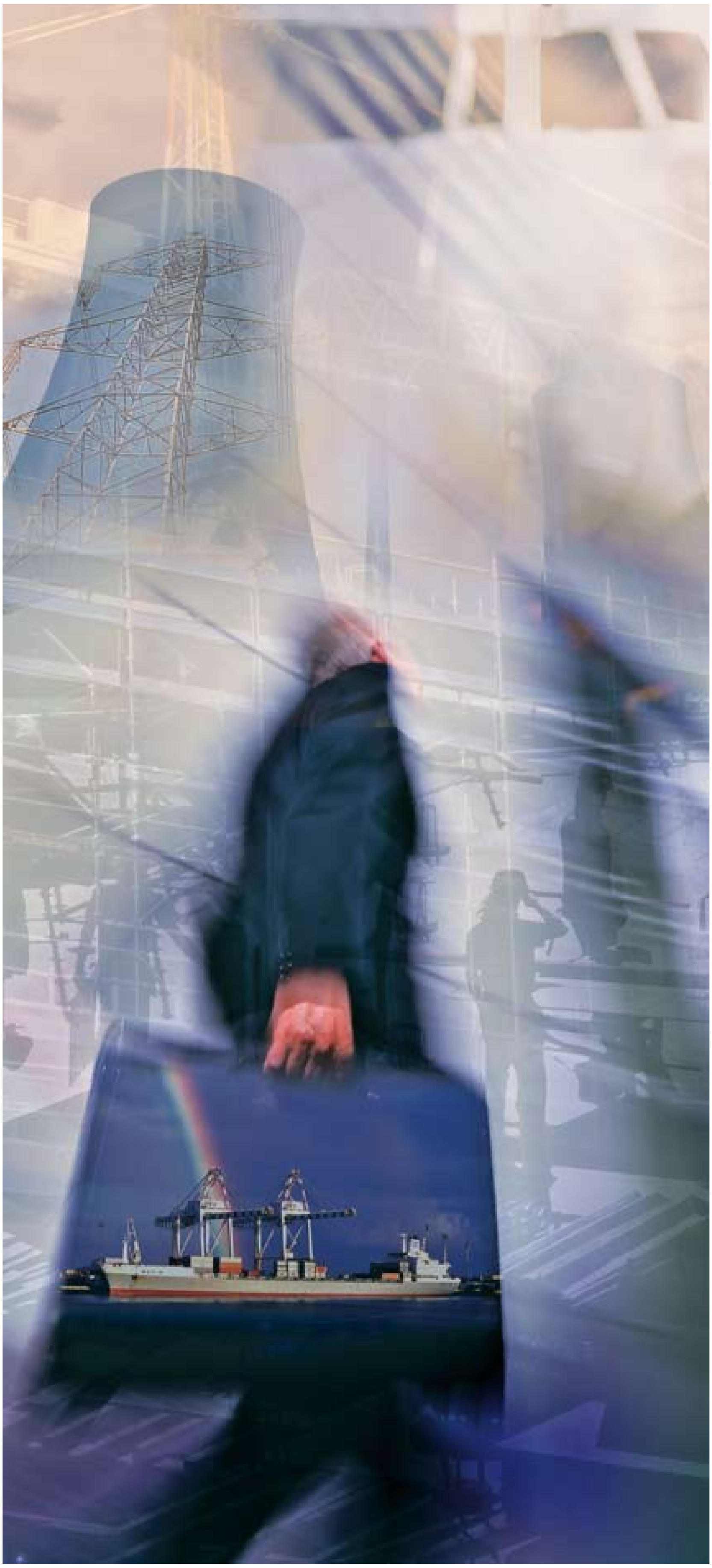

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The Paper following forms part of - *Proceedings of the 37th Australian Conference of Economists*
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Public and Private Expenditures on Health in the Presence of Inequality and Endogenous Mortality: A Political Economy Perspective[1]

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Abstract

In this paper we study a two-period overlapping-generations model in which mortality risk is endogenously determined by health investment in the form of private and public expenditures on health care. The proportion of public revenues that are used for the public provision of health care is also endogenous, and is determined by a political process, modelled in this context as the outcome of voting by agents. Agents are heterogeneous in their initial endowments of wealth inherited from the previous generation. We find that the political outcome critically depends on the degree of substitutability between private and public health expenditures, and has interesting implications for economic growth and the persistence of inequality. The outcome also depends critically on initial conditions, and in some cases exists only if the political process allows a result that is based on the plurality rule rather than the majority rule. Numerical simulations of our model suggest that even in the case of majoritarian outcomes, the political outcome is often influenced by the preferences of the agents at the middle and top end of the wealth distribution. The political result is sometimes also characterized by the "ends against the middle" feature observed in Epple and Romano (1996a, 1996b). In the long run poverty traps may occur, and wealth distributions can be characterized by the emergence of "twin peaks" with the associated polarization of wealth.

[1] We would like to thank Christiane Clemens, Begona Dominguez, Ian King, Richard Rogerson, and seminar participants at the Southern Workshop in Macroeconomics 2008, Auckland, for useful discussions and comments. The usual disclaimer applies.

1. Introduction

The dual provision of health care is an issue commonly discussed in policy circles of both developed and developing economies. Central to some of these discussions is the idea that the extent or optimality of public or private provision depends on whether these services are viewed as substitutes or complements. Also, politico-economic factors play a significant role in the determination of the public/private share in a mixed system of health care provision. The aim of this paper is to explore these issues within the framework of a dynamic general equilibrium model with overlapping generations of heterogeneous agents facing mortality risk. In our model, which is a simple extension of Chakraborty and Das (2005), mortality risk is endogenous, and depends on the individual's private investment in health. In addition, we extend the CD framework by assuming that the mortality risk faced by agents is also affected by *public* investment in health care. The proportion of public revenues that are used for the public provision of health care is also endogenous, and is determined by a political process, modelled in this context as the outcome of voting by agents.

We find that the political outcome critically depends on the degree of substitutability between private and public health expenditures, and has interesting implications for economic growth and the persistence of inequality. The outcome also depends critically on initial conditions, and in some cases exists only if the political process allows a result that is based on the plurality rule rather than the majority rule.

Numerical simulations of our model suggest that even in the case of majoritarian outcomes, the political outcome is often influenced by the preferences of the agents at the middle and top end of the wealth distribution. The political result is sometimes also characterized by the "ends against the middle" feature observed in Epple and Romano (1996a, 1996b), although in their studies the modelling of the dual provision of the public good in question is associated with some agents choosing to "opt out" of using the public good, which is not the case in our model. The only exception in our model, in terms of its *outcomes,* is a situation in which *all* agents opt out of the public good by voting in favour of distributing all of the tax revenue in the form of a lump sum transfer to agents in the economy. This type of situation occurs if public investment in health care is a perfect substitute for private investment in health care in the "health production function", which is of the constant elasticity of substitution form. For relatively low values of the elasticity of substitution, we have another type of "corner solution", in which agents vote in favour of tax revenues being allocated entirely to public investment in health. In this case, since public and private expenditures are somewhat complementary to each other, agents also choose to invest in private health care. For an intermediate range of values of the elasticity of substitution, a diverse set of results emerges, with the proportion of revenues allocated to public health increasing as the elasticity of substitution decreases. The underlying intuition for these results is related to how public expenditure on health influences the mortality of agents in the economy.

The features discussed above also have interesting implications for the dynamics of income distributions. In the long run poverty traps may occur, and wealth distributions may be characterized by the "twin peaks" often associated with polarization of wealth in cross-sectional world income distributions. (Quah 1996, 1997). Within the context of our model, there are in fact numerous possibilities for the evolution of wealth distributions. Depending on initial conditions, the political economy mechanism can either reinforce or alleviate the persistence in inequality.

Various strands of literature have motivational relevance for this study. The model of this paper is in the spirit of the emerging macroeconomics literature on health investment, mortality, and inequality, of which Glomm and Palumbo (1993), Ray and Streufert (1993), and Galor and Mayer (2002) are a few examples. To our knowledge, the political economy implications of such models have not been examined, and our paper is an exploratory step in this direction. Furthermore extant political economy models that examine the public-private mix in health care provision study this issue in a static micro-theoretic context. See for example, Epple and Romano (1996) and Gouveia (1997). It is then of obvious interest to explore the implications of the political economy mechanism in a dynamic, macro-theoretic context, especially if one is seeking potential explanations for the observed diversity in the public-private mix in health care systems across countries.

A further issue of interest relates to discussions in the health economics literature on the degree of substitutability between public and private health services and its implication for the composition of health care demand. Cutler and

Gruber (1997), Rask and Rask (2005), among others, comment on a "crowding out" effect associated with public health care expansions. While it may not be appropriate to infer a political economy link between the degree of substitutability and the public-private mix in health care systems based on these studies, they do provide *indirect* evidence to speculate that such a link exists. Furthermore, discussions in policy circles suggest that the degree of substitutability or complementarity between private and public health care provision matters for the determination of public policy in this regard.[2]

Remaining sections of this paper are organized as follows. Section 2 describes the model of this paper and analytically examines some of its features. Section 3 presents results of numerical simulations based on a parameterization of this model. Section 4 concludes.

2. The Economic Environment

As mentioned above, our model is a simple political-economy extension of the framework presented in Chakraborty and Das (2005), henceforth cited as CD. There are overlapping generations of agents in a small open economy who potentially live for two periods. Time is discrete and indexed by t = 0,1,2,…. As in CD the agent born in any given period survives the first period with certainty, but may die before reaching old age, the probability of premature death being a function of 'health investment' in the first period of her life.

