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Inequality, Mobility and Redistributive Politics*

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Abstract

This paper develops a model where income inequality and intergenerational mobility are jointly determined via redistributive politics. The model includes two key factors: accessibility of tertiary education for poor-born agents and multiple self-fulfilling expectations of agents. Given these factors, the model provides predictions of cross-country differences in inequality and mobility consistent with empirical observations.

Keywords: Inequality; Intergenerational mobility; Redistribution; Markov perfect political equilibrium; Overlapping generations

JEL Classification: D70; H55; I38.

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1 Introduction

The extent to which economic status passes from one generation to the next is a measure of intergenerational mobility. Mobility affects income inequality within a generation through changes in the economic status of each agent. In turn, income inequality affects intergenerational mobility through changes in the incentive to invest in education. Therefore, there is a mutual link between inequality and mobility within and across generations (Hassler, Rodriguez Mora and Zeira, 2007).

Earlier studies have attempted to derive the correlation between inequality and mobility in the presence of financial constraints (Banerjee and Newman, 1993; Owen and Weil, 1998; Maoz and Moav, 1999). In these models, the constraint creates a kind of pecuniary increasing return that results in multiple equilibria, one characterized by low mobility and high inequality, and the other by high mobility and low inequality. These models also indicate a negative correlation between inequality and mobility, as shown by Davies, Zhang and Zeng (2005), who examine the role of education systems in the determination of inequality and mobility.

[Figure 1 about here.]

However, some empirical evidence shows that the negative correlation appears less than exact (Solon, 2002). As shown in Figure 1, a negative correlation is found in some OECD (Organization of Economic Cooperation and Development) countries with low mobility and high inequality, including Italy, the United Kingdom (UK) and the United States (US), while Nordic countries are characterized by high mobility and low inequality. However, despite considerable intergenerational mobility in Australia and Canada, these countries also score relatively highly on measures of cross-sectional inequality (Corak, 2006; D'Addio, 2007). This mixed evidence suggests that there is a need to develop a theory that fully explains the correlation between inequality and mobility in OECD countries.

To our knowledge, few papers discuss these cross-country differences. An exception is Hassler, Rodriguez Mora and Zeira (2007), who demonstrate two opposing effects: the first effect is via the education sector, which produces the negative correlation; and the second effect is via the production sector, which creates the positive correlation. We can use these opposing effects to demonstrate the properties of inequality and mobility in the above-mentioned OECD countries.[1]

[1]The effects of changes in the production and education sectors in Hassler, Rodriguez Mora and Zeira (2007) are as follows. Changes in the production sector, such as skill-biased technological changes, affect the return to factors of production and thus impact on inequality between the skilled and the unskilled. Increased inequality implies an incentive for the gains from education and thus strengthens the incentive

Although Hassler, Rodriguez Mora and Zeira (2007) contribute to explaining cross-country differences in inequality and mobility, the following two issues remain unresolved. First, the link between inequality and mobility via redistributive politics, which is an important policy issue in many OECD countries, is not included in their model. Second, they measure inequality with the wage gap rather than the Gini coefficient (which is affected by redistribution). Therefore, the question arises as to how inequality and mobility are determined via redistributive politics within and across generations when inequality is measured by the Gini coefficient in terms of after-tax-and-transfer income. The purpose of the current paper is to present a model that responds to this challenge.[2]

For the purpose of our analysis, we employ the political economy redistribution model in Hassler, Storesletten and Zilibotti (2007). We extend this model by introducing intergenerational mobility whereby poor-born agents have a chance of becoming rich via educational investment, and rich-born agents have a risk of becoming poor if they fail in education. Furthermore, although poor-born agents have some opportunity for upward mobility, they have disadvantages in terms of opportunities and the costs of education relative to rich-born agents. When greater accessibility is ensured for poor-born agents, the economy attains higher mobility and lower inequality. The parameter representing accessibility of education is the first key factor that accounts for cross-country differences in inequality and mobility.

The second key factor is the multiple self-fulfilling expectations of agents (Hassler, Storesletten and Zilibotti, 2007). In undertaking educational investment, young agents have expectations of redistributive policies in their old age. When young agents hold the expectation of greater redistribution, it provides a disincentive to engage in educational investment, thereby resulting in a lower proportion of the rich. This implies a greater number of low-income young individuals, which in turn increases future demand for redistribution. The opposite mechanism applies when young agents have the expectation of lower redistribution in old age. Therefore, the economy may attain multiple equilibria, including a rich-majority and a poor-majority equilibrium. The outcome depends on the

to invest in education, which increases mobility. By contrast, changes in the education sector increase access to education and thus increase mobility. This reduces the number of poor, unskilled workers, which reduces inequality. Hassler, Rodriguez Mora and Zeira (2007) show that when the education sector effect is larger (smaller) than the production sector effect, the economy displays a negative (positive) correlation between inequality and mobility.

[2] In addition to Hassler, Rodriguez Mora and Zeira (2007), Bernasconi and Profeta (2007) and Ichino, Karabarbounis and Moretti (2009) undertake analyses of intergenerational mobility and inequality. However, Bernasconi and Profeta (2007) focus on the dynamic motion of intergenerational mobility, and there is no consideration of cross-country differences. By contrast, Ichino, Karabarbounis and Moretti (2009) introduce political institutions into the Becker and Tomes (1979) framework of intergenerational mobility and show that two societies with similar economic backgrounds may display different levels of intergenerational mobility depending on their political institutions. However, the cross-country differences in income inequality and mobility are abstracted from their analysis; their focus is on public education rather than income redistribution.

expectations of agents.

We can explain the cross-country differences in inequality and mobility using these two key factors. The first key factor, accessibility of education, creates a negative correlation between inequality and mobility. In the poor-majority equilibrium, greater accessibility of education gives poor-born individuals an incentive to invest in education, thereby resulting in higher mobility and lower inequality. This prediction fits the empirical evidence of at least some countries, where Italy, the UK and the US are low-accessibility economies, and Nordic countries are high-accessibility economies (Schütz, Ursprung and Wößmann, 2008; OECD, 2008a)

The rich-majority equilibrium emerges when accessibility lies beyond a critical level. That is, given greater accessibility of education, the political economy achieves multiple political equilibria. The rich-majority equilibrium attains greater inequality than the poor-majority equilibrium (representing Nordic countries) because the former features lower redistribution as supported by the rich. However, both equilibria attain higher mobility and lower inequality compared with the poor-majority equilibrium with low accessibility (as represented by Italy, the UK and the US). Therefore, in our model economy, Australia and Canada can be interpreted as representing the rich-majority equilibrium.

Our analysis also contributes to the literature on multiple equilibria in inequality and mobility (Banerjee and Newman, 1993; Owen and Weil, 1998; Maoz and Moav, 1999; Mookherjee and Napel, 2007). Extant models show that initial conditions matter for the determination of the long-run steady state. By contrast, our paper shows that the expectations of agents as well as the initial conditions matter. In particular, we demonstrate that: (i) two economies sharing the same initial conditions could converge to different equilibria in the long run because the state of the economy depends on the expectations of agents; and (ii) without any structural change, an economy at one of the equilibria may move to the other because of changes in the expectations of agents. These results help provide an explanation for why developed countries sharing similar backgrounds attain different inequality and mobility over time, and why a country experiences changes in inequality and mobility over time, even though its economic structure has changed little.

Apart from this body of work, the current analysis also relates to the literature on inequality and redistributive politics (Fernandez and Rogerson, 1995; Piketty, 1995; Hassler et al., 2003; Hassler, Storesletten and Zilibotti, 2007; Ono and Arawatari, 2008; Arawatari and Ono, 2008, 2009). In these studies, the following issues are abstracted from the analysis: a mutual link between inequality and mobility (Fernandez and Rogerson, 1995), dynamic aspects of inequality and mobility (Piketty, 1995), and intergenerational mobility (Hassler et al., 2003; Hassler, Storesletten and Zilibotti, 2007; Ono and Arawatari, 2008, 2009). Our previous work (Arawatari and Ono, 2008, 2009) demonstrates mobility using the framework in Hassler, Storesletten and Zilibotti (2007). However, the focus there is on earning mobility over the life cycle. By contrast, the current paper presents the dynamic aspects of the correlation between intergenerational mobility and inequality affected by redistributive politics.

The organization of the paper is as follows. Section 2 develops the model. Section 3 focuses on some period t and provides the characterization of the period$-t$ political equilibrium. Section 4 characterizes the dynamic political equilibrium defined as a sequence of period$-t$ political equilibriums. Using the characterization of political equilibrium in Sections 3 and 4, Section 5 focuses on the steady state and demonstrates how the accessibility of education affects inequality, mobility and redistribution. Section 6 provides empirical implications of the numerical result. Section 7 provides some concluding remarks.

2 The Model

The model is a two-period overlapping-generations model based on Hassler, Storesletten and Zilibotti (2007). Time is discrete and denoted by $t = 0, 1, 2, \cdots$. The economy consists of a continuum of agents living for two periods, youth and old age. Each generation has a unit mass. The main departure from the model in Hassler, Storesletten and Zilibotti (2007) is that agents are heterogeneous at birth. Some are born into poor families, while others are born into rich families. Poor-born agents have the chance of becoming rich via educational investment, while rich-born agents face the risk of becoming poor if they fail in education. Therefore, there is intergenerational mobility in this economy.

Let u_t denote the size of the old poor in period t. Among the young born in period t, u_t are born into poor families and $1 - u_t$ into rich families. Young agents can affect their prospects in life using educational investment. Those who are successful in education become rich, and obtain a high wage, normalized to one, for both periods. Those who are unsuccessful in education become poor and obtain a low wage, normalized to zero, for both periods. Figure 2 illustrates the timing of events and the distribution of rich and poor across the generations.

[Figure 2 about here.]

The opportunities for, and costs of, education depend on the status of the families into which agents are born. Let e_t^r and e_t^p denote the probabilities of educational success (i.e., becoming rich) for rich-born and poor-born agents, respectively. Those who are born into rich families have full access to education and can increase the probability e_t^r of remaining rich by undertaking costly investment with the cost function $(e_t^r)^2$. However, those who are born into poor families have limited access to education. With probability $1 - \mu \in [0, 1]$, they have no opportunity of education. With probability μ, they have an opportunity, but the cost of education is given by $\gamma \cdot (e_t^p)$ where $\gamma > 1$. This assumption implies that the educational cost for the poor-born young is higher than for the rich-born young. Therefore, poor-born young agents have a disadvantage in terms of opportunities and costs.

