Health and Income Inequality: An Analysis of Public versus Private Health Expenditure

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Abstract

This paper examines the link between income inequality and health expenditure under public and private health regimes. We investigate this issue in a two period overlapping generations model in which mortality is endogenous and human capital is the engine of growth.

We find that under the public regime, while rich countries will exhibit high income growth and low income inequality, poor countries will converge to a vicious cycle of poor health and low income. Under the private health regime, initial differences in economic and health status get exacerbated over time. The income growth rate depends on the initial distribution of income. Finally, we use panel cointegration techniques to assess the impact of public health expenditure on income inequality.

JEL classification: I14, I15, O11

Keywords: Public and Private Health, Longevity, Income inequality, Growth

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1 Introduction

This paper contributes to the growing debate on whether the delivery of health care should be public or private by examining the interplay between health investment and income inequality under both public and private health care regimes. Our objective is to examine the role that investment in health plays under the two regimes in explaining the intergenerational transmission of inequality and its persistence. We examine this issue in a two period overlapping generations growth model in which mortality is endogenous and human capital is the engine of growth.

Our work in this paper is motivated by two strands of empirical research. First is the substantial evidence showing a positive relation between inequality and intergenerational correlation of economic status in both developed and developing economies (Corak 2013). Countries with greater inequality of incomes also tend to be countries in which there is greater persistence of income across generations. This relationship between income inequality and income persistence, termed as the "The Great Gatsby Curve" by Alan Krueger is depicted in Figure 1. The figure ranks countries along two dimensions. The horizontal axis shows income inequality in a country as measured by the Gini coefficient while the vertical axis has a measure of the persistence of income. Countries like Brazil, China and Chile that have high income inequality tend to be characterized by high intergenerational correlation in income. On the other hand countries like Denmark, Norway and Finland which are characterized by low income inequality tend to have low intergenerational income persistence.

Secondly, there is considerable evidence that points to the fact that poor health in childhood lowers future income through its effects on schooling and labour force participation. What is less understood is the effect of the type of health care system (public vs. private) on health and persistence of income inequality. This is the gap in the literature that we attempt to address in this paper.

Our paper extends Glomm and Ravikumar (1992) model of endogenous growth, to include investment in health. Mortality is endogenous in our setup where the length of life of the adult depends upon the investment in health. Each parent has a bequest motive and invests in the health of the offspring. Each agent's stock of human capital depends on the parent's stock of human capital, time spent in school, and parental investment in health. As in Glomm and Ravikumar (1992), under the public health regime, a government levies taxes on the income of the old and uses tax revenues to provide "free" public health. Public health investment is therefore an increasing function of the tax revenues. Under the private health regime, every parent decides on the health investment to be made on the offspring.

The linkage across generations in our model stems from two distinct channels. Firstly, as mentioned earlier, the stock of human capital of the parent directly affects the human capital stock of the young. Secondly, the stock of human capital of the parent indirectly affects the human capital accumulation choices of the young by impacting their old age longevity. The lower the stock of human capital of the older generation, the lower is the amount they invest in the health of their progeny. The consequent reduction in length of life increases the rate at which children discount the future, thereby impacting their investment in human capital.

We begin by comparing the equilibrium paths of per capita income for the two health regimes when the distribution of income is degenerate. Our results show the existence of multiple steady states under both regimes depending on the initial levels of income. High mortality reduces returns on education which results in lower income and "poverty traps" under both regimes. Interestingly, we find that the threshold "growth takeoff" income levels are lower and per capita incomes are higher in the private when compared to the public regime. Intuitively, in the private health regime, each individual accounts for the fact that an additional unit of time spent toward learning increases her future earnings and thereby her ability to invest in health of her offspring. In the public health regime, the latter benefit is not taken into account. This results in underinvestment in human capital under the public regime.

Next, we seek to understand the impact of health investment on income inequality under the two health regimes. We demonstrate that in an economy where the income distribution is skewed and per-capita income is above a threshold, income inequality decreases over time under the public regime whereas it increases under the private regime. Intuitively, in such an economy with a high per capita income, expenditure on health under the public regime is high. The higher old age longevity incentivises increased investment in human capital by the young. In particular, due to diminishing returns to human capital, low income individuals enjoy higher earnings growth than high income individuals in transition causing income inequality to shrink under this regime. By contrast, under the private regime high income individuals invest more in health and grow faster whereas low income individuals get stuck in the vicious cycle of poor health and low income. Hence any differences in the initial level of income are exacerbated over time under the private regime.

It also follows that when the initial per capita income is low, health expenditure under the public regime tends to be low, leading to a vicious cycle of poor health and low income for all individuals in the economy. Since all individuals in the economy converge to low income equilibrium, income inequality falls over time under this regime. Under the private regime once again, income inequality would rise, with high income individuals converging to high income growth rates and low income individuals experiencing falling incomes over time.

This paper is linked to a growing volume of literature that has sought to examine the link between income inequality and income growth. While traditional channels have mainly focused on credit market constraints and non-convexities in technology (Galor and Zeira 1993, Piketty 1997 and others), the role of health in explaining income inequality has been less explored. Chakraborty (2004), in a seminal paper explores the link between public health expenditure and economic growth. Castelló-Climent and Doménech (2008) and Chakraborty and Das (2005) extend the work of Chakraborty (2004) to examine the link between income inequality and health in an endogenous growth framework. Chakraborty and Das (2005) introduce endogenous mortality and accidental bequests in an otherwise standard overlapping generations model with production; in particular, the probability with which a young agent survives into old age depends on the private health investment made by the young. Owing to lower longevity, children from poorer households are more likely to receive low bequests and the resultant wealth effect sets off a cycle of poor health and income. Castelló-Climent and Doménech (2008) quantitatively and empirically analyze the relationship between inequality in the distribution of education, life expectancy and human capital accumulation. Our paper complements both these papers and focuses instead on the dynamics of income inequality under private and public health regimes. The key linkage between generations in our model occurs through parental investment in the progeny's health and we abstract away from issues related to accidental bequests.

Moreover, this paper also contributes to the emerging empirical literature that analyses the influence of health expenditure on income inequality. A number of papers have examined the link between income inequality and health outcomes (See Deaton, 2003 for a review). Our work complements this literature by examining the link between public health spending and income inequality.[1] We examine this issue using data from a sample of OECD countries. There are two key empirical issues in the literature which we attempt to address in this paper. Firstly, several studies have pointed to the possible non-stationarity in health care spending and income inequality (Baltagi and Moscone 2010, Herzer and Nunnenkamp 2014 and others). Secondly, when income and health interactions are important, health can not only be a consequence but can also be a cause of income inequality. This issue of endogeneity is something that the literature has pointed out but not addressed adequately. Our work addresses both these issues by applying panel cointegration techniques. Results show a statistically significant negative long-run effect of public health spending on Gini coefficient. These appear consistent with our theoretical findings.

The rest of the paper is structured as follows: Section 2 discusses the theoretical model, with the private and public health regimes discussed in Sections 2.1 and 2.2 respectively. Section 2.3 looks at outcomes for homogeneous individuals and Section 2.4 illustrates the same for heterogeneous individuals. Section 3 is the empirical evidence for a proposition of the model. Section 3.1 discusses the empirical strategy of using panel cointegration. Section 3.2 discusses the preliminary results in support of our proposition. Section 4 contains the concluding remarks.

[1] Such a relation has been studied in the context of education. Glomm and Ravikumar (1992) theoretically show declining income inequality in a public education regime.

2 Model

Our model and its structure follow Glomm and Ravikumar (1992). We extend their two-period overlapping generations framework to include endogenous mortality. We abstract away from issues related to fertility or population growth and assume that at the end of one's youth an individual gives birth to a single offspring. Individuals born at time period t have identical preferences over leisure when young, consumption when old, and the opportunity to invest in health of their offspring.