However, we modify this construct in that we allow the agent's survival probability to be a function of a 'composite good' that incorporates public health services in addition to individual private health investment. This modification also entails introducing a role for the government in this economy, particularly in relation to the financing of public health services. Specifically, in order to finance various redistributive expenditures, the government raises revenue by means of a progressive linear wealth tax τ, levied on the heterogeneous wealth endowments W_t of the young agents in the economy. Wealth endowments of the young essentially constitute intended or unintended bequests left by the previous

[2] Australian Industry Commission report on private health insurance in 1997 suggests that "the core issue is the extent to which private funding should be seen as, or in fact is replacing public funding (eg private patients in private hospitals) or topping up public funding to provide extra dimensions of service (eg doctor of choice, or private room". (As quoted in Butler and Connely, 2007).

generation. We assume that the distribution of these endowments is described by a density function $g(W)$ with support $[0, \bullet)$. Tax revenue raised in any period in then given by $\tau \int_0^{\bullet} W g(W) dW = \tau \overline{W}$.

A proportion ψ of this revenue is used to finance the 'public health care system' which is part of the composite good affecting the agent's survival probability. The remainder of revenues, i.e. $(1-\psi)\tau\overline{W}$, is used to finance a lump sum transfer to the young agents in the economy. However, the proportion ψ is endogenously determined – at the beginning of each period, before making their lifetime consumption, savings, and bequest plans, the young agents vote for the proportion allocated to the public health care system. The political outcome is then determined using the plurality rule. The equilibrium outcome is *subgame perfect* – the consumption, savings, and bequest plans made in the "second stage" after the vote on ψ has taken place are taken into account by agents during the voting process.

We first characterize the agent's optimization in the second stage. The agents' consumption and bequest plans are denoted by c_t, c_{t+1}, b_{t+1}, and expected lifetime utility is described by

$$U_t = u(c_t) + \phi(h_t)\left[u(c_{t+1}) + \theta v(b_{t+1})\right]. \tag{1}$$

In the above *u* and *v* are twice continuously differentiable, $\phi(h_t)$ is the survival probability function where h_t represents the composite good 'health' given by

$$h_t = \left[\alpha(h_t^p)^{-\nu} + (1-\alpha)(h_t^g)^{-\nu}\right]^{-\frac{1}{\nu}},$$

where h_t^p and h_t^g represent private and public health expenditures and $h_t^g = \psi\tau\overline{W}_t$. The agent born in t chooses her consumption, saving and bequest plans by maximizing (1) subject to the following budget constraints:

$$c_t = \overline{w} + (1-\tau)W_t + (1-\psi)\tau\overline{W}_t - h_t^p - s_t, \tag{2}$$

$$c_{t+1} = \overline{w} + Rs_t - b_{t+1}. \tag{3}$$

In equations (2) and (3), $\overline{w}$ represents income earned as a result of supplying the unit endowment of labor when young or old in a perfectly competitive market, and R is the gross world interest rate, taken as given in this small open economy. In the first period of her life the agent uses her post-tax wealth endowment, income earned in the labor market, and lump-sum transfers from the government to finance consumption, saving and private health investment. In the second period, the income endowment and returns to saving are used to finance consumption and bequests. As in CD we assume that in the event the agent does not survive to the second period the unintended bequests to the next generation equal s_t.

Assumptions regarding the survival probability function $\phi(h_t)$ are identical to those in CD. Specifically,

$$\phi(h_t) \in [0,1], \quad \phi' > 0, \quad \phi'' < 0, \quad \lim_{h \to \bullet} \phi(h) \int \bar{\phi} \leq 1 .$$

Furthermore, as in CD, the functional form for $\phi(h_t)$ is described as follows:

$$\phi(h_t) = \begin{cases} a h_t^{\varepsilon} & \mathit{if}\ h_t \in [0, \hat{h}_t] \\ \bar{\phi} & \mathit{otherwise.} \end{cases} \tag{4}$$

In equation (4) $\hat{h}_t = \left(\frac{\bar{\phi}}{a} \right)^{1/\varepsilon}$. Note, however, that in our model *h* is a composite good including both public and private health expenditures, while in the CD model it refers to private health investment only. In the analysis below we also consider a critical level of private health investment, which given the tax rate and other parameters, is implicitly defined by

$$\hat{h}_t = \left[\alpha \left(\hat{h}_t^p \right)^{-\nu} + (1-\alpha) \left(\psi \tau \bar{W} \right)^{-\nu} \right]^{-\frac{1}{\nu}} = \left(\frac{\bar{\phi}}{a} \right)^{\frac{1}{\varepsilon}} .$$

Rearranging,

$$\hat{h}_t^p = \left[\frac{1}{\alpha} \left(\frac{\bar{\phi}}{a} \right)^{-\frac{\nu}{\varepsilon}} - \frac{1-\alpha}{\alpha} \left(\psi \tau \bar{W} \right)^{-\nu} \right]^{-\frac{1}{\nu}} . \tag{5}$$

As is obvious from (5), the critical level of private health investment for which the survival probability function attains its maximum value is negatively related to the proportion of tax revenue used to finance the public health good, the average tax rate, and the average level of wealth in the economy. We also assume, as in CD, the following functional forms for the period utility functions *u(c)* and *v(b)*:

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma}, \quad v(b) = \frac{b^{1-\sigma}}{1-\sigma}, \quad \sigma \in (0,1).$$

The reason for restricting σ to be less than unity are discussed in CD and are similar in spirit to assumptions generally required in models with variable rates of time preference.

First, we characterize the optimal solution given ψ in the range $[0, \hat{h}_t^p]$, or equivalently $[0, \hat{h}_t]$. The first order necessary conditions associated with $s_t, h_t^p, \& \, b_{t+1}$ are:

$$u'(c_t) = R_t \phi(h_t) u'(c_{t+1}) \quad \Rightarrow \quad c_t^{-\sigma} = R\phi(h_t)(c_{t+1})^{-\sigma} \tag{6}$$

$$u'(c_t) = \frac{\partial \phi}{\partial h_t}\frac{\partial h_t}{\partial h_t^p}\left[u(c_{t+1}) + \theta\, v(b_{t+1})\right] \quad \Rightarrow \quad (1-\sigma)c_t^{-\sigma} = \frac{\partial \phi}{\partial h_t}\frac{\partial h_t}{\partial h_t^p}\left[c_{t+1}^{1-\sigma} + \theta\, b_{t+1}^{1-\sigma}\right] \tag{7}$$

$$u'(c_{t+1}) = \theta\, v'(b_{t+1}) \quad \Rightarrow \quad b_{t+1} = \beta\, c_{t+1}, \tag{8}$$

where $\beta = \theta^{\frac{1}{\sigma}}$. Manipulating (6), (7), (8), and the budget constraints (2) and (3) we can write the variables c_t, c_{t+1}, s_t, and b_{t+1} as functions of h_t^p:

$$c_t = \left(R^{1-\frac{1}{\sigma}}\right)(\phi(h_t))^{-\frac{1}{\sigma}} \frac{\delta h_t}{\frac{\partial h_t}{\partial h_t^p}}, \tag{9}$$

$$c_{t+1} = \frac{\delta R h_t}{\frac{\partial h_t}{\partial h_t^p}}, \tag{10}$$

$$s_t = \frac{\delta(1+\beta)h_t}{\frac{\partial h_t}{\partial h_t^p}} - \frac{\overline{w}}{R}, \tag{11}$$

$$b_{t+1} = \frac{\beta\delta R h_t}{\frac{\partial h_t}{\partial h_t^p}}. \tag{12}$$

In the above equations $\delta = \dfrac{(1-\sigma)}{(1+\beta)\varepsilon}$. Derivations are shown in part A of the Appendix. It is worth noting here that the CD model has similar expressions for the above variables with the difference that in our model the term $\partial h_t / \partial h_t^p$ appears in the denominator of (9), (10), and (12), and in the denominator of the first term in (11). In the special case in which public and private health expenditures are perfect substitutes (i.e. $\nu = -1$), $\partial h_t / \partial h_t^p = \alpha$, the features of our model are likely to be more similar to the CD model. Now, the period *t* and *t+1* budget constraints can be combined to yield

$$c_t + h_t^p + \frac{c_{t+1}}{R} + \frac{b_{t+1}}{R} = y_t, \tag{13}$$

where $y_t \int \overline{w} + (\overline{w}/R) + (1-\tau)W_t + \tau(1-\psi)\overline{W}_t$. Substituting for (9)-(12) in (13) we get

$$\xi(h_t^p) \int h_t^p + \frac{\delta h_t}{\frac{\partial h_t}{\partial h_t^p}}\left[1 + \beta + \frac{R^{1-\frac{1}{\sigma}}}{(\phi(h_t))^{1/\sigma}}\right] = y_t. \tag{14}$$

Equation (14) implicitly determines the optimal private health expenditure as a function of income $h_t^p = \eta(y_t)$ in the range $[0, h_t^p]$, given policy parameters ψ and τ .