The assumption of γ and μ is motivated by the following observations. Hassler and Rodriguez Mora (2000) and Roemer (2004) argue that the distribution of innate and social assets among individuals is not independent between generations and that parents affect their children's chances for acquisition of income through innate and social heritage. For example, rich-born children can achieve a high score with low costs thanks to their high innate ability received from their parents. In addition, they can apply promising strategies for success thanks to precise information given by their educated parents. In our framework, an intergenerational heritage of innate and social assets is captured by the parameter γ, which represents the difference in costs of education for skill acquisition.

Empirical evidence suggests that the above-mentioned family background effects differ across countries (OECD, 2008). The difference comes from the variation in equality of opportunities related to school systems like early tracking and preschool education (Schütz, Ursprung and Wößmann, 2008). Based on the two international student achievement tests, the Third International Mathematics and Science Study (TIMSS) and its replication for a partly different set of countries (TIMSS-repeat), Schütz, Ursprung and Wößmann (2008) show that the family-background effect is larger (i.e., equality of opportunity is lower) the earlier a country tracks its students into different school types of ability and the shorter is the preschool education. In our framework, equality of opportunity is captured by the parameter μ, which demonstrates the degree of accessibility to education for the poor-born children.[3]

The numbers of agents who experience upward and downward mobility are given by $M_t^{up} = u_t \mu e_t^p$ and $M_t^{down} = (1 - u_t)(1 - e_t^r)$, respectively. The poor-born agents of size u_t have the opportunity of education with probability μ, and they succeed in education and become rich with a probability of e_t^p. The rich-born agents of size $1 - u_t$ fail in education and become poor with a probability of $1 - e_t^r$. Because the size of each generation is unity, M_t^{up} and M_t^{down} also indicate the proportions of agents experiencing upward and

[3]It should be noted that the current paper abstracts from the pecuniary link between the budgetary constraints of parents and the educational investments of children. Instead, the paper focuses on the nonpecuniary link between parents and children in terms of education acquisition. The reason behind the focus on the nonpecuniary link is twofold. First, the nonpecuniary link plays an important role in determination of educational acquisition as shown by Schütz, Ursprung and Wößmann (2008) and OECD (2008a). Second, the long-run state becomes dependent on initial conditions when the pecuniary link is introduced into the model (see, for example, Banerjee and Newman, 1993; Owen and Weil, 1998; and Maoz and Moav, 1999). In other words, two economies sharing similar initial conditions converge to the same equilibrium. This prediction fails to explain the variation in inequality and mobility among some OECD countries sharing similar economic backgrounds.

downward mobility, respectively.

There is no storage technology in this economy. Each agent uses his/her endowments within the period. The government provides lump-sum transfers, s, financed by taxes levied on the rich. The tax rates are age dependent, τ^o for the old and τ^y for the young. The tax rates are also determined before the young agents decide on their investments. Therefore, the expected utility functions of agents alive at time t are given as follows:

$$V_t^{o,r} = (1-\tau_t^o) + s_t, \tag{1}$$
$$V_t^{o,p} = s_t, \tag{2}$$
$$V_t^{y,r} = e_t^r \cdot (1-\tau_t^y) - (e_t^r)^2 + s_t + \beta \cdot \left\{ e_t^r \cdot (1-\tau_{t+1}^o) + s_{t+1} \right\}, \tag{3}$$
$$V_t^{y,p} = \mu \cdot \left\{ e_t^p \cdot (1-\tau_t^y) - \gamma \cdot (e_t^p)^2 \right\} + s_t + \beta \cdot \left\{ \mu \cdot e_t^p \cdot (1-\tau_{t+1}^o) + s_{t+1} \right\}, \tag{4}$$

where $V_t^{o,r}$, $V_t^{o,p}$, $V_t^{y,r}$ and $V_t^{y,p}$ denote the utility of the old rich and the old poor, and the expected utility of the young born into rich families and the young born into poor families, respectively, and the parameter $\beta \in (0,1)$ is a discount factor. The utility levels of $V_t^{o,r}$, $V_t^{o,p}$, $V_t^{y,r}$ and $V_t^{y,p}$ are computed prior to the success or failure of individuals.

Given these preferences, a young agent born into a rich family chooses e_t^r to maximize $V_t^{y,r}$, and a young agent born into a poor family chooses e_t^p to maximize $V_t^{y,p}$. Therefore, the optimal investment of the rich-born and poor-born young agents are respectively given by:

$$e^{r*}(\tau_t^y, \tau_{t+1}^o) = \frac{1}{2} \cdot \left\{ (1-\tau_t^y) + \beta \cdot (1-\tau_{t+1}^o) \right\},$$
$$e^{p*}(\tau_t^y, \tau_{t+1}^o) = \frac{1}{2\gamma} \cdot \left\{ (1-\tau_t^y) + \beta \cdot (1-\tau_{t+1}^o) \right\}.$$

Given the assumption of $\gamma > 1$, it holds that $0 \leq e^{p*}(\tau_t^y, \tau_{t+1}^o) < e^{r*}(\tau_t^y, \tau_{t+1}^o) \leq 1$, $\forall\ \tau_t^y, \tau_{t+1}^o \in [0,1]$.

Agents with the same family background choose the same investment, implying that the proportion of the old poor in period $t+1, u_{t+1}$, is given by:

$$\begin{aligned} u_{t+1} &\equiv (1-u_t) \cdot \left(1 - e^{r*}(\tau_t^y, \tau_{t+1}^o)\right) + u_t \cdot \left\{ \mu \cdot \left(1 - e^{p*}(\tau_t^y, \tau_{t+1}^o)\right) + (1-\mu) \right\} \\ &= 1 - \frac{1}{2} \cdot \left\{ (1-u_t) + \frac{\mu}{\gamma} \cdot u_t \right\} \cdot \left\{ (1-\tau_t^y) + \beta \cdot (1-\tau_{t+1}^o) \right\}. \end{aligned} \tag{5}$$

Thus, the proportion of old poor (i.e., the proportion of agents who were unsuccessful in their youth), u_{t+1}, depends on the tax levied on the rich young agents in period t, τ_t^y, the tax levied on the old rich agents in period $t+1$, τ_{t+1}^o, and the proportion of old poor, u_t.

The tax revenues from rich agents are transferred to every agent in a lump-sum fashion.

The government budget is balanced in each period so that it can be expressed as:

$$2s_t = W(\tau_t^o, u_t) + Z(\tau_t^y, \tau_{t+1}^o, u_t),$$

where:

$$W(\tau_t^o, u_t) \equiv (1-u_t)\cdot\tau_t^o \text{ and}$$
$$Z(\tau_t^y, \tau_{t+1}^o, u_t) \equiv \left\{(1-u_t)\cdot e^{r*}(\tau_t^y, \tau_{t+1}^o) + u_t\cdot\mu\cdot e^{p*}(\tau_t^y, \tau_{t+1}^o)\right\}\cdot\tau_t^y$$

are the tax revenues financed by the old rich and the young rich, respectively. The function Z, representing tax revenue from the young rich, is rewritten as:

$$Z(\tau_t^y, \tau_{t+1}^o, u_t) = \frac{1}{2}\cdot\left\{(1-u_t) + u_t\cdot\frac{\mu}{\gamma}\right\}\cdot\widetilde{Z}(\tau_t^y, \tau_{t+1}^o), \tag{6}$$

where:

$$\widetilde{Z}(\tau_t^y, \tau_{t+1}^o) \equiv \left\{(1-\tau_t^y) + \beta\cdot(1-\tau_{t+1}^o)\right\}\cdot\tau_t^y.$$

Equation (6) implies that, given the state variable u_t, maximizing the revenue from the young $Z(\tau_t^y, \tau_{t+1}^o, u_t)$ is equivalent to maximizing $\widetilde{Z}(\tau_t^y, \tau_{t+1}^o)$.

3 Period-t Political Equilibrium

This section considers the determination of redistribution policy and the distribution of rich and poor in some period t. Section 3.1 provides the definition of a period-t political equilibrium based on the concept of a stationary Markov-perfect equilibrium with majority voting. Sections 3.2 and 3.3 characterize the period-t political equilibrium by focusing on the pattern of taxation and the distribution of rich and poor. The dynamic equilibrium sequence of redistribution and the distribution of rich and poor are analyzed in the following section.

3.1 Definition of Period-t Political Equilibrium

Following Hassler, Storesletten and Zilibotti (2007), we assume that elections are held at the end of each period and the elected politician sets tax rates for the following period. The old have no interest in the following period's tax rates and thus abstain from voting. At the end of each period, the young know their wage realization in the following period. Therefore, this assumption of voting is observationally equivalent to assuming that agents vote over current taxes at the beginning of each period but that only the old vote (Hassler et al., 2003; Hassler, Storesletten and Zilibotti, 2007). We employ the latter interpretation in the following analysis.

With the optimal investments $e^{r*}(\tau_t^y, \tau_{t+1}^o)$ and $e^{p*}(\tau_t^y, \tau_{t+1}^o)$ and the government budget constraint, the indirect utility functions of the old rich and the old poor are respectively given by:

$$V_t^{o,r} = (1-\tau_t^o) + \frac{1}{2} \cdot \left(W(\tau_t^o, u_t) + \frac{1}{2} \cdot \left\{ (1-u_t) + u_t \cdot \frac{\mu}{\gamma} \right\} \cdot \widetilde{Z}(\tau_t^y, \tau_{t+1}^o) \right),$$
$$V_t^{o,p} = \frac{1}{2} \cdot \left(W(\tau_t^o, u_t) + \frac{1}{2} \cdot \left\{ (1-u_t) + u_t \cdot \frac{\mu}{\gamma} \right\} \cdot \widetilde{Z}(\tau_t^y, \tau_{t+1}^o) \right),$$

where the term in the first line, $(1-\tau_t^o)$, is the after-tax income of the old rich, and the term $(1/2) \cdot \left(W + (1/2) \cdot \{(1-u_t) + u_t \cdot (\mu/\gamma)\} \cdot \widetilde{Z} \right)$ is the lump-sum transfer.

The present paper focuses on stationary Markov-perfect equilibria with majority voting. The proportion of old poor (u_t) summarizes the state of the economy, and the identity of a decisive voter depends on this proportion. An office-seeking politician elected by voters sets policies to maximize the utility of the larger group. Given these features, we provide the definition of the period-t political equilibrium as follows.