All young individuals survive to the second period but are alive only for a fraction $\phi(.)$ of the second period.[2] We term $\phi(.)$ as the longevity function, which depends on the health investment incurred by the parental generation. As in Bhattacharya and Qiao (2007) we interpret these as preventive medicines that extend the length of life. These investments may be privately or publicly funded. We assume a constant elasticity form for ϕ. It is strictly increasing and concave in health spending.

$$\phi(.) \text{ with } \phi(0) = 0;\ \phi' > 0;\ \phi'' \leq 0;\ lim_{h\to\infty}\phi(h) = \overline{\phi} \leq 1$$

We follow the literature in assuming the longevity function to be,

$$\begin{aligned} \phi(h) &= Ah^{\epsilon} \text{ for } h < \overline{h} \\ \phi(h) &= \overline{\phi} \text{ for } h \geqslant \overline{h} \end{aligned} \tag{1}$$

where $A > 0$, indicates the state of medical technology. h is the health investment, with returns given by ϵ lying between $(0, 1)$. The parameter $\overline{\phi}$ denotes the maximum longevity (under current medical technology) and $(\overline{h}, \overline{e})$ is the corresponding critical level of health investment and earnings.

Under the public health regime, the health investment on the young in time period t is financed by levying a tax on the income of the old. Under this regime, all individuals face the same health care investment. By contrast, in the case of private health regime,

[2] As in Bhattacharya and Qiao (2007), ours is a model of longevity in old age as opposed to child or infant mortality. This allows us to abstract away from issues relating to unintended bequests, which is the focus of Chakraborty and Das (2005).

every adult allocates her income between own consumption and health investment on her offspring. Young individuals at time t accumulate human capital, e_{t+1} according to,

$$e_{t+1} = \xi \; (1 - n_t) e_t^{\delta} h_t^{\nu} \tag{2}$$

where e_t is the stock of human capital of the corresponding parent. ξ denotes the productivity parameter associated with human capital accumulation. The income of the individual during the second period of life is equal to the stock of human capital, e_{t+1}. When young, individuals allocate n_t units of their unit time endowment towards leisure and the remaining towards accumulating human capital. Parental knowledge and health are also critical inputs in our human capital accumulation equation. The importance of parental knowledge as an input in the process of human capital accumulation is a feature that has been well documented. The seminal work by Becker and Tomes (1979) attribute intergenerational income persistence not only to genetic factors but also to parental human capital. Recent work by Black and Devereux (2011) has highlighted the link between parental human capital and income persistence. The effect of health status on human capital accumulation is also well established. Numerous studies have shown that poor health adversely affects cognitive skills, productivity and educational outcomes. Currie and Hyson (1999) use British cohort data and find a positive relation between birth weight and educational outcomes. More recently, Figlio et.al (2013) using US data provide evidence on the long-term effects of birth weight on cognitive development. They find that increases in birth weight can have a positive effect on cognitive skills, and hence on adult earnings.

2.1 Private Health Regime

Formally, the preferences of an individual born at time t is represented by

$$U = ln(n_t) + \phi(h_t)[ln(c_{t+1}) + \alpha ln(h_{t+1})] \tag{3}$$

where n_t is leisure at time t, c_{t+1} is consumption at time $t+1$, and h_{t+1} is the health investment at time $t+1$. The parameter α captures parental altruism. The budget constraint is then given by

$$e_{t+1} = c_{t+1} + h_{t+1} \tag{4}$$

The optimisation follows a two-step maximisation procedure. In the first step, an individual maximizes her second period utility function subject to the budget constraint to obtain

$$c_{t+1} = \frac{1}{1+\alpha} e_{t+1}; \quad h_{t+1} = \frac{\alpha}{1+\alpha} e_{t+1} \tag{5}$$

Both second period consumption and health investment by the adult are a rising function of human capital. From equation (5), it follows that health investment varies positively with the degree of altruism, α. In the second step we substitute the optimal level of second period consumption and health spending back into the lifetime utility function and solve for optimal leisure to obtain

$$n_t = \frac{1}{1 + (1+\alpha)\phi(h_t)} \tag{6}$$

Equation (6) shows that leisure choice varies inversely with parental health expenditure, $\frac{dn_t}{dh_t} < 0$. Intuitively, with a rise in health expenditure, the longevity of the young rises, thereby incentivising investment in human capital.

Next we proceed to formulate the human capital accumulation equation under the private health regime. Unlike most of the literature which assumes some form of non-convexity of technology to study the issue of development traps, we assume constant returns to scale, i.e. $\delta + \nu = 1$. Substituting equations (5) and (6) into equation (2) gives,

$$J(e_t) = e_{t+1} = \begin{cases} \frac{\theta_1 \theta_2 e_t^{\epsilon+1}}{1+\theta_1 e_t^{\epsilon}} & \text{for} \quad e^{\varphi} \leq e_t < \overline{e} \\ \frac{\theta_1 \theta_2 \overline{e}^{\epsilon}}{1+\theta_1 \overline{e}^{\epsilon}} e_t & \text{for} \quad e_t \geq \overline{e} \end{cases} \tag{7}$$

where $\theta_1 = A(\frac{\alpha}{1+\alpha})^{\epsilon}(1+\alpha)$ and $\theta_2 = \xi(\frac{\alpha}{1+\alpha})^{\nu}$ are positive constant terms. Notice that $J^{'}(e) > 0$ for any e; $J^{''}(e) > 0$ for $e < \overline{e}$; but $J^{''}(e) = 0$ for $e \geq \overline{e}$. The above equation indicates that the income locus has a convex portion till the critical health spending $\overline{h}$ (corresponding to $\overline{e}$), is reached, beyond which the locus starts following a linear path.

2.2 Public Health Regime

Under the public regime an individual takes health spending as given and chooses n_t and c_{t+1} to maximize

$$U = ln(n_t) + \phi(H_t)[ln(c_{t+1}) + \alpha ln(H_{t+1})] \quad (8)$$

subject to,

$$c_{t+1} = (1 - \tau_{t+1})e_{t+1} \quad (9)$$

where τ_{t+1} is the income tax rate imposed on the adults in period $t+1$; H_{t+1} is public health spending in period $t+1$ and is given by $\tau_{t+1}E_{t+1}$ where $E_{t+1} = \int e_{t+1}dF_{t+1}(e_{t+1})$ is the per capita earnings as of period $t+1$ and F denotes the earnings distribution. Following Glomm and Ravikumar (1992), we solve for the preferred tax rate by maximising the second period utility,

$$[ln((1 - \tau_{t+1})e_{t+1}) + \alpha ln(\tau_{t+1}E_{t+1})]$$

to obtain

$$\tau_{t+1} = \frac{\alpha}{1+\alpha}, \quad (10)$$

The optimal tax rate is therefore independent of the level of individual income and is constant over time. It varies positively with α, indicating the more altruistic a society is the higher the tax individuals are willing to pay. On substituting equation (10) into equation (9) we find the second period optimal consumption level is,

$$c_{t+1} = \frac{1}{1+\alpha}e_{t+1} \quad (11)$$

It is easy to see that the time allocated to leisure under the public regime is,

$$n_t = \frac{1}{1+\phi(H_t)} \quad (12)$$

Unlike in the private health regime, individuals here do not factor health investment on their progeny. They therefore compare only the marginal benefit of leisure with marginal cost of future consumption. The opportunity cost of leisure consumption being lower makes the individuals invest lesser time for education in this regime. This results in lower future stream of income under the public regime. Substituting equations (10) and (12) into equation (2) gives,

$$M(e_t, E_t) = e_{t+1} = \begin{cases} \frac{\theta_2 \theta_3 E_t^{\epsilon+\nu} e_t^{\delta}}{1+\theta_3 E_t^{\epsilon}} & \text{for} \quad e^{\varphi} \leq E_t < \overline{e} \\ \frac{\theta_2 \theta_3 \overline{e}^{\epsilon}}{1+\theta_3 \overline{e}^{\epsilon}} E_t^{\nu} e_t^{\delta} & \text{for} \quad E_t \geq \overline{e} \end{cases} \tag{13}$$

where $\theta_3 = A\left(\frac{\alpha}{1+\alpha}\right)^{\epsilon} < \theta_1$. To facilitate comparison of this income locus with that under the private regime, consider the case of homogeneous individuals under which, $E_t = e_t$. Notice that in this case, it follows from equation (13), $M^{'}(e) > 0$ for any e; $M^{''}(e) > 0$ for $e < \overline{e}$; but $M^{''}(e) = 0$ for $e \geq \overline{e}$. Therefore, as in the private regime, the income locus has a convex portion till the critical human capital, $\overline{e}$ is reached, beyond which the locus starts following a linear path.