Before discussing the characterization of the agent's optimal choices in the range of income levels above $\hat{y}_t = \xi(\hat{h}_t^p)$ it is useful to examine some of the analytical results in the CD article corresponding to the income levels below this critical level, with reference our extension. Specifically, they show that the restriction $\sigma > \varepsilon$ implies that private health investment is a luxury good, as are bequests and second period consumption. This assumption also implies that first period consumption is a normal good. While analytical results of this sort are difficult to derive in our extension of the CD model, we can show that they hold in the special case of our model in which private and public health are perfect substitutes, i.e. in the case $\nu = -1$. We can also analyse the special case of $\nu = 0$; in this case the health production function is of the Cobb-Douglas form. In the latter case, however, similar results are obtained by imposing slightly different assumptions regarding the parameters. We summarize these results in Propositions 1 and 2 below:

Proposition 1: Let $\nu = -1$ and $\sigma > \varepsilon$. Then,

(i) Private health investment is a luxury good. That is, $\frac{\partial \eta}{\partial y_t} > 0$, and $\frac{\partial^2 \eta}{\partial y_t^2} > 0$, so that the income-expansion path for private health is convex .

(ii) Old age consumption, and bequests are luxury goods.

(iii) Consumption when young is a normal good.

Proposition 2: Let $\nu = -1$ and $\sigma > \varepsilon\alpha$. Then,

(i) Private health investment is a luxury good. That is, $\frac{\partial \eta}{\partial y_t} > 0$, and $\frac{\partial^2 \eta}{\partial y_t^2} > 0$, so that the income-expansion path for private health is convex .

(ii) Old-age consumption and bequests are luxury goods.

(iii) Consumption when young is a normal good.

The proofs of the above propositions are presented in parts B and C of the appendix respectively. From the point of view of our paper, the above propositions establish that for a range of parameters considered the features of the extended model are common to that of the CD model. Therefore, studying the political economy implications of the above model is to some degree the same as studying the implications of some of the specific features of the CD model, in addition to studying the implications of the specific features of our more general framework.

Next, we consider the agent's optimization problem for incomes above $\hat{y}_t = \eta(\hat{h}_t^p)$. As described above, the survival probability function reaches its maximum value at $\hat{h}_t^p$, which means health investment will be maintained at the level $\hat{h}_t^p$ for income levels $y_t > \hat{y}_t$. The agent's problem then reduces to

$$\max_{c_t, b_{t+1}} \frac{c_t^{1-\sigma}}{1-\sigma} + \bar{\phi}\left[\frac{c_{t+1}^{1-\sigma}}{1-\sigma} + \theta \frac{b_{t+1}^{1-\sigma}}{1-\sigma}\right]$$

subject to

$$c_t + \frac{c_{t+1}}{R} + \frac{b_{t+1}}{R} = y_t - \hat{h}_t^p .$$

Analogous to the CD framework, we can then derive closed form solutions described by:

$$c_t = \left(\frac{1}{1+\rho(1+\beta)}\right)\left(y_t - \hat{h}_t^p\right) \tag{15}$$

$$c_{t+1} = \left(\frac{\rho R}{1+\rho(1+\beta)}\right)\left(y_t - \hat{h}_t^p\right) \tag{16}$$

$$b_{t+1} = \left(\frac{\beta\rho R}{1+\rho(1+\beta)}\right)\left(y_t - \hat{h}_t^p\right) \tag{17}$$

$$s_t = \left(\frac{\rho(1+\beta)}{1+\rho(1+\beta)} \right)\left(y_t - \hat{h}_t^p\right) - \frac{\overline{w}}{R}, \tag{18}$$

where $\rho \int \bar{\phi}^{1/\sigma} R^{\frac{1}{\sigma}-1}$. Combining (9)-(12) and (15)-(17), we then have a complete characterization of the agent's problem in the second stage.

Since it is hard to explicitly characterize the political outcome in the first stage, our analysis is primarily based on the numerical simulations presented in the next section. However, to extract some intuition about the political equilibrium, we now analyse how the agents' consumption, saving and bequest plans are affected by changes in ψ. We also look at the implications of these changes on their indirect utility functions $V(\psi, W)$; while one cannot analytically obtain a solution for the political outcome, such an analysis identifies the tradeoffs faced by the agents while making their voting decision. In what follows, we therefore attempt to establish some benchmark conditions under which agents prefer extreme values of ψ - i.e a value of ψ equal to 0 or 1, which would be the case if the indirect utility functions were decreasing or increasing over the entire range of $\psi \in [0,1]$. Interpreting these conditions also enables us to gain some insight about what must occur when "interior" values of ψ are to be the preferred outcome, and makes it a little easier to interpret the results of the numerical experiments in Section 3 of the paper.

We first analyse the case in which agents' incomes are above the critical level of income and wealth above which the survival probability is at the maximum possible level of $\bar{\phi}$. Note that the critical level of private health investment required to attain the maximum survival probability is decreasing in ψ, so that changes in ψ alter the number of agents in the two different groups we consider, namely, those with incomes such that their survival probability is less than $\bar{\phi}$, and those with income and wealth above the level required to attain the maximal survival probability $\bar{\phi}$. For agents with survival probability $\bar{\phi}$, we can establish some conditions under which the preferred choice of ψ will be either 0 or 1. These conditions are summarized below in the following results, proved in Appendix D.

Proposition 3: For agents with survival probability $\bar{\phi}$

(i) Consumption in both periods of life, intended bequests, and savings are decreasing in ψ *iff* $\left(\frac{1-\alpha}{\alpha}\right) < \left(\frac{h_t^g}{\hat{h}_t^p}\right)^{1+v}$

(ii) The indirect utility function is decreasing in ψ *iff* $\left(\frac{1-\alpha}{\alpha}\right) < \left(\frac{h_t^g}{\hat{h}_t^p}\right)^{1+v}$.

Proposition 3 implies that for agents with survival probability $\bar{\phi}$, the vote on ψ depends on (a) the share of government expenditures relative to private health expenditures in the health production function; (b) the ratio of public health expenditures to the survival-probability maximizing level of private health expenditure; and (c) the elasticity of substitution between private and public health expenditures in the health production function. If the inequality in (i) and (ii) of the proposition above holds, then the agents in this group will prefer $\psi = 0$. If it is reversed, on the other hand, they will prefer $\psi = 1$. A value of $\psi \in (0,1)$ is preferred if $\left(\frac{1-\alpha}{\alpha}\right) = \left(\frac{h_t^g}{\hat{h}_t^p}\right)^{1+v}$. Note, for example, in the case of perfect substitutes $(v = -1)$, the indirect utility function is decreasing in ψ *iff* $\alpha > 1/2$ - i.e if private health matters more than public health in contributing towards composite health, these agents will vote for $\psi = 0$. On the other hand, a value of $\psi = 1$ is preferred if $\alpha < 1/2$. In the Cobb-Douglas case, agents in this group vote for $\psi = 0$ if $\left(\frac{1-\alpha}{\alpha}\right) < \left(\frac{h_t^g}{\hat{h}_t^p}\right)$ and $\psi = 1$ if the inequality is reversed. A value of $\psi \in (0,1)$ is preferred if $\left(\frac{1-\alpha}{\alpha}\right) = \left(\frac{h_t^g}{\hat{h}_t^p}\right)$. The tradeoffs faced by the agents are represented by the ratios $(1-\alpha)/\alpha$ and $h_t^g / \hat{h}_t^p$ - the former may be interpreted as the relative contribution of public expenditures in determining overall health, while the latter may be interpreted as the cost of financing that contribution expressed relative to the maximum expenditure on private health. (Recall that all agents in this group spend the same amount on their health – i.e. $\hat{h}_t^p$, which is enough to attain the survival probability $\bar{\phi}$).

Next, consider agents with incomes lower than the level required to reach a survival probability $\bar{\phi}$. Again, since it is difficult to characterize their preferences over ψ analytically we resort to analysing some special cases, and then consider results based on numerical simulations in the next section. Note that since we do not have closed form solutions for the variables entering the utility function, we can only analyse how the indirect utility function changes with ψ if we can determine how private health investment and composite health of agents responds to changes in ψ. A feature of relevance to the political outcome appears to be the extent of "crowding out" in private health investment that occurs as a result of these changes. We again summarize conditions in which "corner solutions" may emerge for the cases in which the health production function is of linear or Cobb-Douglas form.

Proposition 4. Let $\nu = -1$ and $\sigma > \varepsilon$. Then,

(i) $\dfrac{\partial h_t^p}{\partial \psi} < 0$.

(ii) $\dfrac{\partial h_t}{\partial \psi} < 0 \quad iff \quad 1 + \delta(1-\alpha)^2 \left[1 + \beta + R^{1-\frac{1}{\sigma}} (\phi(h_t))^{-1/\sigma} \right] < 2\alpha$.

(iii) Period t and t+1 consumption, intended bequests, savings are decreasing in ψ iff $\dfrac{\partial h_t}{\partial \psi} < 0$.

(iv) The indirect utility function $V(\psi, W)$ is decreasing in ψ iff $\dfrac{\partial h_t}{\partial \psi} < 0$.