Definition 1: A *period-t (stationary) Markov-perfect political equilibrium* is a triplet of functions $\{T^o, T^y, U\}$, where $T^o : [0,1] \to [0,1]$ and T^y are two public policy rules, $\tau_t^o = T^o(u_t)$ and $\tau_t^y = T^y$, and $U : [0,1] \to [0,1]$ is a private decision rule, $u_{t+1} = U(\tau_t^y)$, such that given u_t, the following functional equations hold.

1. $T^o(u_t) = \arg\max_{\tau_t^o \in [0,1]} W^{dec}(\tau_t^o, u_t)$ $(dec = o, r;\ o, p)$, where:

$$W^{dec}(\tau_t^o, u_t) = \begin{cases} W^{o,r} \equiv (1-\tau_t^o) + \frac{1}{2} \cdot W(\tau_t^o, u_t) & \text{if } u_t \leq 1/2, \\ W^{o,p} \equiv \frac{1}{2} \cdot W(\tau_t^o, u_t) & \text{if } u_t > 1/2. \end{cases}$$

2. $U(\tau_t^y, u_t) = (1-u_t) \cdot \left(1 - e^{r*}(\tau_t^y, \tau_{t+1}^o)\right) + u_t \cdot \left\{ \mu \cdot \left(1 - e^{p*}(\tau_t^y, \tau_{t+1}^o)\right) + (1-\mu) \right\},$
   with $\tau_{t+1}^o = T^o(U(\tau_t^y))$.

3. $T^y = \arg\max_{\tau_t^o \in [0,1]} \widetilde{Z}(\tau_t^y, \tau_{t+1}^o)$ subject to $\tau_{t+1}^o = T^o(U(\tau_t^y, u_t))$.

The first equilibrium condition requires the decisive voter to choose τ_t^o to maximize the utility of the old rich if $u_t < 1/2$ and the utility of the old poor if $u_t > 1/2$. In the case of an equal number, the old rich are assumed to be decisive. The second equilibrium condition implies that all young individuals optimally choose their investments given τ_t^y and τ_{t+1}^o, under rational expectations about future taxes and distributions of types. The third equilibrium condition requires the decisive old voter to choose τ_t^y to maximize revenue from the young. Rational voters also understand that their choice over current redistribution affects future redistribution via the private decision rule and public policy.

3.2 The Determination of T^o and U

We solve the equilibrium conditions recursively. Condition 1 defines a one-to-one mapping from the state variable to the equilibrium choice of taxation of the old: $\tau_t^o = T^o(u_t)$. Suppose that the majority are the old rich: $u_t \leq 1/2$. The objective function of the majority is given by $W^{o,r} = (1-\tau_t^o) + W(\tau_t^o, u_t)/2$, which is strictly decreasing in τ_t^o: $\partial W^{o,r}(\tau_t^o, u_t)/\partial \tau_t^o < 0$. This implies that the old rich pay more than they receive because poor agents pay no tax, but the revenue is distributed equally between the rich and the poor. Therefore, the old rich prefer $\tau_t^o = 0$.

Alternatively, suppose that the majority are the old poor: $u_t > 1/2$. The objective function of the majority is given by $W^{o,p} = W(\tau_t^o, u_t)/2$, which is strictly increasing in τ_t^o: $\partial W^{o,p}(\tau_t^o, u_t)/\partial \tau_t^o > 0$. Therefore, the old poor prefer $\tau_t^o = 1$. The mapping that satisfies equilibrium condition 1 is summarized as follows:

$$T^o(u_t) = \begin{cases} 0 & \text{if } u_t \leq 1/2, \\ 1 & \text{if } u_t > 1/2. \end{cases} \tag{7}$$

Next, we rewrite equilibrium condition 2 by substituting it into the optimal investments $e^{r*}(\tau_t^y, \tau_{t+1}^o)$ and $e^{p*}(\tau_t^y, \tau_{t+1}^o)$. This yields the following functional equation:

$$U(\tau_t^y, u_t) = 1 - \frac{1}{2} \cdot \left\{(1-u_t) + \frac{\mu}{\gamma} \cdot u_t\right\} \cdot \{(1-\tau_t^y) + \beta \cdot (1 - T^o(U(\tau_t^y, u_t)))\}, \tag{8}$$

where $T^o(\cdot) \in \{0,1\}$ is given by (7). Because $T^o(\cdot) \in \{0,1\}$, any solution of (8) must be a combination of the following two linear functions:

$$\begin{cases} U^p(\tau_t^y, u_t) \equiv 1 - \frac{1}{2} \cdot \left((1-u_t) + \frac{\mu}{\gamma} \cdot u_t\right) \cdot (1-\tau_t^y), \\ U^r(\tau_t^y, u_t) \equiv 1 - \frac{1}{2} \cdot \left((1-u_t) + \frac{\mu}{\gamma} \cdot u_t\right) \cdot (1-\tau_t^y + \beta), \end{cases}$$

where $U^p(\tau_t^y, u_t)$ is the proportion of the old poor when $\tau_{t+1}^o = 1$ is expected, and $U^r(\tau_t^y, u_t)$ is the proportion of the old poor when $\tau_{t+1}^o = 0$ is expected.

Under the assumption of rational expectations, any solution to the functional equation (8) must be such that:

$$U(\tau_t^y, u_t) = \begin{cases} \{U^p(\tau_t^y, u_t), U^r(\tau_t^y, u_t)\} & \text{for } \tau_t^y \leq \hat{\tau}^y(u_t), \\ U^p(\tau_t^y, u_t) & \text{for } \tau_t^y > \hat{\tau}^y(u_t), \end{cases} \tag{9}$$

where $\hat{\tau}^y(u_t)$ is given by:

$$\hat{\tau}^y(u_t) \equiv \frac{\left\{(1-u_t) + \frac{\mu}{\gamma} \cdot u_t\right\} \cdot (1+\beta) - 1}{(1-u_t) + \frac{\mu}{\gamma} \cdot u_t}.$$

The process of deriving the solution (9) is as follows. Suppose that young agents in period t expect $\tau_{t+1}^o = 0$. With this expectation, educational investments by the rich-born young and the poor-born young are $e^{r*}(\tau_t^y, 0) = \{1 - \tau_t^y + \beta\}/2$ and $e^{p*}(\tau_t^y, 0) = \{1 - \tau_t^y + \beta\}/2\gamma$, respectively, and the size of the old poor in period $t+1$ is $u_{t+1} = U^r(\tau_t^y, u_t)$. By (7), the expectation of $\tau_{t+1}^o = 0$ is rational if $u_{t+1} = U^r(\tau_t^y, u_t) \leq 1/2$, that is, if $\tau_t^y \leq \hat{\tau}^y(u_t)$. Suppose, instead, that young agents born in period t expect $\tau_{t+1}^o = 1$. By (7), this expectation is rational if $u_{t+1} = U^p(\tau_t^y, u_t) > 1/2$. The expectation is rational for any $\tau_t^y \in [0,1]$ and $u_t \in [0,1]$ because it always holds that $u_{t+1} = U^p(\tau_t^y, u_t) > 1/2$. Consequently, there are multiple solutions for the range of $\tau_t^y \leq \hat{\tau}^y(u_t)$ as long as $\hat{\tau}^y(u_t) \geq 0$ holds. $\hat{\tau}^y(u_t) \geq 0$ holds if $\mu/\gamma \geq 1/(1+\beta)$, or, if $\mu/\gamma < 1/(1+\beta)$ and $u_t \in [0, \beta/(1+\beta)(1-\mu/\gamma)]$.[4]

[Figure 3 about here.]

As depicted in Figure 3, there are multiple, self-fulfilling expectations of U for the range of $\tau_t^y \in [0, \hat{\tau}^y(u_t)]$. Which particular U arises in equilibrium depends on the expectations of agents. To illustrate U in equilibrium, we follow Hassler, Storesletten and Zilibotti (2007) and introduce the critical rate of τ_t^y: $\theta \in [0, \hat{\tau}_t^y(u_t)]$. The rate θ, which depends on the expectations of agents, is the highest tax rate that yields a majority of the old rich. For $\tau_t^y > \theta$, the majority is the old poor. However, for $\tau_t^y \in (0, \theta]$, the majority is either the rich or the poor.

With the expectation parameter θ, the functional solution is reduced as follows. If $\mu/\gamma < 1/(1+\beta)$ and $u_t \in (\beta/(1+\beta)(1-\mu/\gamma), 1]$, then $\hat{\tau}^y(u_t) < 0$ holds. The solution to (8) is uniquely given by $U(\tau_t^y, u_t) = U^p(\tau_t^y, u_t)$ (Fig. 3(a)). If $\mu/\gamma \geq 1/(1+\beta)$, or if $\mu/\gamma < 1/(1+\beta)$ and $u_t \in [0, \beta/(1+\beta)(1-\mu/\gamma)]$, then $\hat{\tau}^y(u_t) \geq 0$ holds (Fig. 3(b)). The solution is given by:

$$U(\tau_t^y, u_t) = \begin{cases} \{U^p(\tau_t^y, u_t), U^r(\tau_t^y, u_t)\} & \text{if } \tau_t^y \in (0, \theta] \\ U^p(\tau_t^y, u_t) & \text{if } \tau_t^y \in (\theta, 1]. \end{cases}$$

[4] $\hat{\tau}^y(u_t) \geq 0$ is rewritten as $u_t \leq \beta/(1-\mu/\gamma)(1+\beta)$. This condition of u_t holds $\forall u_t \in [0,1]$ if $\beta/(1-\mu/\gamma)(1+\beta) \geq 1$, that is, if $\mu/\gamma \geq 1/(1+\beta)$. If $\mu/\gamma < 1/(1+\beta)$, then $\hat{\tau}^y(u_t) \geq 0$ holds for $u_t \in [0, \beta/(1-\mu/\gamma)(1+\beta)]$.