2.3 Homogeneous individuals

The objective of this section is to analyse the paths of earnings under the two health regimes when individuals are homogeneous. The problem therefore reduces to comparing equations (7) and (13) which are the income loci under the private and public regimes respectively. The key results are summarised in the proposition below,

Proposition 1 *Under the assumption of homogeneous individuals in the economy with the same initial level of income,*

(A) Per capita income is lower in the public regime compared to the private regime

(B) The threshold income at which the private regime ($e^r = [\theta_1 (\theta_2 - 1)]^{-\frac{1}{\epsilon}} > 0$) *enters into endogenous sustained growth is less than that in the public regime* ($e^u = [\theta_3 (\theta_2 - 1)]^{-\frac{1}{\epsilon}} > 0$)

(C) Under endogenous sustained growth path ($e \geq \overline{e}$)*, the income growth rate under the private regime* ($g^r = \frac{\theta_1 \theta_2 \overline{e}^{\epsilon}}{1+\theta_1 \overline{e}^{\epsilon}}$) *is higher than under the public regime* ($g^u = \frac{\theta_2 \theta_3 \overline{e}^{\epsilon}}{1+\theta_3 \overline{e}^{\epsilon}}$)

Proof. See Appendix A.1 ■

Figure 2 plots the income loci under the two regimes. The dotted line represents the private income locus and the solid line represents the public income locus. If individuals start off with the same human capital under the two regimes, human capital accumulation under the private regime will always be greater than that in the public regime. The young under the private regime take into account the fact that their health investment impacts the income of their progeny. This in turn leads to higher time investment for accumulating human capital compared to the public regime. As individuals choose to accumulate less human capital under the public regime, the economy requires higher initial income to attain the sustained endogenous growth path. Once the income crosses the critical level and attains endogenous growth, the long-run income growth rate becomes constant. This growth rate is higher under the private compared to the public regime. Once again this is due to the fact that under the private regime health investments are fully internalised unlike the public regime.

Interestingly, if we assume away the endogenous longevity function, our model will not generate income persistence results. In this case $\phi(.)$ is assumed to be a constant, and hence leisure no longer responds to health investments. Without loss of generality, we assume $\phi = 1$ for this analysis. The income loci under the two regimes get modified to,

$$\begin{aligned} J(e_t) &= e_{t+1} = \xi \frac{1+\alpha}{2+\alpha} \left(\frac{\alpha}{1+\alpha} \right)^{\nu} e_t \gtreqless e_t \text{ under the private regime} \qquad (14) \\ M(e_t) &= e_{t+1} = \xi \frac{1}{2} \left(\frac{\alpha}{1+\alpha} \right)^{\nu} e_t \gtreqless e_t \text{ under the public regime.} \end{aligned}$$

Equation (14) denotes the income locus in each case. Depending on the magnitude of the coefficients on e_t, two cases may arise. It follows that in either case, the path of income is independent of the initial level of human capital, thus no persistence in earnings over generations.

We next proceed to discuss the steady states and their stability properties under the two regimes. This can be summarised in the Proposition below,

Proposition 2 *The dynamic system described by equations (7) and (13) may possess* *two steady states under each regime. The possible equilibria are* (e^{φ}, e^{r}) *under the private regime and* (e^{φ}, e^{u}) *under the public regime. Here* e^{φ}*, marks the asymptotically stable low level equilibrium. The positive equilibria represented by threshold income* e^{r} *under the private regime and* e^{u} *under the public regime are unstable. Comparison of equilibria under the two regimes may yield three cases:*

(A) (e^{φ}, e^{r}) *under the private regime and* (e^{φ}, e^{u}) *under the public regime, where* $e^{r} < e^{u}$

(B) Only a low level equilibrium, e^{φ} *under both regimes*

(C) (e^{φ}, e^{r}) *under the private regime and only low level equilibrium,* e^{φ} *under the public regime*

Proof. See Appendix A.2 ■

Case (A) is best understood using Figure 2. Clearly, the private regime is characterised by two equilibria, e^{φ} and $e^{r} = [\theta_1 (\theta_2 - 1)]^{-\frac{1}{\epsilon}} > 0$. Similarly, the public regime is characterised by two equilibria, e^{φ} and $e^{u} = [\theta_3 (\theta_2 - 1)]^{-\frac{1}{\epsilon}} > 0$. Crucially the initial conditions determine if the individual ends up on a sustained growth path or a low level equilibrium. Proposition (1B) shows that any representative family dynasty with an initial income, $e < e^{r}$ in the private regime or $e < e^{u}$ under the public regime, converges to $e = e^{\varphi}$. Once income crosses the threshold of e^{r} or e^{u}, one enters the path of sustained endogenous growth. The equilibria, e^{u} or e^{r} are therefore unstable. Intuitively, if a family starts off with an income below the threshold in either regime, investment in health is low. The consequent reduction in longevity causes the young to underinvest in human capital. This results in a vicious cycle of poor health and low income.

Case (B) refers to Figure 3. In this case both regimes always converge to the low level equilibrium e^{φ}. In the appendix we show that this could arise if the longevity function has an upper bound which is pegged at a low level. In other words, under this scenario longevity is low even when health spending is high. In such an economy individuals discount the future heavily and hence underinvest in health, leading to being trapped in a low earnings equilibrium. A longevity-improving medical technology change (higher A) shifts up the income locus, which allows some families to overcome the thresholds.

Case (C) corresponds to the case of only low level equilibrium under the public regime and multiple equilibria in the private regime (see Figure 4). This case arises when the maximum attainable longevity is bounded between the values defined in Cases (A) and (B). For such intermediate levels of medical infrastructure, the private regime could potentially enter a path of sustained growth, whereas the public regime would always converge to the low level equilibrium irrespective of its initial level of income. Our results indicate that the "state of medical infrastructure" as proxied by the longevity function in an economy, is a key determinant of the income dynamics. In countries with intermediate levels of medical infrastructure, the private regime appears to outperform a public regime. On the other hand if the state of medical infrastructure is well developed both public and private regimes exhibit similar income dynamics. If the initial income is greater than a given threshold then economies under both regimes converge to sustained growth paths. Recall that $g^r > g^u$, the private regime has a higher growth rate than the public regime, given homogeneous population (Proposition 1C). In the next section we relax the assumption of homogeneous individuals to discuss the impact of health investment on income inequality.

2.4 Heterogeneous individuals

In this section we compare the income inequality dynamics when the initial income distribution is not degenerate.[3] Proposition 3 summarises the results pertaining to the two regimes.

Proposition 3 *(A) Under the private health regime, income inequality rises over time (B) Under the public health regime, income inequality declines over time*

Proof. See Appendix A.3 ■

We restrict our attention to the case where we have multiple equilibria under both regimes (case A from A.2). Consider the case of a private regime (see Figure 5). If income is less than the threshold e^r, one's income growth rate would be negative, resulting in income converging to the low level equilibrium. On the other hand if

[3] Irrespective of the health regime under study, we ignore the trivial case of all individuals lying on the same side of an income distribution.

the income is above the threshold, the income growth rate would be positive and the individual would eventually be on a sustained growth path. Thus given any initial income, income of the individuals above the threshold will keep increasing while those below the threshold will keep decreasing. This will result in an increase in income inequality.

Next we examine the equilibrium long-run growth rate under the private regime. Let λ be the proportion of the population with an initial income below the threshold, e^r. The long run growth rate is therefore given by,

$$g^r = (1-\lambda)\frac{\theta_1\theta_2\overline{e}^{\epsilon}}{1+\theta_1\overline{e}^{\epsilon}} \tag{15}$$

It follows from equation (15) that the higher the value of λ, the lower is the income growth rate in the economy in the long-run. The income growth rate under the private regime is therefore crucially dependent on the initial distribution of income.