Proposition 5. Let $\nu = 0$ and $\sigma > \alpha\varepsilon$. Then,

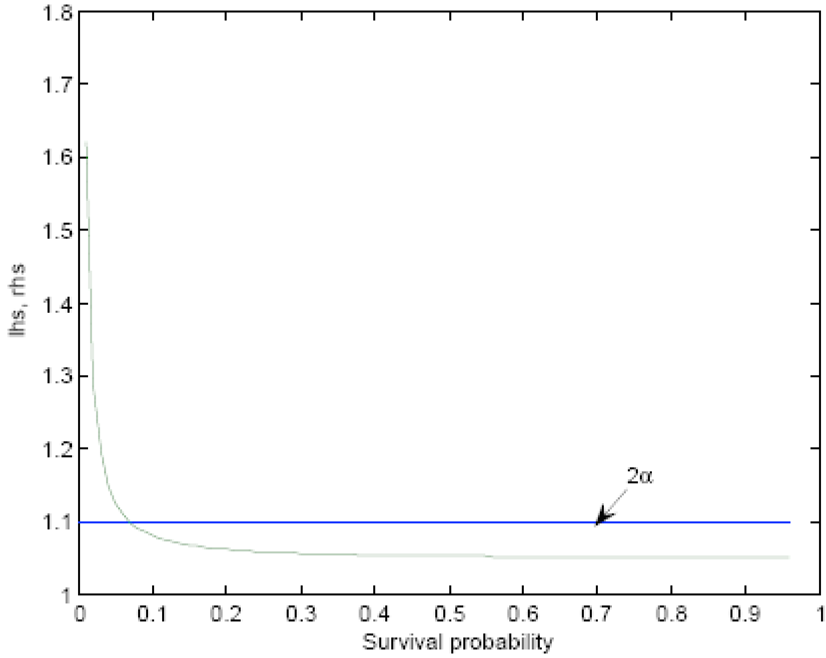
(i) $\dfrac{\partial h_t^p}{\partial \psi} < 0 \quad iff \quad \dfrac{\delta}{\alpha} \left(\dfrac{h_t^p}{h_t} \right) \left(\dfrac{\varepsilon}{\alpha} \right) (\phi(h_t))^{-1/\sigma} R^{1-\frac{1}{\sigma}} < 1$.

(ii) The sign of $\dfrac{\partial h_t}{\partial \psi}$ is ambiguous.

(iii) Period t+1 consumption, savings and intended bequests are decreasing in ψ iff $\dfrac{\partial h_t^p}{\partial \psi} < 0$.

(iv) The sign of $\frac{\partial V}{\partial \psi}$ and $\frac{\partial c_t}{\partial \psi}$ is ambiguous.

Proofs are relegated to parts E and F of the appendix. The "crowding out" effect, which we interpret as the situation in which private health expenditures decrease if the proportion ψ of tax revenues devoted to health increases, seems to have a role to play in the numerical simulations discussed in the next section. In particular, private health expenditures unambiguously decrease as ψ decreases in the case of perfect substitutes. Whether the agents in this group vote for a certain value of ψ depends on the extent to which composite health h_t is affected by the crowding-out effect. Examining the condition stated in part (ii) of Proposition 4, we find again that the parameter α is of relevance. To obtain some intuition, we graph the left hand side of this condition for values of the survival probability ranging from 0 to $\bar{\phi}$, with parameters set according to those we have used for our simulations in the next section.

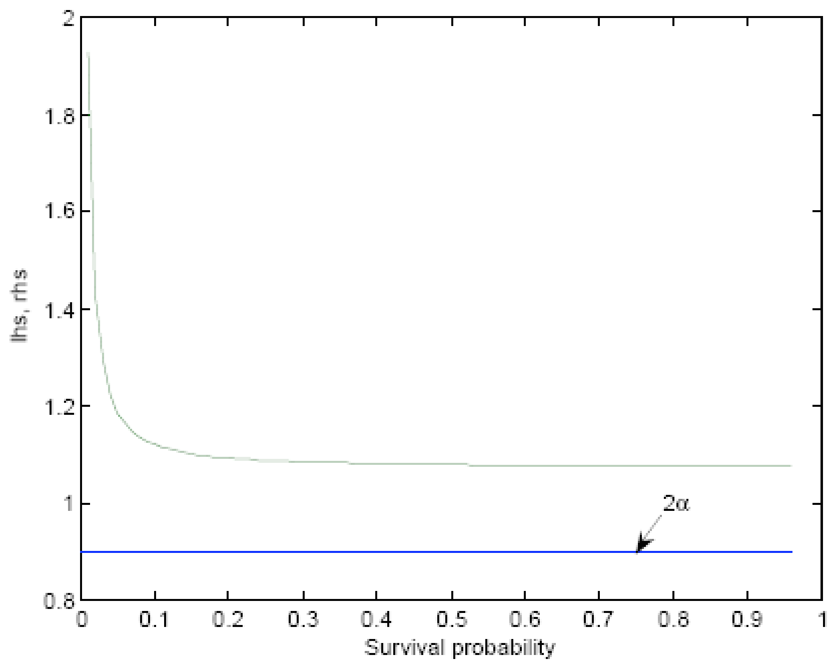


$$lhs = 1 + \delta(1-\alpha)^2\left[1 + \beta + R^{1-\frac{1}{\sigma}}\left(\phi(h_t)\right)^{-1/\sigma}\right]; \quad rhs = 2\alpha; \; \alpha = 0.55;$$

$\sigma = 0.8; \quad R = 1.04; \quad \beta =, \quad \delta =$

Figure 1(a)

Figures 1(a) and (b) present cases in which $\alpha = 0.55$ and $\alpha = 0.45$ respectively. Figure 1(a) shows that the left hand side of the condition stated in proposition 4 is decreasing in the survival probability. The condition stated in the proposition therefore does not hold for agents with survival probability that is lower than 0.07, but applies in the case of all other agents above that level but below $\bar{\phi}$. Combined with the analysis of the case of agents in the cohort with survival probability $\bar{\phi}$, it would then seem that in this case the outcome of majority voting would be $\psi = 0$, provided initial inequality levels were not too high.



$$lhs = 1 + \delta(1-\alpha)^2 \left[1 + \beta + R^{1-\frac{1}{\sigma}} \left(\phi(h_t)\right)^{-1/\sigma}\right]; \quad rhs = 2\alpha; \ \alpha = 0.45;$$

Figure 1(b)

In Figure 1(b), however, the left hand side of the inequality is reversed and one would expect all agents to vote for $\psi = 1$. Intuitively this makes sense – given that private health expenditures are perfect substitutes, and α is low, public expenditures matter more in determining the overall or composite health of the agent, so agents prefer ψ to be as high as possible. If α is high, however, public expenditures do not matter much for the agent's overall health; they would prefer government revenues redistributed via a lump sum transfer, which can be used for consumption smoothing in addition to investment in private health.

In the Cobb-Douglas case, on the other hand, it appears that interior outcomes for ψ are more likely – private health investment may not be decreasing in ψ, so the crowding-out effect is not as strong as in the perfect-substitutes case. Even in the case private health investment is decreasing in ψ, overall health investment may not decrease as ψ increases, leading to a higher survival probability and a more patient attitude towards the future. In effect, the agents face tradeoffs which may balance out in such a way that an interior value of ψ may be optimal.

We now turn to the discussion of the dynamic aspects of the model. Based on the characterization of the agent's optimization problem discussed above, the intended and unintended bequests for the entire wealth distribution are given by

$$b_{t+1} = \Omega_1(W_t) \int \begin{cases} \frac{\beta(1-\sigma)}{(1+\beta)\varepsilon}\left[\eta_0(W_t) + \left(\frac{1-\alpha}{\alpha}\right)(\psi\tau\overline{W}_t)^{-v}(\eta_0(W_t))^{1+v}\right], & W_t < \hat{W}_t \\ \frac{\beta\rho R}{1+\rho(1+\beta)}\left[\overline{w} + \frac{\overline{w}}{R} + (1-\tau)W_t + \tau(1-\psi)\overline{W}_t - \hat{h}_t^p\right], & W_t \geq \hat{W}_t \end{cases}$$

$$s_t = \Omega_2(W_t) \int \begin{cases} \frac{(1-\sigma)}{\varepsilon}\left[\eta_0(W_t) + \left(\frac{1-\alpha}{\alpha}\right)(\psi\tau\overline{W}_t)^{-v}(\eta_0(W_t))^{1+v}\right] - \frac{\overline{w}}{R}, & W_t < \hat{W}_t \\ \frac{\rho(1+\beta)}{1+\rho(1+\beta)}\left[\overline{w} + \frac{\overline{w}}{R} + (1-\tau)W_t + \tau(1-\psi)\overline{W}_t - \hat{h}_t^p\right], & W_t \geq \hat{W}_t \end{cases}$$

Given the optimal savings and bequest decisions above, the wealth dynamics for the *ith* agent in the economy are characterized by the following non-linear Markov process:

$$W_{t+1}^i = \Omega(W_t^i) \int \begin{cases} \Omega_1(W_t^i) & \textit{with probability } \phi(h(W_t^i)) \\ \Omega_2(W_t^i) & \textit{otherwise} \end{cases}. \qquad (15)$$

As in CD, whether inequality is persistent depends on the shape of $\eta_0(W)$, which in turn determines the shape of the savings and bequest functions described above. Specifically, whether (15) has a unique invariant distribution depends on the shape of $\Omega_1(W)$ and $\Omega_2(W)$, which is in turn determined by the shape of $\eta_0(W)$. While we cannot determine this shape for the general case of the model, we can establish the same results as in CD with reference to the special cases of the model in which v is set equal to -1 or 0. Essentially, in these special cases it can be shown that the shape of the savings and bequest functions is convex for wealth levels below $\hat{W}_t$ and linear for wealth levels greater than or equal to $\hat{W}_t$. The technical details are presented in the appendix. In what follows, it is convenient to reiterate the argument made in CD in relation to persistence in inequality, given that the argument applies to some degree in the special cases of our model. Figure 2 below represents $\Omega_1(W)$ and $\Omega_2(W)$ and the expected bequest line defined by

$$\Omega^E(W_t^i) \int \phi(h(W_t^i))\Omega_1(W_t^i) + \left[1 - \phi(h(W_t^i))\right]\Omega_2(W_t^i)$$