The functional solution is therefore summarized as follows:

$$U(\tau_t^y, u_t) = \begin{cases} U^p(\tau_t^y, u_t) & \text{if } \frac{\mu}{\gamma} < \frac{1}{1+\beta} \text{ and } u_t \in \left(\frac{\beta}{(1+\beta)(1-\mu/\gamma)}, 1\right] \\ \begin{cases} \{U^p(\tau_t^y, u_t), U^r(\tau_t^y, u_t)\} & \text{for } \tau_t^y \in (0, \theta] \\ U^p(\tau_t^y, u_t) & \text{for } \tau_t^y \in (\theta, 1] \end{cases} & \text{otherwise.} \end{cases} \tag{10}$$

3.3 The Determination of T^y and the Characterization of the Period$-t$ Political Equilibria

Given the characterization of T^o and U satisfying equilibrium conditions 1 and 2, respectively, we consider the political determination of τ_t^y that satisfies equilibrium condition 3. Because there are two possible cases of a majority, we introduce the corresponding definition of the political equilibria: a *poor-majority equilibrium* and a *rich-majority equilibrium*. When $u_t > 1/2$, there is a poor-majority equilibrium where agents expect $\tau_{t+1}^o = 1$ and choose τ_t^y to induce a majority of the poor in period $t+1$. When $u_t \leq 1/2$, there is a rich-majority equilibrium where agents expect $\tau_{t+1}^o = 0$ and choose τ_t^y to induce a majority of the rich in period $t+1$.

The objective of the decisive voter is to choose the τ_t^y that maximizes revenue from the young Z. Given the state variable u_t, maximizing Z is equivalent to maximizing $\tilde{Z}$ as presented in (6). Therefore, the objective function of the decisive voter is given by $\tilde{Z}(\tau_t^y, 1)$ if agents expect $\tau_{t+1}^o = 1$, and is given by $\tilde{Z}(\tau_t^y, 0)$ if agents expect $\tau_{t+1}^o = 0$. These two objective functions demonstrate Laffer curves with the following properties: (i) $\tilde{Z}(\tau_t^y, 1)$ is a hump-shaped function of τ_t^y, with a maximum at $\tau_t^y = 1/2$; (ii) $\tilde{Z}(\tau_t^y, 0)$ is a hump-shaped function of τ_t^y, with a maximum at $\tau_t^y = (1+\beta)/2$; (iii) $\tilde{Z}(\tau_t^y, 0) > \tilde{Z}(\tau_t^y, 1)\ \forall \tau_t^y \in (0, 1]$ (see Figure 4).

[Figure 4 about here.]

The properties of the objective functions imply that the decisive voter may maximize revenue from the young by taking the top of the Laffer curve $\tilde{Z}(\tau_t^y, 0)$; i.e., by setting $\tau_t^y = (1+\beta)/2$ under the expectation of $\tau_{t+1}^o = 0$. However, this choice is inconsistent with the second equilibrium condition because the choice of τ_t^y is limited to the range of $(0, \theta]$ where $\theta \leq \hat{\tau}^y(u_t) < (1+\beta)/2$. By contrast, the decisive voter can take the top of the other Laffer curve $\tilde{Z}(\tau_t^y, 1)$ by setting $\tau_t^y = 1/2$ under the expectation that $\tau_{t+1}^o = 1$ is consistent with the second equilibrium condition. Therefore, the revenue from the young is maximized by setting $\tau_t^y = \theta$ under the expectation of $\tau_{t+1}^o = 0$, or by setting $\tau_t^y = 1/2$ under the expectation of $\tau_{t+1}^o = 1$. The former choice produces a higher level of revenue than the latter if and only if $\widetilde{Z}(\theta, 0) \geq \widetilde{Z}(1/2, 1)$; that is, if and only if $\theta \geq \widetilde{\theta}$, where:

$$\widetilde{\theta}(\beta) = \frac{(1+\beta) - \sqrt{\beta(\beta+2)}}{2} > 0.$$

Given u_t and $\widetilde{\theta}(\beta)$, we obtain the following characterization of the period-t political equilibria.

Proposition 1

(i) *For any* $u_t \in [0, 1]$, *there exists a set of poor-majority equilibria such that* $\forall t$, T^o *is given by* (7), $U(\tau_t^y, u_t)$ *is given by* (10), *and* $T^y = 1/2$. *The equilibrium outcome is unique and such that* $\forall t$, $\tau_t^y = 1/2$, $\tau_{t+1}^o = 1$, *and* $u_{t+1} = 1 - ((1-u_t) + (\mu/\gamma) \cdot u_t)/4$.

(ii) *Suppose that* $\beta \geq 1/4$ *and* $u_t \in [0, \hat{u}]$ *hold where:*

$$\hat{u} \equiv \frac{\left\{\sqrt{\beta(\beta+2)} - (1-\beta)\right\}}{(1-\mu/\gamma)\left\{(1+\beta) + \sqrt{\beta(\beta+2)}\right\}}.$$

There exists a set of rich-majority equilibria such that $\forall t$, T^o *is given by* (7), $U(\tau_t^y, u_t)$ *is given by* (10), *and* $T^y = \theta \in [\widetilde{\theta}(\beta), \hat{\tau}^y(u_t)]$. *The equilibrium outcome is indeterminate such that* $\forall t$, $\tau_t^y = \theta \in [\widetilde{\theta}(\beta), \hat{\tau}^y(u_t)]$, $\tau_{t+1}^o = 0$, *and* $u_{t+1} = 1 - \{(1-u_t) + (\mu/\gamma) \cdot u_t\}(1-\theta+\beta)/2$.

Proof. See the appendix.

[Figure 5 about here.]

Figure 5 indicates the set of (β, u_t) satisfying the condition given in Proposition 1. When the size of poor-born agents is large such that $u_t > \hat{u}$ (see the area P.1(i)), a unique poor-majority equilibrium exists. Although the poor-born agents have the chance of becoming rich via educational investment, the rich can never become a majority in period t because the number of poor-born agents is large. Therefore, when $u_t > \hat{u}$ holds, voting that induces a future majority of the poor is the only option. The economy then features a unique equilibrium with a poor majority who prefer 100% taxation on the old. The young are taxed at the top of the Laffer curve, conditional on the expectation of 100% taxation when old.

When the size of poor-born agents is small, such that $u_t \leq \hat{u}$ (see the area P.1(i)&(ii)), there is still an option that induces a future majority of the poor. However, there is an alternative option that induces a future majority of the rich by setting $\tau_t^y = \theta$. The equilibrium realized depends on the expectation of agents. The rich-majority equilibrium is sustained as an equilibrium if $Z(\theta,0) \geq Z(1//2,1)$; that is, if the expectation parameter θ is above the critical level $\widetilde{\theta}(\beta)$. Given that the upper bound of θ is $\hat{\tau}^y(u_t)$, there exists a rich-majority equilibrium if θ is set within the range $[\widetilde{\theta}(\beta), \hat{\tau}^y(u_t)]$. This set is nonempty if and only if $u_t \leq \hat{u}$, where $\hat{u}$ is nonnegative if and only if $\beta \geq 1/4$.

As illustrated in Figure 5, the condition given in Proposition 1(ii) requires a high β and a low u_t. A high β implies that agents attach a high weight to their utility in their old age, thereby having a strong incentive to invest in education. This results in a large number of the old who have been successful in their youth. A low u_t indicates a large number of rich-born young agents, thereby implying a large number of future rich agents. Given these two factors, the economy can attain a rich-majority equilibrium when agents expect no taxation on the old.

4 Dynamic Political Equilibrium

This section investigates the motion of the distribution of rich and poor over time. The definition of the dynamic political equilibrium is as follows.

Definition 2: A *dynamic political equilibrium* is a sequence of u_t with the initial condition u_0 such that (i) (τ_t^y, τ_{t+1}^o) constitutes the period-t political equilibrium; and (ii) the sequence of u_t is determined by $u_{t+1} = (1-u_t)\cdot\left(1-e^{r*}(\tau_t^y,\tau_{t+1}^o)\right) + u_t \cdot \left\{\mu\cdot\left(1-e^{p*}(\tau_t^y,\tau_{t+1}^o)\right) + (1-\mu)\right\}$.

Based on the characterization of the period-t political equilibrium in Proposition 1, a sequence of u_t is characterized by:

$$u_{t+1} = \begin{cases} \{U^p(1/2,u_t), U^r(\theta,u_t)\} & \text{if } \beta \geq 1/4 \text{ and } u_t \leq \hat{u}, \\ U^p(1/2,u_t) & \text{otherwise,} \end{cases} \tag{11}$$

where:

$$\begin{cases} U^p\left(\frac{1}{2},u_t\right) = 1 - \frac{1}{4}\left\{(1-u_t) + \frac{\mu}{\gamma}\cdot u_t\right\}, \\ U^r(\theta,u_t) = 1 - \frac{1}{2}\left\{(1-u_t) + \frac{\mu}{\gamma}\cdot u_t\right\}(1-\theta+\beta). \end{cases}$$

Suppose that $\beta \geq 1/4$ and $u_t \leq \hat{u}$ hold. There are multiple period-t political equilibria with $(\tau_t^y,\tau_{t+1}^o) = (1/2,1)$ and $(\theta,0)$. The economy attains a poor-majority equilibrium with $\tau_t^y = 1/2$ and $u_{t+1} = U^p(1/2,u_t) > 1/2$ when agents expect $\tau_{t+1}^o = 1$, and a rich-majority equilibrium with $\tau_t^y = \theta$ and $u_{t+1} = U^r(\theta,u_t) \leq 1/2$ when agents expect $\tau_{t+1}^o = 0$. Suppose, instead, that $\beta \geq 1/4$ or $u_t \leq \hat{u}$ fails to hold. There is a unique period-t equilibrium with $(\tau_t^y,\tau_{t+1}^o) = (1/2,1)$, and u_{t+1} is uniquely given by $U^p(1/2,u_t)$.

For precise consideration of the dynamic motion of u_t, we illustrate (11) in a $u_t - u_{t+1}$ space. For this purpose, we present the properties of the functions $U^p(1/2,u_t)$ and

$U^r(\theta, u_t)$ as follows:

$$
\begin{aligned}
U^p\left(\frac{1}{2}, 0\right) &= \frac{3}{4}, \quad U^p\left(\frac{1}{2}, 1\right) = 1 - \frac{\mu}{4\gamma}, \\
U^r(\hat{\tau}^y(u_t), u_t) &= \frac{1}{2} \ \forall u_t \in [0,1], \qquad\qquad (12) \\
U^r(\widetilde{\theta}, 0) &= 1 - \frac{1}{4}\left\{(1+\beta) + \sqrt{\beta(\beta+2)}\right\}, \quad U^r(\widetilde{\theta}, \hat{u}) = \frac{1}{2}.
\end{aligned}
$$

Based on these properties, we can illustrate the dynamic path of u_t given by (11) as in Figure 6.

[Figure 6 about here.]