To examine income inequality dynamics under the public health regime, we need to understand the dynamics of both individual income (e_t) and per capita income (E_t) in the economy. Figure 6 depicts an individual earnings locus for a given level of the economy's per capita income, in a public regime. When the per capita income, E_t is held constant, the individual's earnings locus (equation 13) is concave in e_t, implying diminishing returns to parental income. For a given per capita earnings, each family's earnings within a generation $t+1$ converges to

$$\hat{e}\left(E_t\right) = \min\left\{\frac{\theta_2\theta_3E_t^{\varepsilon+\nu}}{1+\theta_3E_t^{\varepsilon}},\ \frac{\theta_2\theta_3\overline{e}^{\varepsilon}}{1+\theta_3\overline{e}^{\varepsilon}}E_t^{\nu}\right\}^{1/(1-\delta)}$$

where $\hat{e}$ solves $M\left(\hat{e};E_t\right)=\hat{e}$. Since $\hat{e}=\hat{e}\left(E_t\right)$, it follows that the steady state income in the long run will depend on the evolution of per capita income. It follows from equation (13) and Figure 6 that the individual level of income varies directly with the per capita income in the economy. In particular, with a rise in per capita income, low income individuals grow at a faster rate than the high income individuals owing to diminishing returns. Eventually, all individuals in the economy converge to the constant growth rate g^u. In the appendix we establish that the per capita income rises as long as the initial per capita income is greater than a threshold $e^{u'} = [\theta_3(\theta_2\chi_0 - 1)]^{-\frac{1}{\epsilon}} > e^u$ where $\chi_t = \int e_t^\delta dF(e_t)/E_t^\delta \leq 1$ measures earnings inequality. The threshold in turn is negatively related to the initial income inequality, χ_0. Under the public regime, the equilibrium long-run growth rate would depend upon the initial per capita income and income distribution. If the initial per capita income is greater than $e^{u'}$, then the economy converges to a growth rate given by $g^u = \frac{\theta_2\theta_3\bar{e}^\epsilon}{1+\theta_3\bar{e}^\epsilon}$. It follows from the discussion above, that unlike the homogeneous case, it is possible that in the heterogeneous case growth rate under the public regime exceeds that of the private regime. Conversely, if the initial per capita income is below $e^{u'}$, the per capita income declines over time and individual incomes converge to the poverty trap. Importantly, in both these cases, the income inequality as measured by the dispersion of income is reduced under the public regime.

Our findings in this section are able to relate the Great Gatsby curve in Figure 1, with the type of the health care system and specifically suggests that high income countries with predominantly public health regimes, such as Denmark and Norway, exhibit low income inequality whereas middle income countries such as Brazil and Chile with largely private health regimes exhibit high income inequality.

We next proceed to test empirically our hypothesis that countries with high per capita income and predominant public healthcare system will experience decreasing income inequality. In Section 3, we use data on OECD countries to carry out the empirical analysis.

3 Empirical Evidence

In this section we try to examine the long-run relation between public health spending and income inequality. There is large literature which looks at the impact of income inequality on health outcomes. However our theoretical model shows that as income and health interact, income inequality and health spending get determined simultaneously. Even though such endogeneity is commonly acknowledged, not many papers address it empirically. So we create an empirical framework wherein we show that causality can run both ways. An econometric concern in executing this arises since literature has shown that these variables are likely to be non-stationary.[4] We try to correct for both these limitations by applying panel cointegration and vector error correction models. Section 3.1 outlines the basic steps and Section 3.2 summarises the results.[5]

3.1 Methodology & Data sources

One of the challenges of addressing this problem is the lack of data availability. We therefore select a group of OECD countries for which data is available for an extended period of time. Specifically we select a sample of OECD countries with at least 20 continuous annual observations on public health spending and income inequality. Pedroni (2004) reports that the nuisance parameters associated with serial correlation properties are eliminated asymptotically as T grows large relative to N. Hence we give more importance to the time dimension and ensure that T is sufficiently larger than N. Our bivariate regression of interest is,

$$Gini_{it} = \eta_i + \varrho_i t + \beta(Public \ \ health \ \ expenditure)_{it} + \epsilon_{it} \tag{16}$$

$i = 1, 2, \ldots, N$ denotes the number of OECD countries as the cross-sectional units, and $t = 1, 2, \ldots, T$ represents the time periods. We use two samples of 8 countries each. We restrict our sample years to either 1980-2011 or 1988-2011, depending on data availability in each case.

Gini is a proxy for income inequality. The intercept η_i controls for country-specific time invariant factors. ϱ_i represents the country-specific time trends. β captures the permanent change in the income inequality measure associated with a unit percentage increase in public health spending share.

We use cross-country Gini coefficients from a recently developed dataset, the Standardized World Income Inequality Database SWIID (2013) by Solt (2009). The SWIID dataset was developed using a missing-data algorithm to standardise the Luxembourg

[4] Several studies point to the possible non-stationarity of health care spending and income inequality. Non-stationary variables may yield spurious regressions.

[5] We execute all our econometric exercises on EVIEWS8.

Income Study (LIS) and the World Income Inequality Database (WIID). The indices are reported on a scale of 0 to 100 with higher values indicating higher extent of income inequality. We obtain public health expenditure from the OECD Health Statistics (2014). We proxy for the public health share by the percentage of public health expenditure in total health expenditure (henceforth represented as PUBHE).

The public health expenditure and the inequality measures are assumed non-stationary integrated processes. We verify this assumption from panel unit root tests. Then we use the Pedroni cointegration test to check for presence of any long-run relation. We address endogeneity by using fully modified OLS (FMOLS) estimator. The residuals from FMOLS are then used in the panel vector error correction model (PVECM).

As a final step we use the error correction mechanism (equation 17). When two variables are cointegrated, at least one of them adjusts next period to correct for the disequilibrium. We estimate the following PVECM,

$$\begin{cases} \triangle Gini_{it} = \eta_{1i} + \lambda_{1i}\widehat{e}_{i,t-1} + \sum_j \beta_{11ij}\triangle Gini_{i,t-j} + \sum_j \beta_{12ij}\triangle PUBHE_{i,t-j} + \epsilon_{1i,t} \\ \triangle PUBHE_{it} = \eta_{2i} + \lambda_{2i}\widehat{e}_{i,t-1} + \sum_j \beta_{21ij} \triangle Gini_{i,t-j} + \\ \qquad\qquad\qquad\qquad \sum_j \beta_{22ij}\triangle PUBHE_{i,t-j} + \epsilon_{2i,t} \end{cases} \tag{17}$$

where $\triangle$ represents the first difference. η_{1i} and η_{2i} are the intercept terms; λ_{1i} and λ_{2i} are the speeds of adjustments; $\widehat{e}_{i,t-1}$ is the disequilibrium error term from the previous period estimated via FMOLS. β represents the respective slope coefficients, $\varepsilon_{1i,t}$ and $\varepsilon_{2i,t}$ are the white noise terms.

3.2 Empirical results

Table 1 provides details on each sample. The samples are classified mainly by data availability. Canada, Finland, Norway, Spain and Sweden are in both samples, Netherlands, Denmark, the Republic of Korea are only in Sample 1 whereas Austria, Italy and Switzerland are only in Sample 2. Covering the time period between 1980-2011, Sample 1 uses Gini coefficient of disposable income. Sample 2 uses the Gini coefficient of total income over 1988-2011 period. Table 2 provides the average values of the variables over the respective time periods. All countries in our samples had more than 50% of total health spending provided by public sources, except the Republic of Korea.

We begin by checking the stationarity of variables. To this end, we follow Levin et.al (2002, LLC) and Im et.al (2003, IPS) panel unit root tests. The LLC unit root test allows for fixed effects and individual deterministic trends. The null hypothesis of this test is that each individual time series contains a unit root against the alternative that each time series is stationary. One problem with this methodology is that rejection of the null would imply that the autocorrelation coefficient across all countries is the same. The IPS test overcomes this problem by averaging ADF tests. This test allows for heterogeneous coefficients. The null hypothesis of the IPS test is that each series has a unit root against the alternative that some of the individual series have unit roots. In other words there are at least some cross-sectional units which have a stationary series but not necessarily all. Since ours is a cross-country balanced data, we use both LLC and IPS tests and check if the variables are I(1) processes.