Following CD, three possible scenarios in relation to the wealth dynamics of the model are presented in Figure 2 (a), (b) and (c). Referring to figure 2 (a), although the bequest and savings functions are initially convex, the intersection of these lines with the 45 degree line occurs at a relatively higher level of wealth. The intended and unintended bequest functions are however linear in the region where they intersect the 45 degree line. In this scenario, all agents converge towards a distribution with support $\left[\overline{W}_H^2, \overline{W}_H^1\right]$. No development trap is observed and all dynasties converge to a unique invariant long-run distribution, as shown in the second panel of Figure 2a. Figure 2 (b), however, illustrates the case where $\Omega_1(W)$ and $\Omega_2(W)$ intersect with the 45 degree line in both the convex and the linear region. Dynasties which start out with wealth above $\overline{W}$ converge to a distribution on the support $\left[\overline{W}_H^2, \overline{W}_H^1\right]$ whereas dynasties who have wealth below this ‘threshold’ converge to $\left[\overline{W}_L^2, \overline{W}_L^1\right]$. Therefore one observes polarisation in the distribution of wealth. A third scenario is presented in Figure 2 (c). Note here that $\Omega_1(W)$ and $\Omega_2(W)$ intersect the 45 degree line once only but at a point associated with a low level of wealth, in the region where they are convex. Therefore, irrespective of initial wealth, all dynasties asymptotically converge to a distribution on support $\left[\overline{W}_L^2, \overline{W}_L^1\right]$. Whilst inequality is not persistent in the case, all agents converge to a low wealth distribution where everyone ends up in a “poverty trap”. Numerical experiments in the following section indicate that, in our model, this particular scenario is the most likely outcome.

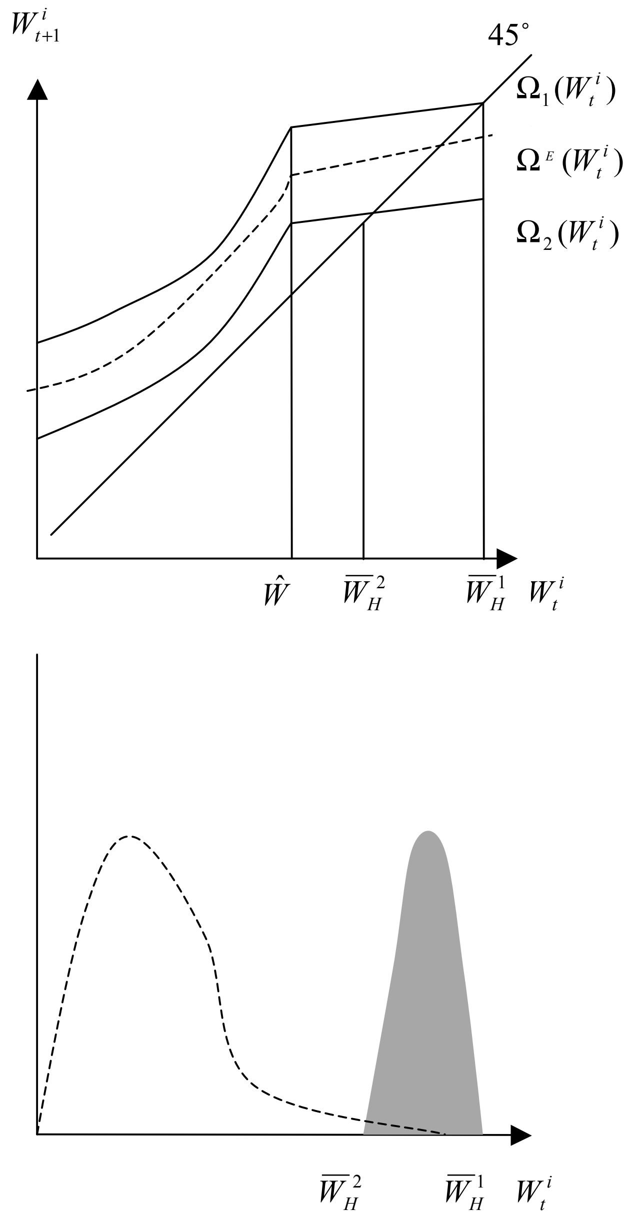


Figure 2(a)

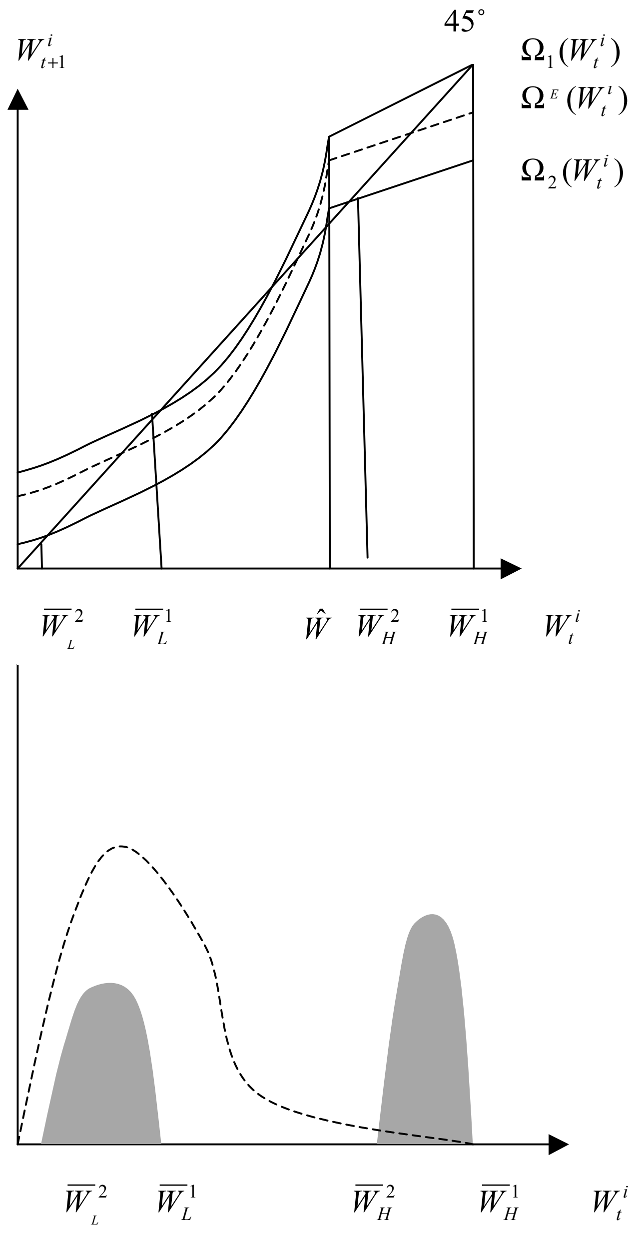


Figure 2(b)

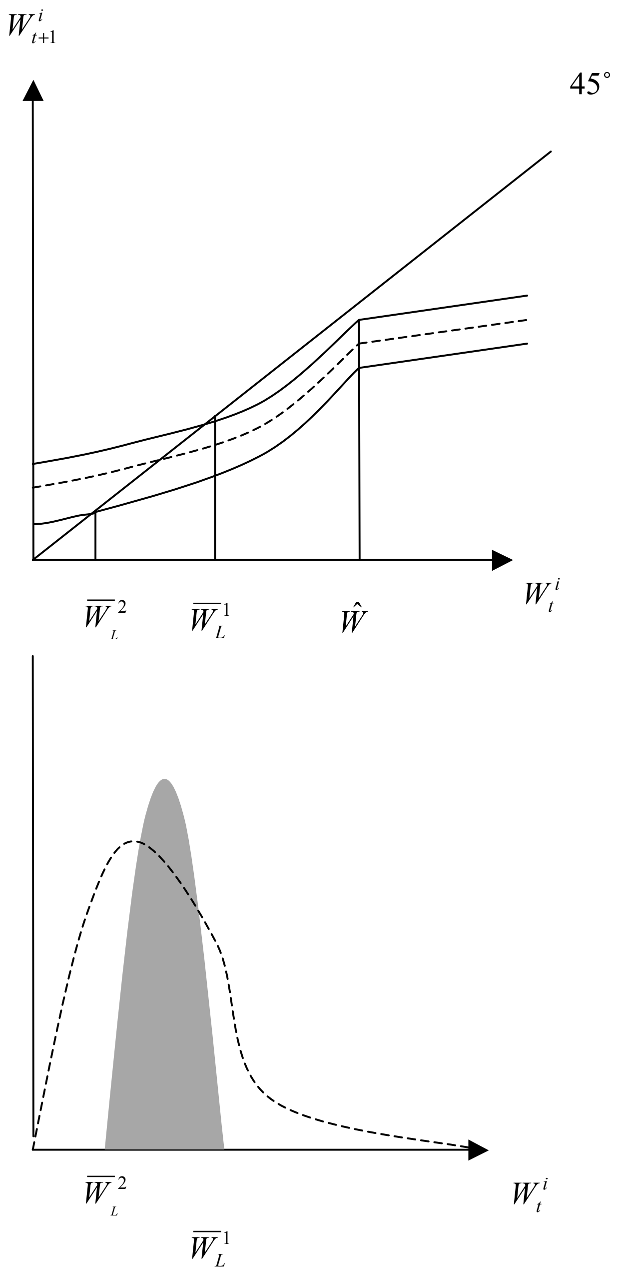


Figure 2 (c) Catching Point Dynamics

Note, however, that in our model, intended and unintended bequests are also a function of $\tilde{\psi}$, the political outcome of the vote on ψ. The above discussion in relation to the dynamics of the model, nevertheless applies in our case as well.