In what follows, we focus on a *steady-state equilibrium* where the sequence of u_t is stationary over time, and we show that there are multiple steady-state equilibria under a certain condition. The *steady-state* equilibria are illustrated by the crossing points of the 45-degree line and $u_{t+1} = \{U^p(1/2, u_t), U^r(\theta, u_t)\}$. We denote by $\bar{u}^p$ the steady-state level of the old poor in a poor-majority equilibrium, and we denote by $\bar{u}^r$ the steady-state level of the old poor in a rich-majority equilibrium. By definition, $\bar{u}^p$ and $\bar{u}^r$ satisfy $\bar{u}^p = U^p(1/2, \bar{u}^p)$ and $\bar{u}^r = U^r(\theta, \bar{u}^r)$; that is:

$$
\bar{u}^p = \frac{3}{3 + \mu/\gamma}, \qquad (13)
$$

$$
\bar{u}^r(\theta) = \frac{1 - \frac{1}{2}\cdot(1-\theta+\beta)}{1 - \frac{1}{2}\cdot\left(1 - \frac{\mu}{\gamma}\right)\cdot(1-\theta+\beta)} \in \left[\bar{u}^{r,low}, \frac{1}{2}\right], \qquad (14)
$$

where:

$$
\bar{u}^{r,low} \equiv \frac{4 - \left\{(1+\beta) + \sqrt{\beta(\beta+2)}\right\}}{4 - (1-\mu/\gamma)\left\{(1+\beta) + \sqrt{\beta(\beta+2)}\right\}}.
$$

Within the range of $\theta \in [\widetilde{\theta}(\beta), \hat{\tau}^y(u_t)]$, $\bar{u}^r(\theta)$ attains a minimum at $\theta = \widetilde{\theta}(\beta)$ and a maximum at $\theta = \hat{\tau}^y(u_t)$ because $\bar{u}^r(\theta)$ is increasing in θ. Direct calculation leads to $\bar{u}^r(\widetilde{\theta}(\beta)) = \bar{u}^{r,low}$ and $\bar{u}^r(\hat{\tau}^y(u_t)) = 1/2$, implying that $\bar{u}^r(\theta) \in \left[\bar{u}^{r,low}, 1/2\right]$.

The following proposition establishes the condition for the existence and stability of the steady-state equilibria.

Proposition 2

(i) *Suppose that $\beta < 1/4$ holds, or that $\beta \geq 1/4$ and $\hat{u} < 1/2$ hold. There exists a unique, globally stable poor-majority steady-state equilibrium.*

(ii) *Suppose that* $\beta \geq 1/4$ *and* $\hat{u} \geq 1/2$ *hold. There exist multiple steady-state equilibria.*
(a) *The equilibrium path is determinate and converges to the poor-majority steady-state equilibrium if* $\hat{u} \in [1/2, \bar{u}^p)$ *and* $u_0 \in (\hat{u}, 1]$*; it is indeterminate otherwise.*

Proof. The proof is immediate from Figure 6.

The properties of the steady-state equilibria depend on the parameter values and the expectations of agents as illustrated in Figure 6. Panels (a) and (b) demonstrate a unique, stable poor-majority steady-state equilibrium. The majority is always poor along the equilibrium path in panel (a). By contrast, in panel (b), the majority could be rich along the transition path but finally converge to the poor-majority steady-state equilibrium.

Panels (c) and (d) demonstrate the multiple steady-state equilibria. Panel (c) indicates that given $u_0 > \hat{u}$, the equilibrium path definitely converges to the poor-majority steady-state equilibrium. However, when $u_0 \leq \hat{u}$, the equilibrium is indeterminate: the economy might attain the rich-majority steady-state equilibrium depending on the expectations of agents. By contrast, panel (d) illustrates a situation where the equilibrium is indeterminate for all initial condition of u. An economy that stays in the poor-majority steady state might move to the rich-majority steady state because of changes in the expectations of agents. Moreover, the changes in the expectations of agents could produce electoral cycles that move back and forth between the two equilibria as illustrated in panel (d) of Figure 6. These expectations play a key role in the dynamic motion of the equilibrium path.

Figure 7 illustrates the set of parameters $(\mu/\gamma, \beta)$ classified according to the characterization of the steady states. As illustrated in Figure 7, given (μ/γ), a high β is required for the existence of the rich-majority steady state. This is because a high β implies that agents place large weight on their future income, thereby giving young agents an incentive to invest in education, and the successful (rich) agents then form a majority. On the other hand, given the discount factor, a high (μ/γ) is required for the existence of the rich-majority steady state. A high (μ/γ) implies that the poor-born young agents have many opportunities for education and that education costs are low. Therefore, young agents have a strong incentive to invest in education, and this results in a majority of rich agents.

[Figure 7 about here.]

5 Comparative Statics Analysis

We have characterized the political equilibria and qualitatively assessed the impacts of γ and μ on the determination of tax rates and the size of the poor. To facilitate understanding, this section undertakes numerical analysis by focusing on the relative magnitude of the two parameters μ and γ, (μ/γ), that represent accessibility of education for poor-born agents. We examine how accessibility (μ/γ) affects intergenerational mobility, income inequality, and the size of redistribution in the steady states.

For the purposes of this analysis, we assume a generation to be 20 years. This is shorter than the usual assumption of, say, 30 years. We adopt a shorter generation length because the current model assumes that agents work in both periods of life. The first and second periods correspond to ages 25–44 and 45–64 years, respectively. We assume a single-period discount rate given by 0.96. Because agents under the current assumption plan over generations that span 20 years, we discount the future by $(0.96)^{20}$.

We first examine how accessibility of education, (μ/γ), affects the pattern of political equilibria. In the current environment, there is a threshold level of (μ/γ) given by 0.6123, as illustrated in Figure 8. For a low value of (μ/γ) such that $(\mu/\gamma) \in [0, 0.6123]$, there is a unique poor-majority steady state with 50% taxation on the young and 100% taxation on the old. A low value of (μ/γ) means a low μ and/or a high γ, evidencing the difficulty that poor-born agents have in obtaining education. Because of this, the majority is always the poor, who support 100% taxation on the old. By contrast, for a high value of (μ/γ) such that $(\mu/\gamma) \in (0.6123, 1]$, there are multiple steady-state equilibria, comprising the poor-majority equilibrium above and a rich-majority equilibrium with no taxation on the old. In the rich-majority equilibrium, the young and the old both have a lower tax burden than in the poor-majority equilibrium.

[Figure 8 about here.]

In what follows, we demonstrate some numerical results for intergenerational mobility, income inequality, and the size of redistribution and consider how these variables are affected by the size of (μ/γ).

5.1 Intergenerational Mobility

From the definition in Section 2, the levels of upward and downward mobility are given by:

$$M_t^{up} = u_t \cdot \mu \cdot e^{p*}(\tau_t^y, \tau_{t+1}^o) = u_t \cdot \frac{\mu}{2\gamma} \cdot \{(1-\tau_t^y) + \beta \cdot (1-\tau_{t+1}^o)\},$$
$$M_t^{down} = (1-u_t) \cdot (1-e^{r*}(\tau_t^y, \tau_{t+1}^o)) = (1-u_t) \cdot \left\{1 - \frac{1}{2}\left((1-\tau_t^y) + \beta \cdot (1-\tau_{t+1}^o)\right)\right\},$$

respectively. In the steady state, the distribution of rich and poor becomes stationary over time. The upward and downward mobility levels are equal in the steady state:

$M^{up} = M^{down}$. We denote by $\bar{M}^p$ and $\bar{M}^r$ the levels of intergenerational mobility in the poor-majority steady state and the rich-majority steady state, respectively. $\bar{M}^p$ and $\bar{M}^r$ are given by:

$$\bar{M}^p = \overline{u}^p \cdot \mu \cdot e^{p*}(1/2, 1) = (1 - \overline{u}^p) \cdot (1 - e^{r*}(1/2, 1)),$$
$$\bar{M}^r(\theta) = \overline{u}^r \cdot \mu \cdot e^{p*}(\theta, 0) = (1 - \overline{u}^r) \cdot (1 - e^{r*}(\theta, 0)).$$

Figure 9 illustrates the numerical result.

[Figure 9 about here.]

To consider the effect of (μ/γ) on $\bar{M}^j (j = p, r)$, we rewrite $\bar{M}^p$ and $\bar{M}^r(\theta)$ as follows:

$$\bar{M}^p = \frac{3}{4} \cdot \frac{\mu/\gamma}{3 + \mu/\gamma},$$
$$\bar{M}^r(\theta) = \frac{1 - \frac{1}{2} \cdot (1 - \theta + \beta)}{\frac{1 - \frac{1}{2} \cdot (1 - \theta + \beta)}{\frac{\mu}{2\gamma} \cdot (1 - \theta + \beta)} + 1}, \quad \theta \in [\tilde{\theta}(\beta), \hat{\tau}^y(\bar{u}^r)].$$

These equations indicate that $\bar{M}^p$ and $\bar{M}^r(\theta)$ are increasing in μ and decreasing in γ. For poor-born agents, a higher μ yields greater opportunities for going on to education, while a lower γ provides lower costs of receiving education. In turn, these effects increase the number of poor-born agents who can become rich via education. Therefore, an increase in (μ/γ) enhances intergenerational mobility, as depicted in Figure 9.

Figure 9 demonstrates that for the case of $(\mu/\gamma) \in (0.6123, 1]$ featuring multiple equilibria, mobility in the rich-majority steady state is higher than in the poor-majority steady state:

$$\bar{M}^r(\theta) = \bar{u}^r(\theta)\mu e^{p*}(\theta, 0) > \bar{M}^p = \bar{u}^p \mu e^{p*}(1/2, 1) \;\; \forall \theta \in [0, \hat{\tau}^y_t(u_t)] \, .$$

To understand this relation, we focus on the two factors that determine mobility: the size of the poor and the probability of success for poor-born agents. The size of the poor is less than half in the rich-majority equilibrium, while it is more than half in the poor-majority equilibrium: $\bar{u}^r(\theta) \leq 1/2 < \bar{u}^p$. The probability of success for poor-born agents is also higher in the rich-majority equilibrium than in the poor-majority equilibrium: $e^{p*}(\theta, 0) > e^{p*}(1/2, 1)$. Therefore, two competing effects determine the relative size of $\bar{M}^r(\theta)$ and $\bar{M}^p$. Figure 9 shows that the effect via the probability of success is greater than the effect via the size of the poor, thereby resulting in $\bar{M}^r(\theta) > \bar{M}^p$.