Panel unit root tests in each sample with individual intercept and trend are reported in Table 3. The two variables in each sample are non-stationary at levels but stationary at first difference. Thus the unit root test statistics indicate that the two variables follow I(1) processes. A caveat is that we do not assume either income inequality or public health expenditure to be inter-related across our sample of countries. So we do not correct for any cross-sectional dependence.

Any two variables are said to be cointegrated when they share a common stochastic drift. Pedroni (2004) extended the Engle-Granger two step residual based procedure to test for the null of no cointegration. This test provides "panel" and "group" test statistics. The panel statistics assume that the first order autoregressive parameters are same for all countries. Rejection of the null hypothesis implies that the variables are cointegrated for all the countries. The group statistics allow for heterogeneous autoregressive parameters. The alternative is in favour of cointegration for at least one country. Following Pedroni (2004), we use the group and panel ADF tests only, since they perform better when the number of time periods is small. The Pedroni residual cointegration results are provided in Table 4. The test results from Sample 1 show that the null hypothesis of no cointegration is rejected around 10% level of significance. Although the unweighted ADF cannot reject the null at 10%, its p-value barely exceeds 10% (0.118). Sample 2 shows stronger statistical significance. All tests reject the null of no cointegration at 5%. The test based on group ADF statistics rejects the null at 1%.

Given the evidence of long-run linear relationship between income inequality and public health expenditure, we estimate the equilibrium equation using FMOLS. As mentioned earlier, our model indicates possible endogeneity between public health expenditure and earnings inequality. To address endogeneity problem, literature has largely employed the use of instrumental variables (IV). As it is difficult to find an appropriate IV for a panel setting here, we apply FMOLS (Pedroni, 2001) to correct for endogeneity and serial correlation. Table 5 reports the FMOLS results. The negative effect of public health expenditure on inequality is evident in both the samples. The coefficient is statistically significant.

Table 6 reports the results. The first and third columns indicate causality running from public health spending to the respective inequality measure. The second and fourth columns indicate causality from income inequality to public health spending. The statistically significant coefficient of the cointegrating vector in the first and third columns indicate that previous disequilibrium in income inequality is corrected every period. The short-run effects of public expenditure are however insignificant. This shows that public health spending and income inequality have a long-run rather than a short-run relation. When checking for the other direction of causality, from inequality to public health spending, we observe statistically insignificant coefficients. Further the estimated λ_{2i} is about one order of magnitude smaller than λ_{1i}. It can thus be concluded that public health spending is weakly exogenous and has a long-run negative causal effect on income inequality. This effect is consistent with our theoretical result of declining income inequality under the public health regime. Our finding specifically implies that measures which equalize health conditions across the population, are likely to narrow the income distribution.

4 Conclusion

In this paper we seek to explain the persistence of health status and income inequality across generations. Specifically, we contrast the dynamics of the economy under a public and a private health care regime. We show that under the private regime, income inequality generally rises; with the affluent converging to high income growth and the lower income segment getting stuck in a vicious cycle of poor health and low income growth. By contrast, income inequality always falls under the public health regime. It is however worth noting that all individuals under the public regime end up converging to either a "high" growth or a "low" growth equilibrium depending upon the initial distribution of income. In other words, reduced income inequality could be potentially accompanied by a low income growth rate under a public regime.

Interestingly, our analysis would *suggest* that should the state of medical infrastructure as proxied by our longevity function be "good" and the income distribution be such that the initial per capita income is sufficiently high, the public regime would be preferred by a majority of the population. We establish that under these circumstances the public regime would result in an increase in longevity while reducing income inequality. The private regime on the other hand would also see increased longevity for a section of the population but this might come at the cost of higher income inequality. However, in the case where the state of medical infrastructure is "intermediate", the public regime would result in all individuals in the economy converging to a low income, poor longevity equilibrium. The private health regime on the other hand would deliver high growth and longevity for the high income individuals.

Empirically, we use data from a group of OECD countries where health care spending is predominantly public to investigate the relationship between health expenditure and income inequality. We do find evidence that *suggests* that higher public health expenditure leads to a decline in income inequality over time in these countries.

One critical handicap that we face in understanding the relation between health expenditure and income inequality is the lack of data availability for an extensive period. This is particularly the case for developing countries. Ideally, we would also like to investigate how the share of private health expenditure impacts income inequality.

This would then help us test the validity of our theoretical predictions more directly. We leave this for future research.

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A Appendix

In this section, we provide proofs of the propositions.

A.1 Proof of Proposition 1

For this proposition, we focus on the homogenous agent case in which $e_t = E_t$ for all individuals.

Proposition (1A)

Given that $\theta_1 > \theta_3$, it follows from (7) and (13) that $J(e) > M(e)$ and $J'(e) > M'(e)$ for any e.

Proposition (1B)

If the economy does not reach the threshold earnings over the convex part ($e < \bar{e}$), it can never enter the sustained growth path. Therefore, the threshold value must lie on the convex part of the earnings locus. To see this, consider the private regime. When $J(\bar{e}) \geq \bar{e}$, $J(\bar{e})$ is on or above the 45 degree line. This implies that the growth rate for $e \geq \bar{e}$ is $J'(\bar{e}) \geq 1$. This means a sustained constant growth in steady state. Conversely, if $J(\bar{e}) < \bar{e}$, $J'(\bar{e}) < 1$. Thus the growth rate for $e < \bar{e}$ is negative.

To obtain the threshold level of earnings, we set $e_{t+1} = J(e_t) = e_t$. Solving for e_t using the convex part of J, we get

$$e_t^r = \left[\frac{1}{\theta_1(\theta_2 - 1)}\right]^{\frac{1}{\epsilon}} > 0 \tag{A.1}$$

for the private regime. Similarly, under the public regime the threshold income is attained when,

$$e_t^u = \left[\frac{1}{\theta_3(\theta_2 - 1)}\right]^{\frac{1}{\epsilon}} > 0 \tag{A.2}$$

Comparing equations (A.1) and (A.2), we see that, $e_t^r < e_t^u$ because $\theta_1 > \theta_3$. Thus the threshold earnings to attain sustained endogenous growth is higher under the public regime.

Proof of Proposition (1C)

$J(e) > M(e)$ for any e also implies this. Furthermore, J and M imply that the earnings growth rates $\frac{e_{t+1}}{e_t}$ along the sustained growth paths are,

$$g^r = \frac{\theta_1\theta_2\bar{e}^{\epsilon}}{1 + \theta_1\bar{e}^{\epsilon}} \tag{A.3}$$

under the private regime and

$$g^u = \frac{\theta_3\theta_2\bar{e}^{\epsilon}}{1 + \theta_3\bar{e}^{\epsilon}} \tag{A.4}$$

under public regime. Clearly, $g^r > g^u$ because $\theta_1 > \theta_3$.

A.2 Proposition 2

Proposition (2A)

The case of (e^φ, e^r) and (e^φ, e^u) under the private and the public regimes can happen if

$$J'(\bar{e}) > M'(\bar{e}) \geq 1.$$

Given Proposition 1, the first part is satisfied when, $M'(\bar{e}) = \frac{\xi\ A(\frac{\alpha}{1+\alpha})^{\epsilon+\nu}\bar{e}^\epsilon}{1+A(\frac{\alpha}{1+\alpha})^\epsilon\bar{e}^\epsilon} \geq 1$, which implies that

$$\overline{\phi} \geq \frac{1}{\xi(\frac{\alpha}{1+\alpha})^\nu - 1} = \phi_1 \tag{A.5}$$

i.e. when the highest attainable longevity is greater than the above specified level.

Proposition (2B)

The case of only a low level equilibrium under both regimes may arise when

$$1 > J'(\bar{e}) > M'(\bar{e})$$

This case requires $J'(e) = \frac{\xi\ A(\frac{\alpha}{1+\alpha})^{\epsilon+\nu}(1+\alpha)\bar{e}^\epsilon}{1+A(\frac{\alpha}{1+\alpha})^\epsilon(1+\alpha)\bar{e}^\epsilon} < 1$ and thus,

$$\overline{\phi} < \frac{1}{\{\xi(\frac{\alpha}{1+\alpha})^\nu - 1\}(1+\alpha)} = \phi_2 < \phi_1 \tag{A.6}$$

i.e. when the highest attainable longevity is less than the above specified level.