Based on the analysis above, we can claim that in the special cases at least, the shape and curvature of the savings and bequest functions do not change – only the magnitude is altered. However, we can speculate that initial conditions with respect to the distributional statistics and parameters of the "health production function" will matter a great deal in determining the path that is taken by the economy during the transition to the long-run distribution. To analyse these issues further, we turn to the numerical experiments presented in the next section.

3. Results Based on Numerical Experiments

Our focus in this section is on the political results of the voting on ψ, and how it changes depending on the degree of substitutability between private and public health inputs in contributing to each agent's overall health. We are also interested in the extent to which the initial inequality in the distribution matters for the determination of the proportion of revenues allocated to health.

To examine the effect of changing the parameter ν, which inversely impacts on the elasticity of substitution (measured as $1/(1+\nu)$), we examine the results summarized in Table 1. The results presented in this table are based on a random sample of 501 observations drawn from a lognormal distribution with mean 3.2 and standard deviation 1.5. The associated Gini coefficient of the wealth distribution based on this sample is .7507. The parameter α represents the contribution of private expenditures in overall health. An approximate measure of this parameter would be the percentage share of private expenditure in total health expenditures. Since there is a great deal of variation in these estimates across countries, we consider different values in experiments to follow. However, for the results in Table 1 $\alpha = 0.55$, implying a relatively larger contribution to overall health, as would be the case for a transitional economy. This roughly corresponds to the private share of total health expenditures in Mexico for the year 2005. (World Bank, 2006). We set $R = 1 + \bar{r} = 1.055$, as in Heidjra and Romp, 2008. We set $\sigma = 0.8$, a value consistent with the assumption that $\sigma < 1$ described in Section - .[3] The parameter θ is calibrated as per the restriction suggested in Chakraborty and Das (2005). That is, to ensure that intended bequests in the model are always higher than unintended bequests we must impose $\theta > (1/\bar{r})^{\sigma}$.

[3] Estimates in the literature range from 1 to ---. (Insert reference)

To that end, we set $\theta = (1/\bar{r})^{\sigma} + .01$. The parameters of the survival probability function are set as $a = 0.06$, and $\varepsilon = 0.85$ - for an elasticity of substitution close to 1 these parameters ensure a range of survival probability that increases from 0.3 to $\bar{\phi}$, which is set at 0.96. This range roughly corresponds to estimates of cross-country survival probabilities based on the data presented in World Health Organisation, *Core Health Indicators*, 2004.

However keeping a and ε fixed while we vary ν leads to some problems in relation to interpreting the results presented in Table 1. In particular, the range of the survival probability function decreases as we increase the elasticity of substitution, so we are in effect looking at economies with different mortality risks. An alternative would be to change these parameters as we change the elasticity of substitution, such that the range of survival probabilities would be preserved across the experiments. We conducted some simulations of this nature, and the results are presented in Appendix G – in a qualitative sense at least, the results were similar to those presented in Table 1 below.

Table 1

ν	Elasticity of Substitution	$\tilde{\psi}$	Percent in favour of $\tilde{\psi}$	Welfare maximising ψ	Desired ψ poorest agent	Desired ψ of the median agent	Desired ψ of the richest agent
-1	∞	0	100	0	0	0	0
-.95	20	.05	97.8	.05	.05	.05	.05
-.94	16.66	.05	97.6	.05	.05	.05	.05
-.93	14.28	.1	94.8	.1	.15	.1	.1
-.92	12.50	.15	91.6	.15	.2	.15	.15
-.91	11.11	.2	82.4	.2	.25	.2	.2
-.90	10.00	.25	78.2	.25	.25	.25	.25
-.89	9.09	.3	81.0	.3	.3	.3	.3
-.87	7.69	.35	62.9	.35	.4	.35	.35
-.85	6.66	.45	65.1	.5	.5	.45	.45
-.84	6.25	.45	48.7	.55	.45	.65	.45
-.83	5.88	.5	51.8	.55	.5	.65	.5
-.82	5.55	.5	42.1	.6	.55	.7	.5
-.78	4.54	.6	35.5	.7	.6	.85	.6
-.05	1.05	1	69.1	1	.85	1	.95

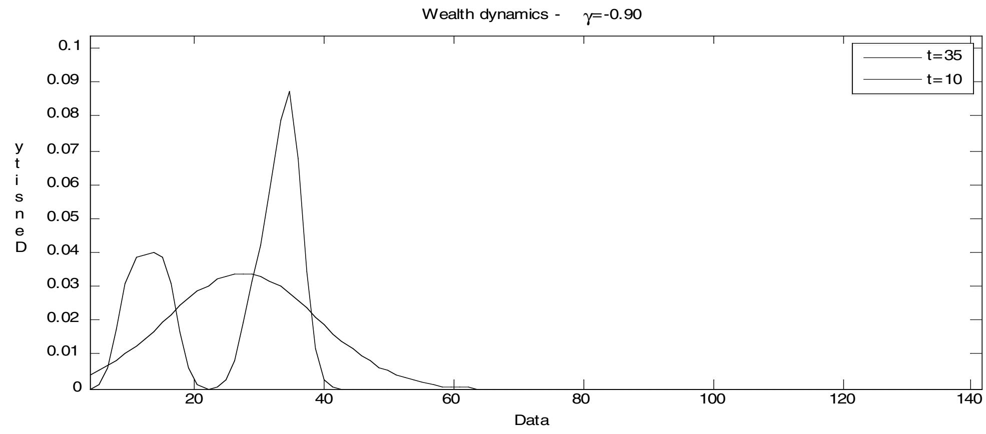
According to the experiments summarized in Table 1, decreasing the elasticity of substitution between private and public health expenditures leads to a vote in favour of higher levels of ψ - the proportion of revenues allocated to health care. In the case of higher substitutability, there is a "crowding out" effect – higher ψ leads to a decline in private health investment that is large enough to offset the increase in public health spending, so that the survival probability is adversely affected. As shown in the previous section the decline in overall health has implications for other variables – consumption, savings, bequests and consequently utility decrease as ψ increases. For lower levels of the elasticity of substitution, however, the crowding-out effect is not that strong – private health investment falls, but overall health increases as ψ increases. The resulting increase in survival probability makes the agent more patient, so that declines in future consumption and bequests are not as large as the perfect-substitutes case, and expected lifetime utility increases as ψ increases.

Another interesting feature of the results here is that for some ranges of parameters, the rich and middle-income agents in the economy prefer a higher ψ relative to poorer agents. This may simply be the result of a preference for the lump sum transfer, which serves as a better mechanism of redistribution due to its direct nature. Furthermore, it is important to note that the share of the government's contribution to overall health is relatively small.

For lower values of the elasticity of substitution, there are some cases which exhibit the "ends-against-the-middle" feature discussed in Epple and Romano(1996). The tradeoffs to the richer agents are as follows: a higher ψ may be preferred because it is somewhat complementary to private health investment, which is increasing in wealth. A higher ψ also implies that the lump sum transfer to the richer agents is substantially smaller relative to what they pay in taxes. The poor may prefer a lower ψ because the direct lump-sum transfer is more progressive than the health transfer, given that it can be regarded as a perfect substitute for consumption.

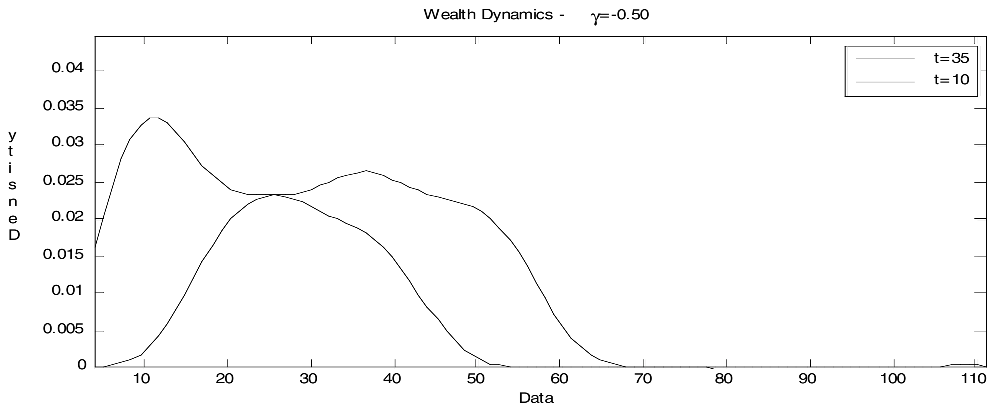
Also note that in some of these cases a political outcome exists only if we allow for a plurality-rule based results. In such cases the political outcome also differs from the outcome that maximizes social welfare, measured using a utilitarian social welfare function with equal weights. (See column 5 of Table 1).

The features discussed above also have interesting implications for the dynamics of income distributions. Preliminary numerical simulations indicate numerous possibilities, some of which are presented in Figures 3(a) and (b) below.



