gamma)\log(\tilde{c}_{it} - \hat{c}_t) + \gamma\log(\tilde{a}_{it+1})] + \beta^{\tau+1}V(\tilde{a}_{i\tau+1}) \tag{A.9}$$

The final step in this solution technique is to establish a rule by which the social planner allocates individuals to the modern sector. It makes sense that the social planner would not want to remove an agent from the modern sector once that individual takes up employment because doing so would result in an unambiguous loss of utility. Therefore, it is reasonable to assume that the social planner would follow some sort of additive rule in which the stock of agents in the modern sector is augmented by χN each period (where $0 \leq \chi \leq 1$). I can write the transition equation for λ as:

$$\lambda_t = \min(\lambda_{t-1} + \chi, 1) \tag{A.10}$$

Now I can solve the social planner's problem by maximizing (A.9) subject to (A.7), (A.8), and (A.10). The parameter values for these simulations are given in table 1.

Parameter	Value	Parameter	Value
β	.96	γ	1/4
$\bar{c}$	211	α	.175
θ	.124	N	100
B	1	η	$\frac{1}{\phi^{1-\omega}}$

$\chi \in \{.01, .025, .05, .1\}$

TABLE 11. Social Planner Parameters

The social planner's problem is solved using the four values of χ listed in the table above. It is important to note that traditional wages have a negative dependence on the modern technology stock. This is important because as the length of time needed to converge to full employment in the modern sector increases, the traditional wages move quickly toward zero. Practically, this poses a problem for values of $\chi < .05$ because the traditional wage gets so small that the agent's income drops below the machine precision effectively making it zero. Therefore the starting points for the simulations must be tailored such that the issues with machine precision do not come into play. The simulations for the social planner's problem are run at .01 increments for the initial value of λ from table **??** (for instance if $\lambda_0 \in \{.5, 1\}$ there would be a simulation for $\lambda_0 = .5, \lambda_0 = .51, \ldots, \lambda_0 = 1$).

Step Size	Initial λ
$\chi = .01$	$\lambda_0 \in \{.8, 1\}$
$\chi = .025$	$\lambda_0 \in \{.525, 1\}$
$\chi = .05$	$\lambda_0 \in \{0, 1\}$
$\chi = .1$	$\lambda_0 \in \{0, 1\}$

TABLE 12. Social Planner Modern Sector Allocation

Figure 33 shows the simulation results for the social planner's problem.

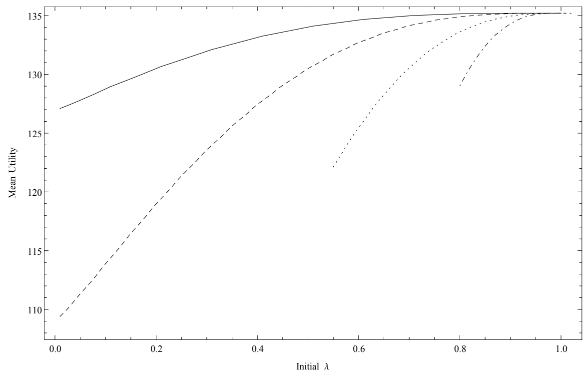


FIGURE 33. Mean lifetime utility associated with each social planner plan. Each point on the x-axis represents a different λ_0. Solid: $\chi = .1$, Dashed: $\chi = .05$, Dotted: $\chi = .025$, Dashed-Dot: $\chi = .01$

Though I am unable to run the simulations for every initial value of λ the pattern is quite clear: mean utility is decreasing in the length of time it takes to reach full employment in the modern sector. The result that mean utility is maximized for $\lambda_0 = 1$ should not be surprising. A large λ results in high technology growth, which drives unnormalized wage growth in the modern sector causing utilities to rise. Therefore, a social planner would want to move everyone in the modern sector to take advantage of this wage growth.

APPENDIX B

INEQUALITY AS A HEALTH HAZARD

Proof of Lemma 1

Proof. Choose agent m s.t. $\forall i > j$:

$$\frac{c_{it+1}}{c_{it}} = 1$$

From the FOC and the definition of the aspirations term I know that:

$$\frac{c_{jt+1}}{c_{jt}} = \left(\frac{\frac{1}{I-J}\left(c_{jt+1} + \sum_{h=j+1}^{N} c_{ht+1}\right)}{\frac{1}{I-J}\left(c_{jt} + \sum_{h=j+1}^{N} c_{ht}\right)} \right)^{\psi} = \left(\frac{c_{jt+1} + \sum_{h=j+1}^{N} c_{ht+1}}{c_{jt} + \sum_{h=j+1}^{N} c_{ht}} \right)^{\psi}$$

Define: $g_{jt+1} = \frac{c_{jt+1}}{c_{jt}}$ Dividing the above first order condition by $\frac{1}{c_{jt}}$ yields:

$$g_{jt+1} = \left(\frac{g_{jt+1} + \frac{\sum_{h=j+1}^{N} c_{ht+1}}{c_{jt}}}{1 + \frac{\sum_{h=j+1}^{N} c_{ht}}{c_{jt}}} \right)^{\psi}$$

Let $A_{jt} = \frac{\sum_{h=j+1}^{N} c_{ht}}{c_{jt}}$. Given the assumption that $c_{it+1} = c_{it}$, it is clear that: $A_{jt+1} = A_{jt}$. Making the appropriate substitutions yields:

$$g_{jt+1} = \left(\frac{g_{jt+1} + A_{jt}}{1 + A_{jt}} \right)^{\psi} \tag{L.1}$$

Clearly $g_{jt+1} = 1$ solves this equation. Note that:

$$\text{If } g_{jt+1} > 1 \rightarrow g_{jt+1} < \left(\frac{g_{jt+1} + A_{jt}}{1 + A_{jt}} \right)^{\psi}$$

$$\text{If } g_{jt+1} < 1 \rightarrow g_{jt+1} > \left(\frac{g_{jt+1} + A_{jt}}{1 + A_{jt}} \right)^{\psi}$$

Therefore the solution $g_{jt+1} = 1$ is also unique. ■

Proof of Proposition 2

Proof. The final step is to show that for I, consumption is constant. Taking the Euler equation for N and applying the definition of the aspirations term, yields:

$$\frac{c_{It+1}}{c_{It}} = \left(\frac{c_{It+1}}{c_{It}}\right)^{\psi}$$

The only solution to this equation is $\frac{c_{It+1}}{c_{It}} = 1$. The result is achieved by applying Lemma X.1.

■

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