5.2 Income Inequality

We use the Gini coefficient as a measure of inequality in our framework. In particular, we focus on the income inequality among young agents rather than among young and old agents for the following reasons. First, income inequality among young agents provides a qualitatively similar result to that among young and old agents because the status of each agent persists over the life cycle. Second, focusing on the inequality among young agents enables us intuitively and graphically to illustrate the numerical result.

We calculate the Gini coefficient among young agents in terms of after-tax-and-transfer income. In each period, there are two types of young agents: young rich agents with per capita income given by $(1-\tau_t^y)+s_t$, and young poor agents with per capita income given by s_t. Panel (a) of Figure 10 summarizes information about per capita income, the size of the population and the total income for each type of young agent. Panel (b) of Figure 10 illustrates a Lorenz curve. The Gini coefficient among young agents is calculated by $A/(A+B)$ in panel (b) where A is the shaded area and B is the unshaded area.

[Figure 10 about here.]

Panel (b) shows that two factors determine the Gini coefficient: (i) the ratio of the rich to the poor denoted by the population ratio (PR), and (ii) the ratio of the per capita income of the rich to the per capita income of the poor, denoted by the income ratio (IR). The role of the first factor is intuitive: given the IR factor effect, a lower PR (i.e., a smaller number of the rich) results in the larger size of the area A and thus a higher Gini coefficient. The second factor arises from the ratio of the slopes (A) and (B). The ratio is rewritten as:

$$
\begin{aligned}
\left(\frac{\text{Slope }(B)}{\text{Slope }(A)}\right) &= \left(\frac{(\text{Total income of the young rich})/(\text{Total income of the young})}{1-u_{t+1}}\right) \\
&\quad \times \left(\frac{(\text{Total income of the young poor})/(\text{Total income of the young})}{u_{t+1}}\right)^{-1} \\
&= \left(\frac{\text{Per capita income of the young rich}}{\text{Per capita income of the young poor}}\right) \\
&= \frac{(1-\tau_t^y)+s_t}{s_t}.
\end{aligned}
$$

Given the PR factor effect, a higher IR implies a higher ratio of (Slope (B)/Slope (A)), a larger size of the area A, and thus a higher Gini coefficient.

[Figure 11 about here.]

These factors can be used to explain the following predictions of the numerical result depicted in Figure 11. First, in the poor-majority equilibrium, a higher (μ/γ) results in a lower level of inequality. An increase in (μ/γ) leads to a larger proportion of the rich, thereby creating a positive PR effect on equality. In addition, a larger proportion of the rich yields a larger share of taxpayers, thereby resulting in a greater redistribution that creates a positive IR effect on equality. Because of these positive effects on equality, a higher (μ/γ) leads to a lower Gini coefficient in the poor-majority equilibrium.

Second, when we compare the rich- and poor-majority equilibria, the rich-majority equilibrium attains a higher or a lower level of inequality depending on the relative size of the PR and IR effects. The rich-majority equilibrium attains a larger proportion of the rich, which produces a positive PR effect on equality. However, the rich-majority equilibrium realizes lower tax rates on the young and old, both of which result in lesser redistribution and thus a negative IR effect on equality.

For the case of $(\mu/\gamma) \in (0.6123, 1]$ featured by multiple equilibria, the positive PR effect is outweighed by the negative IR effect, as the rich-majority equilibrium attains a higher Gini coefficient than the poor-majority equilibrium. However, when the rich-majority equilibrium with a high (μ/γ) (for example, $\mu/\gamma = 0.9$) is compared with the poor-majority equilibrium with a low (μ/γ) (for example, $\mu/\gamma = 0.1$), the positive PR effect overrides the negative IR effect, as the rich-majority equilibrium attains a lower Gini coefficient than the poor-majority equilibrium. Therefore, the accessibility of education, represented by (μ/γ), plays a key role in determining the relative degree of inequality between the rich-majority and poor-majority equilibria.

5.3 The Size of Redistribution

We use the size of transfer, s, rather than the tax rates, as a measure of redistribution for the following reason. In the political economy literature, the skewness of income distribution affects the political determination of tax rates, and tax rates and the number of the rich (i.e., the tax base) determine the size of transfer. In the current framework, the effect of the skewness of tax rates is abstracted except at the threshold level of $u = 1/2$. That is, the political determination of the tax rate on the old is featured by a binary choice of $\tau^o \in \{0, 1\}$ because of simple majority voting by the rich and the poor in the absence of tax distortion. Given the binary choice and the resulting lack of a skewness effect, it is not appropriate to focus on tax rates when we compare cross-country difference of redistribution. Therefore, we instead focus on the size of transfers as a measure of redistribution.

We denote by $\bar{s}^p$ and $\bar{s}^r$ the size of transfers in the poor-majority steady state and in the rich-majority steady state, respectively. From the definition in Section 2, $\bar{s}^p$ and $\bar{s}^r$

are calculated as:

$$\begin{aligned}
\bar{s}^p &= \frac{1}{2}\left[W(1,\bar{u}^p) + Z\left(\frac{1}{2},1,\bar{u}^p\right)\right] \\
&= \frac{1}{2}\left[(1-\bar{u}^p) + \left\{(1-\bar{u}^p)e^{r*}\left(\frac{1}{2},1\right) + \bar{u}^p\mu e^{p*}\left(\frac{1}{2},1\right)\right\}\cdot\frac{1}{2}\right], \\
\bar{s}^r(\theta) &= \frac{1}{2}\left[W(0,\bar{u}^r) + Z\left(\theta,0,\bar{u}^r\right)\right] \\
&= \frac{1}{2}\left\{(1-\bar{u}^r)e^{r*}\left(\theta,0\right) + \bar{u}^r\mu e^{p*}\left(\theta,0\right)\right\}\cdot\theta.
\end{aligned}$$

These equations indicate that two factors determine the size of transfer: the tax rates and the number of the rich (i.e., the tax base). Figure 12 illustrates the numerical result.

[Figure 12 about here.]

We find the following three observations from Figure 12. First, in the poor-majority equilibrium, a higher (μ/γ) results in a larger size of transfer. An increase in (μ/γ) leads to a larger proportion of successful, rich agents, thereby creating a positive tax base effect on the size of transfer. Second, for the case of $(\mu/\gamma) \in (0.6123, 1]$ featured by multiple equilibria, the poor-majority equilibrium attains a larger size of transfer than the rich-majority equilibrium because the former is characterized by higher tax rates.

Third, when the rich-majority equilibrium with a high (μ/γ) (for example, $\mu/\gamma = 0.9$) is compared with the poor-majority equilibrium with a low (μ/γ) (for example, $\mu/\gamma = 0.1$), the rich-majority equilibrium attains a larger size of transfer than the poor-majority equilibrium because of a larger tax base effect. Therefore, the accessibility of education affects the relative size of transfer between the rich-majority and poor-majority equilibria.

6 Empirical Implications of Mobility and Inequality

The numerical analysis in Section 5 shows that intergenerational mobility and inequality depend on the parameter (μ/γ) representing the accessibility of education for poor-born agents. In this subsection, we focus on (μ/γ) and investigate the empirical implications of the model by comparing the model predictions in Figures 9, 11 and 12 with the empirical evidence (Subsection 6.1). We then provide some empirical evidence on the cross-country differences of educational accessibility that supports our interpretation of the numerical result (Subsection 6.2).

6.1 Interpretation of the Numerical Result

The numerical results in Figures 9 and 11 show that where the poor-majority equilibrium is concerned, the political economy tends to generate a negative correlation between inequality and mobility, as shown in previous work (Maoz and Moav, 1999; Owen and Weil, 1998; Hassler, Rodriguez Mora and Zeira, 2007; Mookherjee and Napel, 2007). This prediction also fits some empirical data in Figure 1. Here, Italy, the United Kingdom and the United States feature high inequality and low mobility, while the Nordic countries (Denmark, Sweden, Finland and Norway) feature low inequality and high mobility. Therefore, the substantial difference in inequality and mobility among those countries are produced by differences in the accessibility of education.

The negative correlation between inequality and mobility, however, appears less than exact (Solon, 2002). Despite considerable intergenerational mobility in Australia (D'Addio, 2007) and Canada (Corak, 2006), these countries also score relatively highly on measures of cross-sectional inequality (see Figure 1). One possible explanation is that they are represented by a rich-majority equilibrium with a certain level of $\mu/\gamma(\geq 0.6123)$. To understand this argument, let us compare the poor-majority equilibrium with $\mu/\gamma = 0.9$ (representing the Nordic countries) and the rich-majority equilibrium with $\mu/\gamma = 0.7$ (representing Australia and Canada). Both these equilibria obtain similar levels of mobility: the difference in mobility rates is less than 2% (see Figure 9). However, the rich-majority equilibrium with $\mu/\gamma = 0.9$ attains a much higher Gini coefficient than the poor-majority equilibrium with $\mu/\gamma = 0.7$, the difference being more than 10% (see Figure 11). These properties, the similarity in mobility rates and the substantial difference in inequality between two groups of countries, are produced by multiple, self-fulfilling expectations of agents.

The above-mentioned classification of countries also fits the empirical evidence on the size of redistribution. When the poor majority is considered, a country with higher accessibility of education (such as the Nordic countries) shows a larger size of redistribution compared with one with lower accessibility of education (such as Italy, the United Kingdom and the United States) because of the tax base effect. When the focus is on the rich-majority equilibrium representing Australia and Canada, the equilibrium shows a smaller size of redistribution compared with the poor-majority equilibrium with high accessibility (such as the Nordic countries) because of lower tax rates, but shows a larger size of redistribution compared with the poor-majority equilibrium with low accessibility (such as Italy, the United Kingdom and the United States) because of the tax base effect. This model prediction of the size of redistribution fits in well with the empirical evidence on the size of redistribution reported by OECD (2008b).

6.2 Evidence on the Cross-country Difference of Educational Accessibility

Our interpretation of the numerical result depends on the assumption that Australia, Canada and Nordic countries have higher accessibility of education (i.e., a higher μ/γ) than Italy, the United Kingdom and the United States. We here present some empirical evidence that supports this assumption.