Proposition (2C)

This can arise if,

$$J'(e) > 1 \text{ and } \ M'(e) < 1 \tag{A.7}$$

Combining cases (A) and (B), the case of (e^φ, e^r) under the private regime and only e^φ under the public regime may arise. This can happen if the maximum attainable longevity lies within a range defined by, (ϕ_2, ϕ_1).

A.3 Proof of Proposition 3

Proposition (3A)

Proposition 1 implies that, under the private regime, families whose initial earnings are on or above e^r enters the sustained growth path with the growth rate of g^r whereas those with initial earnings below e^r enters the poverty trap for which the asymptotic growth rate is zero. Thus, the income inequality across two groups widens.

Proposition (3B)

It follows from equation (13), when the per capita earnings E_t is held constant, the earnings locus under the public regime exhibits diminishing returns. This means that the individual earnings within generation $t+1$ converge to a certain level $\hat{e}\left(E_t\right)$. Solving for $\hat{e}$ yields

$$\hat{e}\left(E_t\right) = \min\left\{\frac{\theta_2\theta_3 E_t^{\varepsilon+\nu}}{1+\theta_3 E_t^{\varepsilon}}, \frac{\theta_2\theta_3 \overline{e}^{\varepsilon} E_t^{\nu}}{1+\theta_3\overline{e}^{\epsilon}}\right\}^{1/(1-\delta)}$$

This implies that the earnings dynamics under the public regime depends on the evolution of E_t where $\hat{e}' > 0$. The steady state equilibrium income will rise as the per capita income rises. Therefore, as E_t increases over time, the public regime enters a sustained growth path and vice versa.

Next we derive conditions under which per capita income rises every period. This would imply that, $E_{t+1} > E_t$ and hence by induction, $E_1 > E_0$. Thus the condition of rising per capita income is dependent on the initial level of per capita income. To understand the dynamics of E_t, we find

$$E_{t+1} = \int M(e_t)dF(i) = h(E_t)E_t^{1-\delta}\int e_{it}^{\delta}dF(i)^6$$

where $h(E_t) = \frac{\theta_2\theta_3 E_t^{\epsilon}}{1+\theta_3 E_t^{\epsilon}}$ for $e^{\varphi} < E_t < \overline{e}$ and $h(E_t) = \frac{\theta_2\theta_3\overline{e}^{\epsilon}}{1+\theta_3\overline{e}^{\epsilon}}$ for $E_t \geq \overline{e}$. This can further be simplified as,

$$E_{t+1} = h(E_t)E_t.\chi_t$$

where $\chi_t = \frac{\int e_{it}^{\delta}dF_t(i)}{E_t^{\delta}}$. However, $E_t = \int e_{it}dF_t(i)$. By concave transformation and using Jensen's inequality, $E_t^{\delta} \geq \int e_{it}^{\delta}dF_t(i)$.

Thus we will have $E_1 > E_0$, when $h(E_0)E_0\chi_0 > E_0$. When solved for E_0,

$$E_0 > e^{u'} = \left[\frac{1}{\theta_3\left(\theta_2\chi_0 - 1\right)}\right]^{\frac{1}{\epsilon}} \tag{A.8}$$

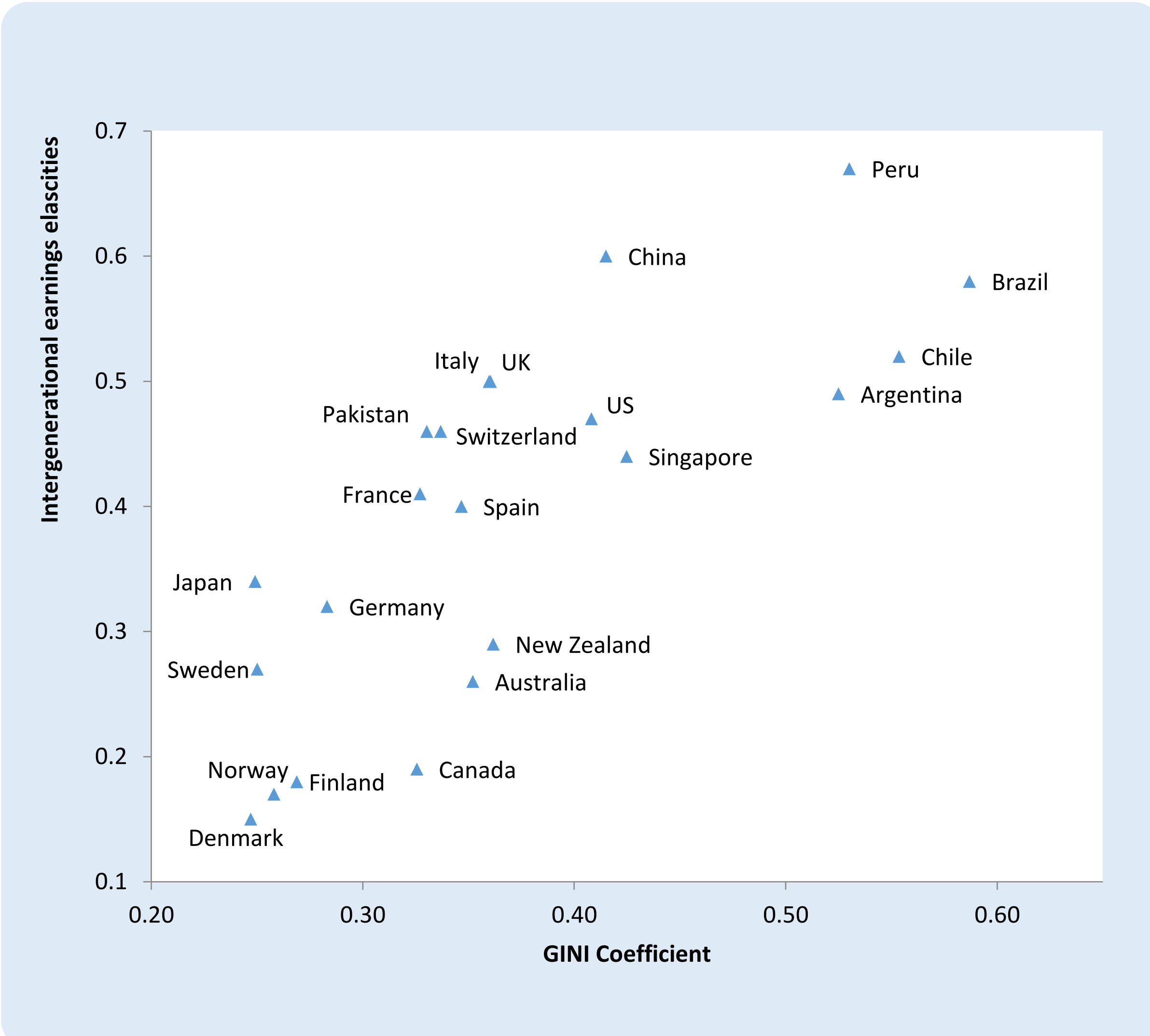
In the case of a degenerate income distribution, with $\chi_0 = 1$, we have $e^{u'} = e^{u}$, the steady state equilibrium derived in Section 2.3 for the homogeneous individuals.

From equation (A.8), we find that as long as the initial income is greater than this defined threshold level, it will keep rising every period. This will lead to all households converging to a high income growth rate in the long-run, resulting in declining income inequality. The reverse will happen when $E_0 < e^{u'}$, and all households will converge to the poverty trap in the long-run. This case will also be characterised by declining income inequality.

[6] When the distribution F is defined over the income order instead of income levels, F is trivially time-invariant in the absence of stochastic shocks. Thus it has no time subscript.

Figures

Figure 1: Intergenerational earnings persistence and income inequality



Source: Corak (2013), data from the State of Working America (http://stateofworkingamerica.org/chart/swa-mobility-figure-3q-intergenerational/), accessed on 25/12/2014.