Wealth + Income

Figure 3(a): Dynamics of wealth distributions: high elasticity of substitution



Wealth + Income

Figure 3(b): Dynamics of wealth distributions: low elasticity of substitution

Figure 3(a) represents the evolution of wealth over time for the case in which $\gamma = -.9$, indicating a high elasticity of substitution between public and private health expenditures. In this case, we observe a polarization of wealth over time, with the t = 35 case represented by a bimodal distribution, where 't' represents the iteration number. For some further detail on the evolution of inequality and the political outcome, see appendix H. In this case inequality initially decreases and subsequently increases over time.

Figure 3(b) represents the low elasticity of substitution case with $\gamma = -.5$. Here we observe a leftward shift in the wealth distribution, but inequality generally decreases over time. (See Appendix H).

4. Concluding Remarks

In this paper we studied a two-period overlapping-generations model in which mortality risk is endogenously determined by health investment in the form of private and public expenditures on health care. The proportion of public revenues that are used for the public provision of health care was also endogenously determined by means of a political process, modelled in this context as the outcome of voting by agents. Agents are heterogeneous in their initial endowments of wealth inherited from the previous generation. We find that the political outcome critically depends on the degree of substitutability between private and public health expenditures, and has interesting implications for economic growth and the persistence of inequality.

The outcome also depends critically on initial conditions, and in some cases exists only if the political process allows a result that is based on the plurality rule rather than the majority rule. Numerical simulations of our model suggest that even in the case of majoritarian outcomes, the political outcome is often influenced by the preferences of the agents at the middle and top end of the wealth distribution. The political result is sometimes also characterized by the "ends against the middle" feature observed in Epple and Romano (1996a, 1996b). In the long run poverty traps may occur, and income distributions can be characterized by the emergence of "twin peaks" with the associated polarization of wealth.

Appendix

A. Derivation of Equations (9)-(12)

Substituting (6) and (8) into (7) we get

$$c_{t+1} = \frac{(1-\sigma)R\phi(h_t)}{(1+\beta)\dfrac{\partial\phi(h_t)}{\partial h_t}\dfrac{\partial h_t}{\partial h_t^p}}.$$

Given the functional form for assumed in (4), note that $\dfrac{\dfrac{\partial\phi(h_t)}{\partial h_t}h_t}{\phi(h_t)} = \varepsilon$. We can then write

$$c_{t+1} = \frac{(1-\sigma)Rh_t}{(1+\beta)\varepsilon\dfrac{\partial h_t}{\partial h_t^p}}.$$

Defining $\delta = \dfrac{(1-\sigma)}{(1+\beta)\varepsilon}$, we obtain (10). It is then easy to derive (9), (11), and (12) using (6), (8), and (3).

B. Proof of Proposition 1

In the case of $\nu = -1$, note that $h_t = \alpha h_t^p + (1-\alpha)h_t^g = \alpha h_t^p + (1-\alpha)\psi\tau\overline{W}_t$, and $\dfrac{\partial h_t}{\partial h_t^p} = \alpha$. Differentiating (14) with respect to h_t^p we get

$$\xi'(h_t^p) = 1 + \delta\left[1 + \beta + \frac{R^{1-\frac{1}{\sigma}}}{(\phi(h_t))^{1/\sigma}}\left(1 - \frac{\varepsilon}{\sigma}\right)\right] > 0 \quad if \quad \sigma > \varepsilon.$$

Also,

$$\xi''(h_t^p) = \delta\left(1 - \frac{\varepsilon}{\sigma}\right)R^{1-\frac{1}{\sigma}}\left(-\frac{1}{\sigma}\right)(\phi(h_t))^{-1/\sigma}\frac{\alpha\varepsilon}{h_t} < 0 \quad iff \quad \sigma > \varepsilon.$$

Using the inverse function rule

$$\frac{\partial\eta}{\partial y_t} = \frac{1}{\xi'} > 0 \text{ and } \frac{\partial^2\eta}{\partial y_t^2} = -(\xi')^{-2}\xi'' > 0.$$

Therefore, as in CD, we find that the income-expansion path for private health is convex, so that (i) follows, i.e. private health is a luxury good. Given that $\dfrac{\partial h_t}{\partial h_t^p} = \alpha$, consumption when old, and intended bequests are linearly related to private health expenditures, and consequently (ii) follows. To prove (ii) note that differentiating (9) w.r.t. y_t we get

$$\frac{\partial c_t}{\partial y_t} = R^{1-\frac{1}{\sigma}} \left(\phi(h_t)\right)^{-1/\sigma} \left(1 - \frac{\varepsilon}{\sigma}\right) \frac{\partial h_t^p}{\partial y_t} > 0 \quad iff \quad \sigma > \varepsilon \,.$$

C. Proof of Proposition 2

In the case $v = 0$, $h_t = \left(h_t^p\right)^{\alpha} \left(h_t^g\right)^{1-\alpha}$. This means that

$$\frac{h_t}{\frac{\partial h_t}{\partial h_t^p}} = \frac{\left(h_t^p\right)^{\alpha} \left(h_t^g\right)^{1-\alpha}}{\alpha \left(h_t^p\right)^{\alpha-1} \left(h_t^g\right)^{1-\alpha}} = \frac{h_t^p}{\alpha} \,.$$

In this case

$$\xi'(h_t^p) = 1 + \frac{1}{\alpha}\left[1 + \beta + \frac{R^{1-\frac{1}{\sigma}}}{\left(\phi(h_t)\right)^{1/\sigma}} \left(1 - \frac{\varepsilon\alpha}{\sigma}\right)\right] > 0 \quad if \quad \varepsilon\alpha < \sigma \,.$$

Also,

$$\xi''(h_t^p) = -\frac{1}{\sigma}\left(1 - \frac{\varepsilon\alpha}{\sigma}\right) R^{1-\frac{1}{\sigma}} \frac{\varepsilon}{h_t^p} < 0 \quad iff \quad \varepsilon\alpha < \sigma \,.$$

Using the inverse function rule

$$\frac{\partial \eta}{\partial y_t} = \frac{1}{\xi'} > 0 \text{ and } \frac{\partial^2 \eta}{\partial y_t^2} = -(\xi')^{-2} \xi'' > 0 \,.$$

Again, we find that the income-expansion path for private health is convex, so that (i) follows, i.e. private health is a luxury good. Given that $\frac{h_t}{\frac{\partial h_t}{\partial h_t^p}} = \frac{h_t^p}{\alpha}$, consumption when old, and intended bequests are linearly related to private health expenditures, and consequently (ii) follows. To prove (ii) note that differentiating (9) w.r.t. y_t we get

$$\frac{\partial c_t}{\partial y_t} = R^{1-\frac{1}{\sigma}} \left(\phi(h_t)\right)^{-1/\sigma} \frac{\delta}{\alpha} \left(1 - \frac{\varepsilon}{\sigma}\right) \frac{\partial h_t^p}{\partial y_t} > 0 \quad iff \quad \sigma > \varepsilon \,.$$

D. Proof of Proposition 3

To show part (i) note that

$$\frac{\partial c_t}{\partial \psi} = \frac{1}{1+\rho(1+\beta)}\left[\frac{\partial y_t}{\partial \psi} - \frac{\partial \hat{h}_t^p}{\partial \psi}\right].$$

To obtain $\frac{\partial \hat{h}_t^p}{\partial \psi}$ we totally differentiate the following expression for $\hat{h}_t$,

$$\hat{h}_t = \left[\alpha\left(\hat{h}_t^p\right)^{-v} + (1-\alpha)\left(\psi\tau\overline{W}\right)^{-v}\right]^{-\frac{1}{v}} = \left(\frac{\overline{\phi}}{a}\right)^{\frac{1}{\varepsilon}}.$$

Then,

$$\frac{\partial c_t}{\partial \psi} = \frac{1}{1+\rho(1+\beta)}\left[-\tau\overline{W}_t + \frac{1-\alpha}{\alpha}\left(\frac{\hat{h}_t^p}{h_t^g}\right)^{1+v}\tau\overline{W}_t\right] < 0 \quad iff \quad \left(\frac{1-\alpha}{\alpha}\right) < \left(\frac{h_t^g}{\hat{h}_t^p}\right)^{1+v}.$$

Part (ii) follows since all other variables are linearly related to period t consumption and

$$\frac{\partial V(\psi, W)}{\partial \psi} = c_t^{-\sigma}\left[1+\overline{\phi}(\rho R)^{1-\sigma}(1+\beta)\right]\frac{\partial c_t}{\partial \psi}.$$

E. Proof of Proposition 4

Starting from (14), we can rearrange terms such that we have an implicit function of the form $\Gamma(h_t^p, \psi) = 0$. Applying the implicit function theorem we then have

$$\frac{dh_t^p}{d\psi} = -\frac{\Gamma_\psi}{\Gamma_{h_t^p}}.$$

Here $\Gamma_\psi = \frac{\delta}{\alpha}(1-\alpha)\tau\overline{W}_t\left[1+\beta+R^{1-\frac{1}{\sigma}}\left(\phi(h_t)\right)^{-1/\sigma}\left(1-\frac{\varepsilon}{\sigma}\right)\right] + \tau\overline{W}_t > 0 \; if \; \sigma > \varepsilon$, and

$\Gamma_{h_t^p} = 1+\delta\left[1+\beta+R^{1-\frac{1}{\sigma}}\phi(h_t)^{-1/\sigma}\left(1-\frac{\varepsilon}{\sigma}\right)\right] > 0 \; if \; \sigma > \varepsilon$. Therefore (i) follows.