Based on the two international student achievement tests, the Third International Mathematics and Science Study (TIMSS) and its replication for a partly different set of countries (TIMSS-repeat), Schütz, Ursprung and Wößmann (2008) report that England, Scotland and the United States are included in the top 10 countries with the least equality of educational opportunity among the sample of 29 OECD countries, whereas Australia, Canada, Denmark, Finland, Italy, Norway, and Sweden are ranked lower than eleventh. This empirical result indicates that the United Kingdom and the United States provide less equality of educational opportunity than other countries. OECD (2008a) supports this evidence using the data from the OECD program for International Student Assessment (PISA) 2000 survey. Finland provides more equitable access to higher education than the United Kingdom among 10 countries including Austria, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain and the United Kingdom.

We should note that equality and mobility are low in Italy, despite fairly equitable access to education, a fact less easy to explain with our model. However, some empirical studies suggest a strong regional variation in educational accessibility in Italy, which might result in low equality and mobility. For example, Checchi and his collaborators show that the southern area in Italy presents a stronger effect of the family background on the test scores of high school students (Checchi and Peragine, 2005; Checchi, Fiorio, Leonardi, 2007) and a higher inequality of educational opportunity (Checchi and Peragine, 2009) compared with the northern area. Therefore, this regional variation in educational accessibility, which is not captured by Schütz, Ursprung and Wößmann (2008) and OECD (2008a), could be a possible explanation for low equality and mobility in Italy.

7 Conclusion

This paper presents a politico-economic model that analyzes the mutual link between income inequality and intergenerational mobility within and across generations. The focus of this paper is the correlation between inequality and mobility. Empirical studies have shown that this correlation across countries is negative for most of the OECD, but it does not fit Australia and Canada, as these counties feature both high mobility and high inequality. The current analysis demonstrates two key factors that explain the empirical evidence: the accessibility of education that provides a negative correlation between inequality and mobility, and the multiple, self-fulfilling expectations that produce an equilibrium characterized by both high inequality and high mobility. Our model can also be used to demonstrate the dynamic motion of inequality and mobility within each country. Under the condition that the economy attains multiple political equilibria, we show that two economies sharing the same initial conditions can converge to different equilibria depending on the expectations of agents, and that without any structural change, the economy at one of the equilibria may move to the other with a change in the expectations of agents. The expectations of agents then play a key role in the determination of the long-run state of the economy.

To obtain these results, we simplify the analysis by adopting a simple linear, risk-neutral utility function. We do not consider an alternative utility function; for example a concave, risk-averse utility function. In addition, we focus on income inequality among young agents, rather than income inequality among young and old agents. Furthermore, the parameters γ and μ representing educational accessibility for poor-born individuals are exogenously given and thus reflect no political decisions. However, we believe that the present analysis provides a suitable framework for understanding cross-country differences in inequality and mobility as well as changes in inequality and mobility over time as affected by redistributive politics and the self-fulfilling expectations of agents.

Appendix

Proof of Proposition 1

(i) Suppose that at time t, agents know that $\tau_t^y = 1/2$ and expect that $\tau_{t+1}^o = 1$. We obtain:

$$\begin{aligned} u_{t+1} &= (1-u_t)\cdot\left(1-e^{r*}\left(\frac{1}{2},1\right)\right) + u_t\cdot\left\{\mu\cdot\left(1-e^{p*}\left(\frac{1}{2},1\right)\right)+(1-\mu)\right\} \\ &= 1-\frac{1}{4}\cdot\left\{(1-u_t)+\frac{\mu}{\gamma}\cdot u_t\right\} \\ &> \frac{1}{2}, \end{aligned}$$

where the inequality in the third line comes from $\mu \in [0,1]$ and $\gamma > 1$. By (7), $u_{t+1} > 1/2$ implies that $\tau_{t+1}^o = 1$, fulfilling initial expectations. Therefore, a poor-majority equilibrium exists if the decisive voter finds it optimal to set $\tau_t^y = 1/2$.

Suppose that $\gamma/\mu > 1+\beta$ and $u_t \in (\beta/(1+\beta)(1-\mu/\gamma), 1]$ hold. The condition (10) implies that the rational expectation is uniquely given by $\tau_{t+1}^o = 1$ for $\tau_t^y \in [0,1]$. The revenue from the young $Z(\tau_t^y, 1)$ is maximized by setting $\tau_t^y = 1/2$. Suppose, instead, that $\gamma/\mu \leq 1+\beta$ holds or that $\gamma/\mu > 1+\beta$ and $u_t \in [0, \beta/(1+\beta)(1-\mu/\gamma)]$ hold. The condition (10) implies that there are multiple, self-fulfilling expectations for $\tau_t^y \in [0,\theta]$. Setting $\tau_t^y = 1/2$ is optimal if $Z(1/2,1) > Z(\theta,0)$; that is, if $\theta \in [0,\tilde{\theta})$.

(ii) Suppose that agents know that $\tau_t^y = \theta \leq \hat{\tau}^y(u_t)$ and expect $\tau_{t+1}^o = 0$. Then:

$$\begin{aligned} u_{t+1} &= (1-u_t)\cdot(1-e^{r*}(\theta,0)) + u_t\cdot\{\mu\cdot(1-e^{p*}(\theta,0))+(1-\mu)\} \\ &= 1-\frac{1}{2}\cdot\left\{(1-u_t)+\frac{\mu}{\gamma}\cdot u_t\right\}\cdot(1-\theta+\beta) \\ &\leq 1-\frac{1}{2}\cdot\left\{(1-u_t)+\frac{\mu}{\gamma}\cdot u_t\right\}\cdot\left(1+\beta-\frac{\left\{(1-u_t)+\frac{\mu}{\gamma}\cdot u_t\right\}(1+\beta)-1}{(1-u_t)+\frac{\mu}{\gamma}\cdot u_t}\right) \\ &= \frac{1}{2}, \end{aligned}$$

where the inequality in the third line comes from $\theta \leq \hat{\tau}^y(u_t)$. By (7), this implies that $\tau_{t+1}^o = 0$, fulfilling initial expectations. Therefore, a rich-majority equilibrium exists if the decisive voter finds it optimal to set $\tau_t^y = \theta \in [\widetilde{\theta}(\beta), \hat{\tau}^y(u_t)]$.

The condition (10) implies that the expectation of $\tau_{t+1}^o = 0$ can be rational if (i) $\gamma/\mu \leq 1+\beta$, or (ii) $\gamma/\mu > 1+\beta$ and $u_t \in [0, \beta/(1+\beta)(1-\mu/\gamma)]$. For each case, setting $\tau_t^y = \theta$ is optimal if and only if $Z(\theta,0) \geq Z(1/2,1)$; that is, $\theta \in [\widetilde{\theta}(\beta), \hat{\tau}^y(u_t)]$. The set $[\widetilde{\theta}(\beta), \hat{\tau}^y(u_t)]$ is nonempty if and only if $u_t \in [0,\hat{u}]$, where $\hat{u} < \beta/(1+\beta)(1-\mu/\gamma)$

always holds and $\hat{u} \geq 0 \Leftrightarrow \beta \geq 1/4$. Therefore, given $\theta \in [\widetilde{\theta}(\beta), \hat{\tau}^y(u_t)]$, there exists a rich-majority equilibrium if $\beta \geq 1/4$ and $u_t \in [0, \hat{u}]$.

■

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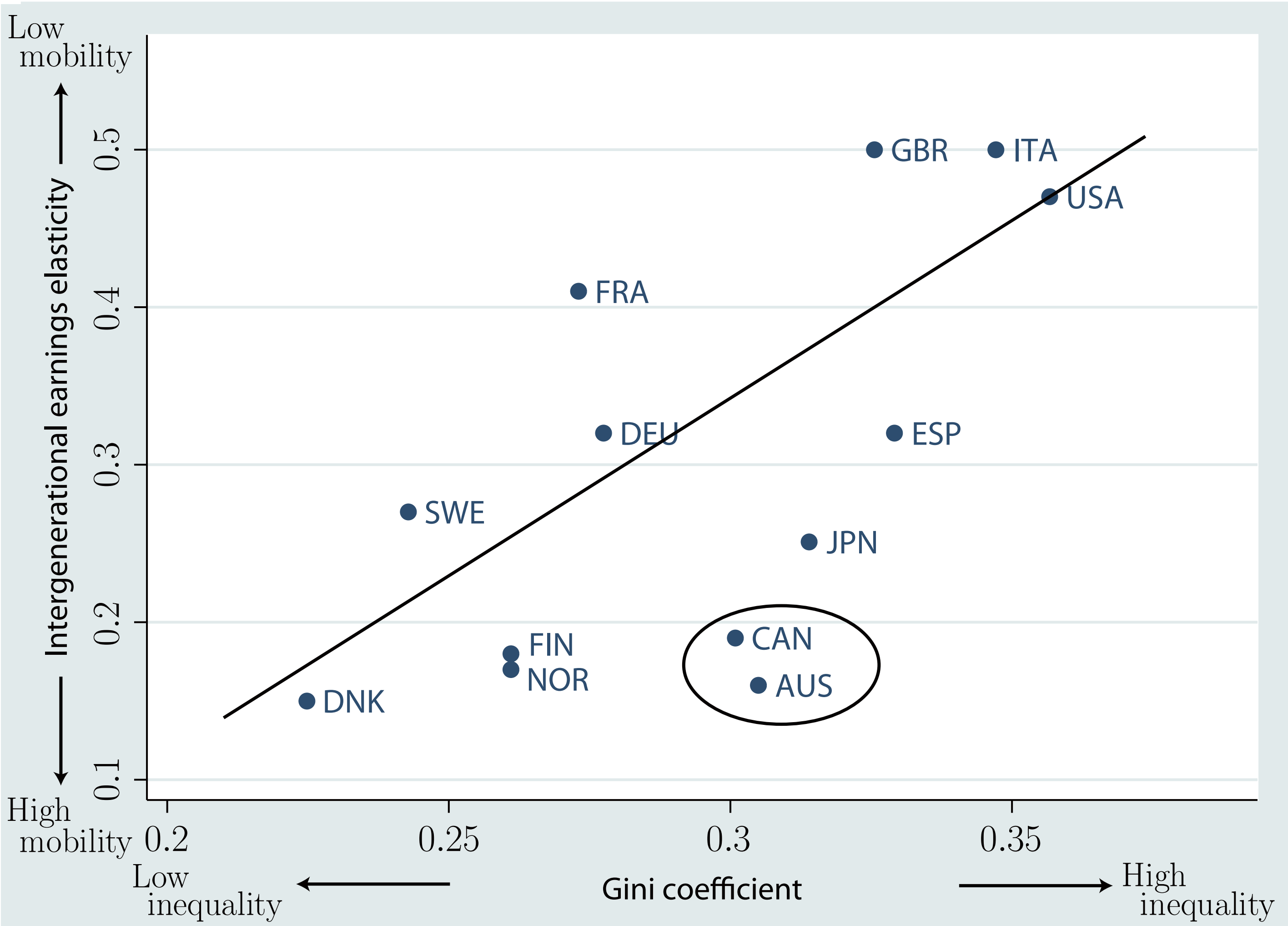

Figure 1: This figure is a scatter plot of the Gini coefficients and intergenerational earnings elasticity for 13 OECD countries (Australia, Canada, Germany, Denmark, Spain, Finland, France, Italy, Japan, Norway, Sweden, the United Kingdom and the United States). All data except for Japan are from OECD (2006). The Gini coefficient and the intergenerational earnings elasticity of Japan are from OECD (2005) and Lefranc, Ojima and Yoshida (2008).