Figure 2: Case (A), Both regimes may have a low level equilibrium or an unstable positive equilibrium

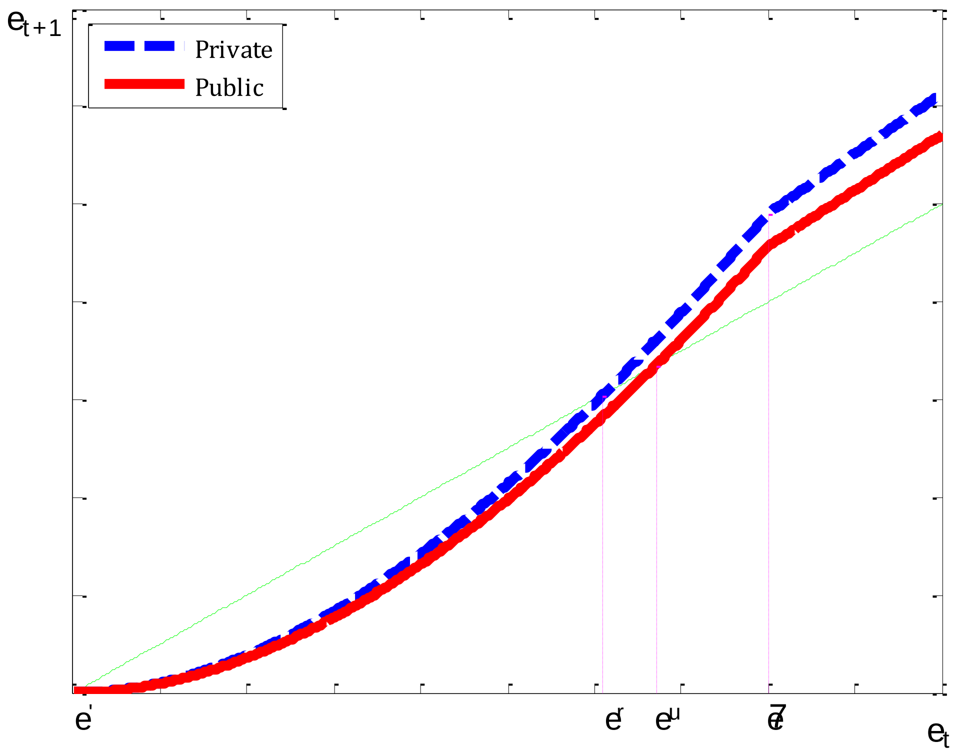


Figure 3: Case (B), Both regimes have only one equilibrium, the low level equilibrium

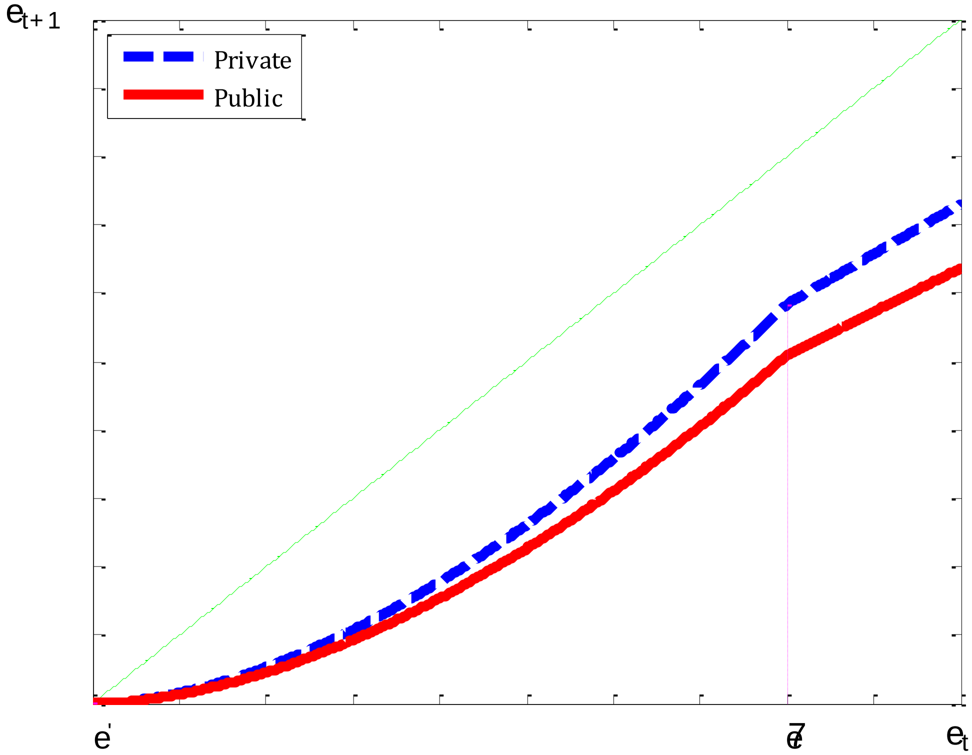


Figure 4: Case (C), Private regime has two equilibria. Public regime has only low level equilibrium

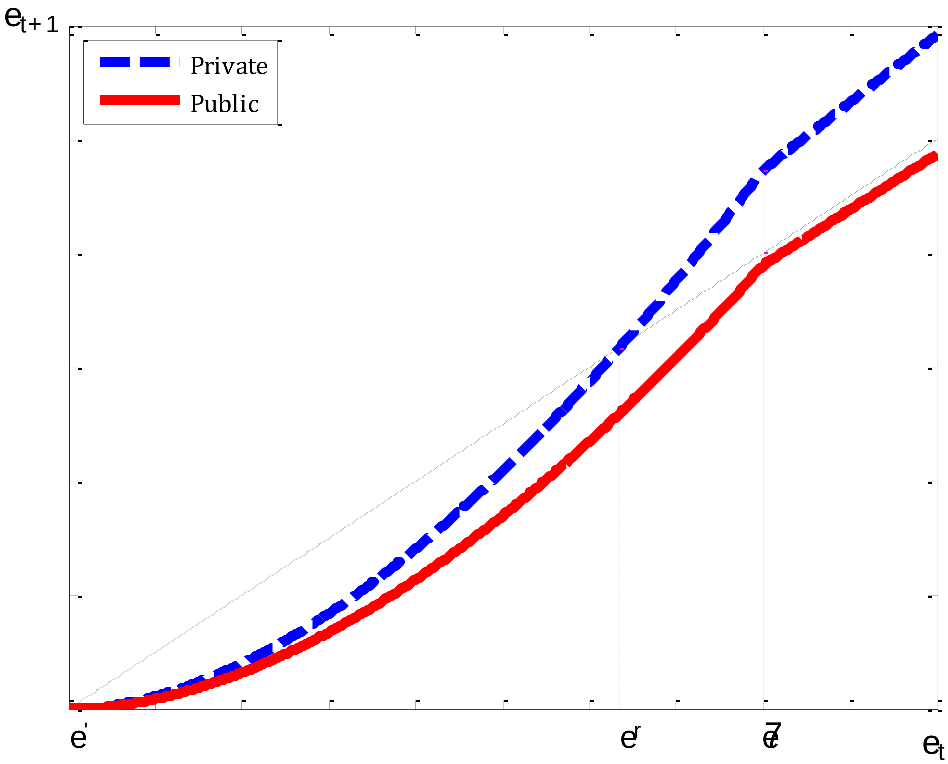


Figure 5: Income divergence under private health regime with heterogeneous individuals