Since in the case of perfect substitutes, $h_t = \alpha h_t^p + (1-\alpha)\psi\tau\overline{W}_t$, differentiating with respect to ψ and manipulating we get (ii). To prove (iii), note that

$$\frac{\partial c_t}{\partial \psi} = \frac{\delta}{\alpha}R^{1-\frac{1}{\sigma}}\left(\phi(h_t)\right)^{-1/\sigma}\left(1-\frac{\varepsilon}{\sigma}\right)\frac{\partial h_t}{\partial \psi}.$$

Also, intended bequests, savings, and period *t+1* consumption are linearly related to composite health given that $\frac{\partial h_t}{\partial h_t^p} = \alpha$. Furthermore, in the range of income and wealth such that $h_t^p \in \left[0, \hat{h}_t^p\right]$, we have

$$\frac{\partial V}{\partial \psi} = u'(c_t)\frac{\partial c_t}{\partial \psi} + \phi'(h_t)\left[u(c_{t+1}) + \theta v(b_{t+1})\right]\frac{\partial h_t}{\partial \psi} + \phi(h_t)\left[u'(c_{t+1})\frac{\partial c_{t+1}}{\partial \psi} + \theta v'(b_{t+1})\frac{\partial b_{t+1}}{\partial \psi}\right]$$

Given our assumptions about u, v, ϕ, and recognizing the linear relation of period t+1 consumption and bequests to overall health, the first term and the third term are negative if *h* is decreasing in ψ. The second term is also negative as we have assumed utility is positive, as is common in the endogenous time preference models of this nature. Therefore (iv) follows.

F. Proof of Proposition 5

Using the same steps as in Proposition 4, we can show that in the Cobb-Douglas case

$$\frac{\partial h_t^p}{\partial \psi} = -\frac{\tau \overline{W}_t\left(1 - \frac{\delta}{\alpha}\left(\frac{h_t^p}{h_t}\right)\left(\frac{\varepsilon}{\sigma}\right)R^{1-\frac{1}{\sigma}}\left(\phi(h_t)\right)^{-1/\sigma}\right)}{1 + \frac{\delta}{\alpha}\left[1 + \beta + R^{1-\frac{1}{\sigma}}\left(\phi(h_t)\right)^{-1/\sigma}\left(1 - \frac{\varepsilon}{\sigma}\right)\right]}.$$

Note that the denominator is positive since $\sigma > \varepsilon$. Therefore the sign of the above depends on the numerator, and (i) follows. Also, in the Cobb-Douglas case,

$$h_t = \left(h_t^p\right)^\alpha \left(h_t^g\right)^{1-\alpha} \Rightarrow \frac{\partial h_t}{\partial \psi} = \alpha\left(\frac{h_t^p}{h_t^g}\right)\frac{\partial h_t^p}{\partial \psi} + (1-\alpha)\left(\frac{h_t^p}{h_t^g}\right)\tau \overline{W}_t.$$

If the inequality in (i) holds and private health investment decreases as ψ increases, then overall health may be negatively or positively affected by ψ, depending on the magnitude of the second term in the above expression. Part (ii) follows from the fact that $\frac{h_t}{\frac{\partial h_t}{\partial h_t^p}} = \frac{h_t^p}{\alpha}$ in the Cobb-Douglas case, so that c_{t+1} and b_{t+1} are linear in private health investment. It is then also difficult to determine the sign of $\frac{\partial c_t}{\partial \psi} = R^{1-\frac{1}{\sigma}}(\phi(h_t))^{-1/\sigma} \frac{\delta}{\alpha}\left[\frac{\partial h_t^p}{\partial \psi} - \frac{\varepsilon}{\sigma h_t}\frac{\partial h_t}{\partial \psi}\right]$. Likewise, the sign of the indirect utility function is difficult to determine.

G. Experiment with the range of survival probabilities preserved across simulations

v	Elasticity of Substitution	$\tilde{\psi}$	Percent in favour of $\tilde{\psi}$	Preferred ψ of the poorest agent	Preferred ψ of the median agent	Preferred ψ of the richest agent
-0.99	100	0.01	100%	0.01	0.01	0.01
-0.97	33.33	0.01	96.008%	0.01	0.01	0.01
-0.95	20	0.05	55.%	0.05	0.05	0.20
-0.92	12.50	0.20	31.7365%	0.15	0.20	0.70
-0.90	10	0.25	24.9501%	0.25	0.30	1.00
-0.85	6.67	0.50	19.5609%	0.45	0.55	1.00
-0.80	5	1	27.9441%	0.55	0.70	1.00
-0.50	2	1	91.6168%	1	1	1

H. Dynamics

CASE 1: $\gamma = -.9$

Iteration	Winning	Welfare maximising	Percentage in favour	Survival probability – minimum	Survival probability – maximum	Gini
1	0.25	0.25	75.4491	0.8553	0.96	0.6358
2	0.3	0.3	97.4052	0.8072	0.96	0.5593
3	0.35	0.4	77.8443	0.7551	0.96	0.5087
4	0.45	0.5	56.0878	0.696	0.96	0.4702
5	0.6	0.6	42.515	0.6444	0.96	0.4538
6	0.85	0.75	25.1497	0.6128	0.96	0.4606
7	1	1	70.2595	0.5692	0.96	0.4789
8	0.85	1	35.7285	0.5418	0.96	0.5014
9	1	1	77.0459	0.5267	0.96	0.6008
10	0.95	0.95	46.1078	0.5128	0.96	0.5852
11	1	1	47.3054	0.5082	0.96	0.7296
12	0.85	1	35.3293	0.5014	0.96	0.8311
13	0.95	1	56.2874	0.4977	0.96	0.9927
14	1	1	56.8862	0.4936	0.781	0.9183
15	1	1	63.0739	0.4942	0.7327	--*
16	0.9	1	40.9182	0.4909	0.7175	0.9415
17	1	1	56.6866	0.4924	0.7166	0.8184
18	1	1	54.491	0.4956	0.718	0.839
19	1	1	63.2735	0.4952	0.7184	0.8397
20	1	1	52.2954	0.4953	0.7185	0.8692
21	1	1	49.1018	0.4954	0.7178	0.8603
22	1	1	62.8743	0.4954	0.7177	0.9475
23	1	1	56.0878	0.4934	0.7166	0.9451
24	0.95	1	50.6986	0.4932	0.7164	0.8877
25	1	1	61.0778	0.4939	0.7172	0.9793
26	0.95	1	38.1238	0.4922	0.7154	--*
27	0.95	1	43.1138	0.4919	0.7151	--*
28	1	1	59.2814	0.4905	0.7138	--*
29	1	1	41.517	0.4891	0.7124	--*
30	1	1	55.6886	0.4891	0.7124	--*
31	1	1	39.7206	0.4896	0.7121	0.9934
32	0.95	1	37.1257	0.492	0.7144	0.8361
33	1	1	48.1038	0.4952	0.7176	0.7928
34	0.95	0.95	64.0719	0.4965	0.7187	0.8025
35	1	1	61.8762	0.4961	0.7193	0.8402

--* Gini coefficient not defined for cases in which bequests are negative.

CASE 2: $\gamma = -.5$

Iteration	Winning	Welfare maximising	Percentage in favour	Survival probability – minimum	Survival probability – maximum	Gini
1	1	1	76.0479	0.5459	0.96	0.6003
2	1	1	91.4172	0.5592	0.96	0.4726
3	1	1	100	0.5602	0.96	0.3734
4	1	1	100	0.5524	0.96	0.2998
5	1	1	100	0.5403	0.96	0.2565
6	1	1	100	0.5261	0.96	0.2136
7	1	1	100	0.5199	0.96	0.1849
8	1	1	100	0.5074	0.96	0.1816
9	1	1	100	0.4972	0.96	0.18
10	1	1	100	0.489	0.8729	0.1832
11	1	1	100	0.4798	0.7694	0.1866
12	1	1	100	0.4722	0.6964	0.1839
13	1	1	100	0.4691	0.6511	0.1919
14	1	1	100	0.4647	0.6217	0.2
15	1	1	100	0.4619	0.6038	0.2002
16	1	1	100	0.4583	0.5909	0.2059
17	1	1	100	0.4571	0.5842	0.2016
18	1	1	100	0.457	0.5812	0.2002
19	1	1	100	0.4547	0.5754	0.2065
20	1	1	100	0.4532	0.5735	0.2088
21	1	1	100	0.4504	0.5708	0.2139
22	1	1	100	0.449	0.5686	0.2147
23	1	1	100	0.4474	0.5676	0.2165
24	1	1	100	0.4479	0.5673	0.2047
25	1	1	100	0.4489	0.5688	0.2032
26	1	1	100	0.4486	0.5692	0.2154
27	1	1	100	0.4476	0.5679	0.2079
28	1	1	100	0.4484	0.5681	0.2073
29	1	1	100	0.449	0.5687	0.2155
30	1	1	100	0.4489	0.5684	0.2192
31	1	1	100	0.447	0.5663	0.2204
32	1	1	100	0.4462	0.5652	0.2145
33	1	1	100	0.4483	0.5672	0.2107
34	1	1	100	0.4477	0.5661	0.2095
35	1	1	100	0.4464	0.5654	0.2066

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