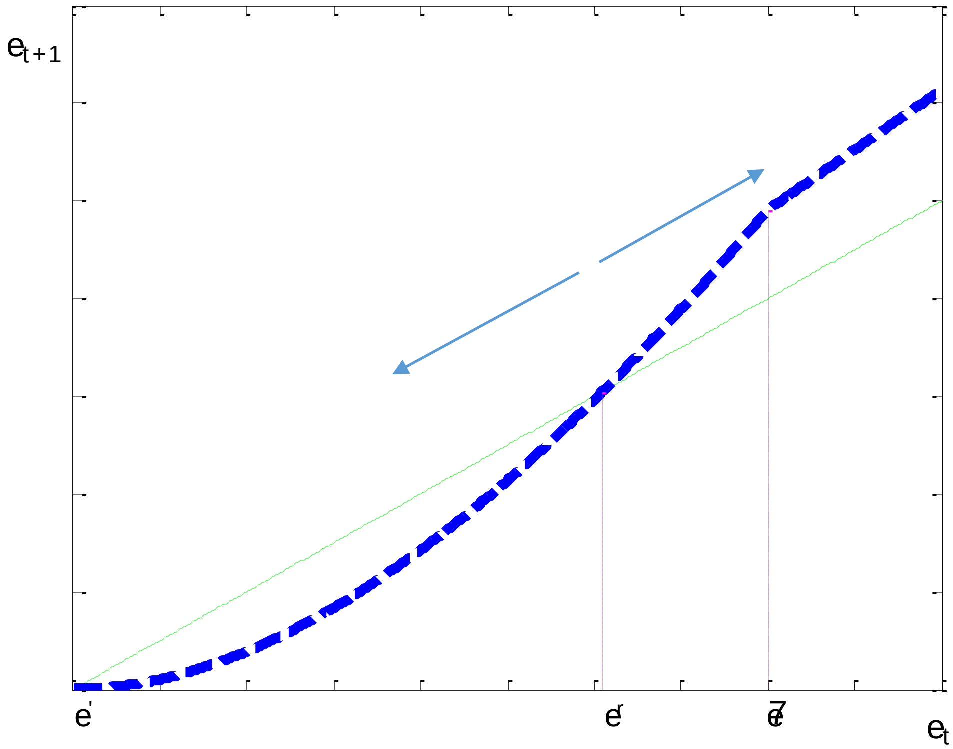
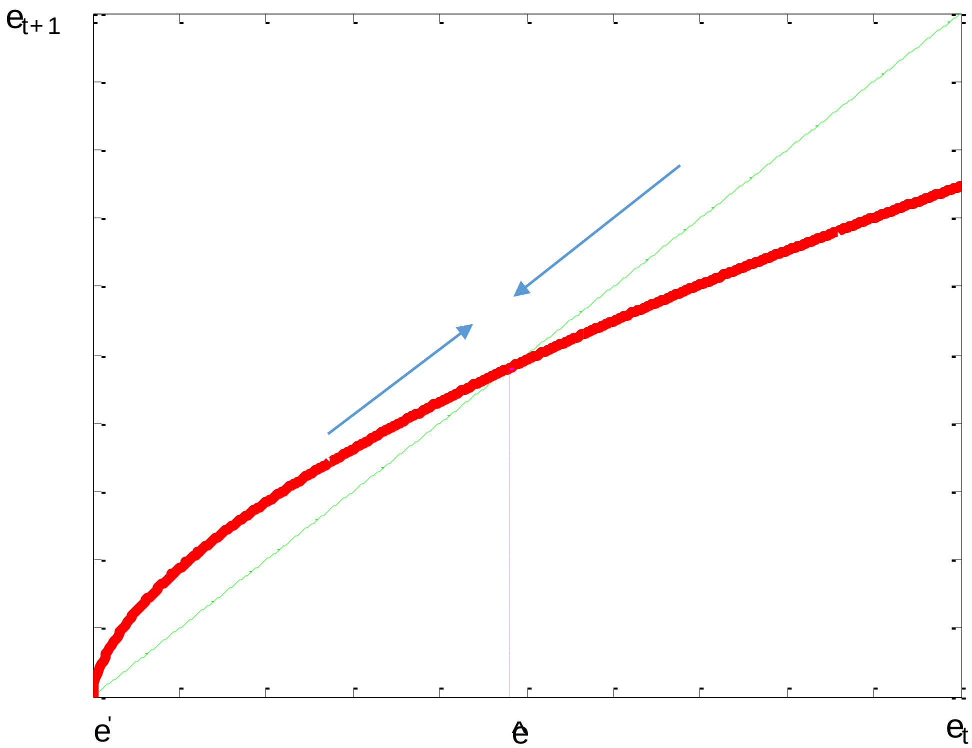


Figure 6: Income convergence under public regime with heterogeneous individuals



Tables

Table 1: Country samples used for analysis

Appendix	Sample 1	Sample 2
Countries	Canada, Denmark, Finland, Rep. of Korea, Netherlands, Norway, Spain, Sweden	Austria, Canada, Finland, Italy, Norway, Spain, Sweden, Switzerland
Time period	1980-2011	1988-2011
Number of observations	256	192
Key dependent variable	Gini of disposable income	Gini of total income
Key independent variable	Public health expenditure (%Total health expenditure)	Public health expenditure (%Total health expenditure)

Table 2: Summary Statistics

Sample 1 (1980-2011)	Average Gini of disposable income	Average of Public health expenditure (as %Total health spending)
Rep. of Korea	32.48	40.78
Spain	32.04	72.72
Canada	29.61	69.35
Netherlands	25.44	69.60
Denmark	23.97	80.86
Norway	23.53	78.96
Finland	22.85	71.87
Sweden	22.78	80.66

Sample 2 (1988-2011)	Average Gini of total income	Average of Public health expenditure (as %Total health spending)
Austria	41.46	71.03
Canada	41.51	68.22
Finland	42.12	71.14
Italy	44.52	74.47
Norway	40.09	78.29
Spain	41.26	71.07
Sweden	45.05	79.68
Switzerland	38.78	56.15

Table 3: Panel unit root tests across the samples

Coefficients (p-values)	Sample 1		Sample 2	
	LLC test	IPS test	LLC test	IPS test
At level				
Gini	-0.241 (0.404)	-0.075 (0.470)	-1.049 (0.147)	-0.185 (0.426)
Public health spending	0.660 (0.745)	1.039 (0.850)	-0.434 (0.332)	-0.038 (0.485)
At First Difference				
Gini	**-5.758 (0.0000)**	**-5.889 (0.0000)**	**-3.778 (0.0001)**	**-3.594 (0.0002)**
Public health spending	**-11.886 (0.0000)**	**-10.687 (0.0000)**	**-7.571 (0.0000)**	**-8.730 (0.0000)**

Notes: Terms in parentheses are p-values, computed assuming asymptotic normality. Tests include country fixed effects and country specific linear trends. An optimal lag of 4 is chosen by the Eview8 automatic lag length selection based on SIC.
H_0 for LLC: Unit root (common unit root process)
H_0 for IPS: Unit root (individual unit root process)

Table 4: Pedroni residual cointegration tests across the samples

Statistic (p-values)	Sample 1	Sample 2
Panel ADF-Statistic	-1.18 (0.118)	**-2.14 (0.016)**
Panel ADF-Statistic (weighted)	**-1.39 (0.0819)**	**-1.84 (0.033)**
Group ADF-Statistic	**-1.29 (0.098)**	**-2.53 (0.006)**

Notes: p-values based on Newey-West automatic bandwidth selection and Bartlett kernel. Tests include country fixed effect and country specific linear trends. Optimal lags of 2 for Sample 1, and 4 for sample 2 are chosen by Eview8 automatic lag length selection based on SIC.
H_0: No cointegration

Table 5: FMOLS Results across the samples (estimates of the effect on Inequality measure)

Independent Variable	Sample 1	Sample 2
PUBHE	**-0.116**	**-0.177**
(p-value)	**(0.0008)**	**(0.0673)**
Adj. R^2	0.869	0.414
Periods included (T)	31	23
Cross-sections included (N)	8	8
Total observations $(T \times N)$	248	184

Notes: Long-run covariance estimates based on Bartlett kernel, Newey-West fixed bandwidth.

Table 6: Vector Error Correction Models across the samples

	Sample 1		Sample 2	
Dependent variable	$\Delta Gini$	$\Delta PUBHE$	$\Delta Gini$	$\Delta PUBHE$
Cointegrating vector coefficient	**-0.108**	-0.006	**-0.236**	0.084
(p-value)	**(0.0000)**	(0.9473)	**(0.0000)**	(0.2105)
Adj. R^2	0.195	0.006	0.309	0.0602
Significant short-run coefficient	None	None	None	$\Delta \mathrm{Gini}_{t-1}$
Periods included (T)	29		19	
Cross-sections included (N)	8		8	
Total observations $(T \times N)$	232		152	

Notes: Lags of 2 for Sample 1 and 4 for Sample 2 are chosen based on Pedroni cointegration tests.