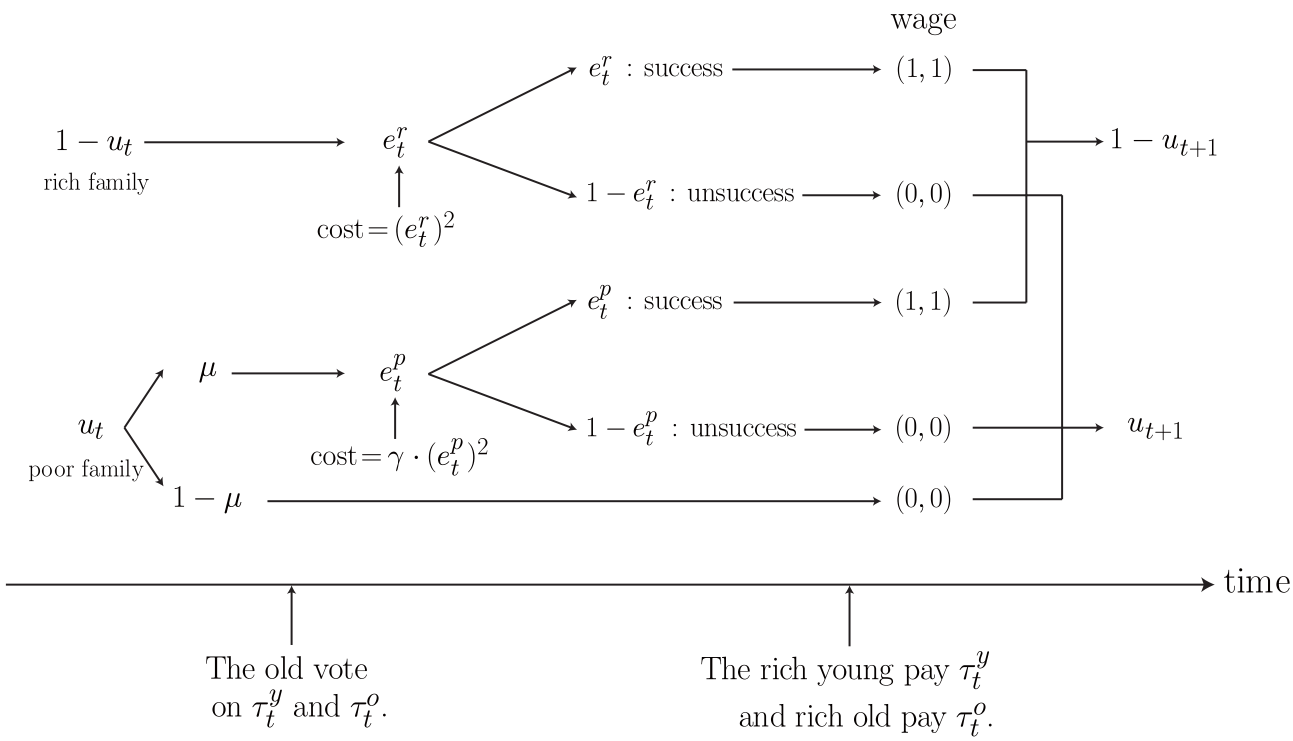

Figure 2: Timing of events and the distribution of rich and poor.

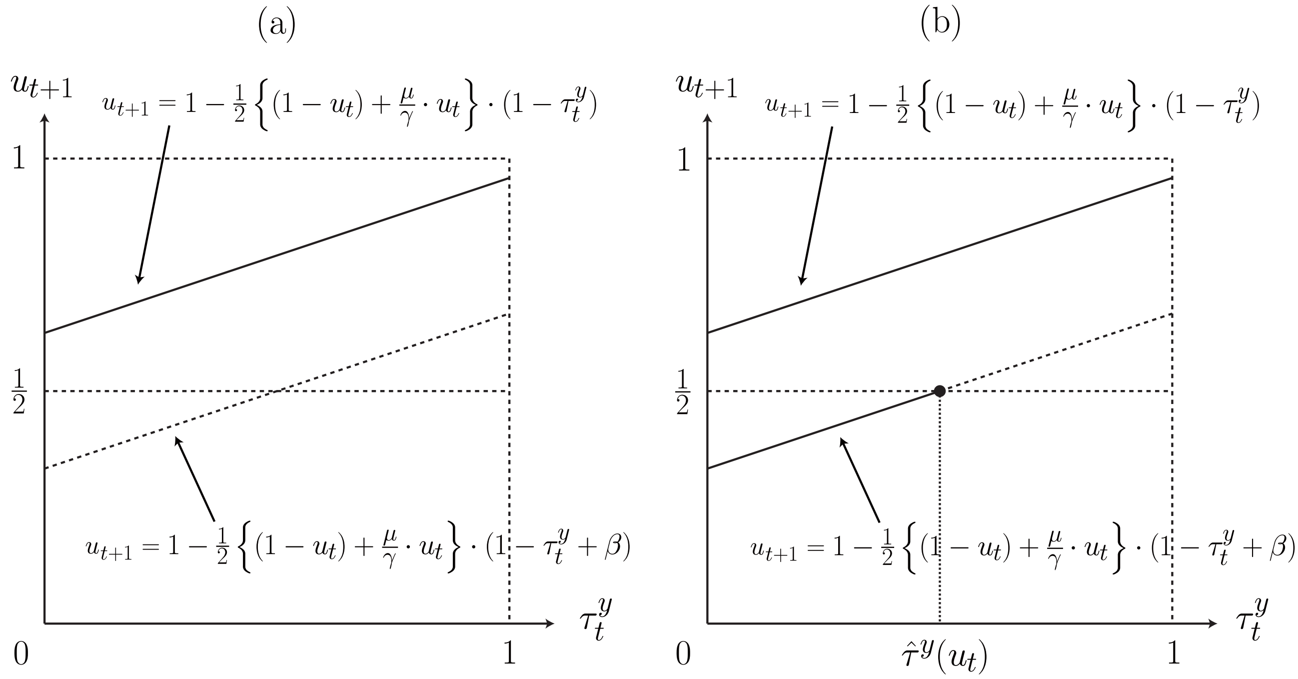

Figure 3: The equilibrium decision rule $u_{t+1} = U(\tau_t^y)$. The solid lines are graphs of U satisfying equilibrium condition 2. Panel (a) illustrates the case of $\gamma/\mu > 1+\beta$ and $u_t \in (\beta/(1+\beta)(1-\mu/\gamma), 1]$; panel (b) illustrates the case of $\gamma/\mu > 1+\beta$ and $u_t \in [0, \beta/(1+\beta)(1-\mu/\gamma)]$, or the case of $\gamma/\mu \leq 1+\beta$.

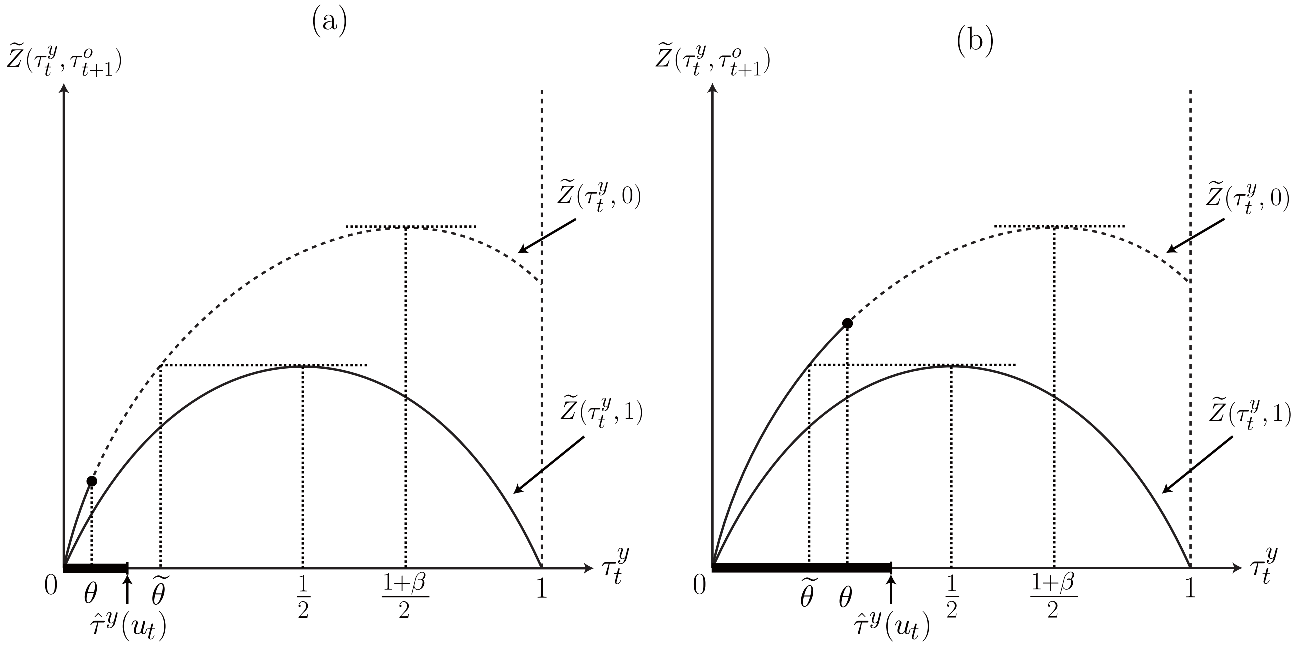

Figure 4: The graph of $\widetilde{Z}$ under the set of parameters provided in Proposition 1. Panel (a) illustrates the case where $u_t > \hat{u}$; panel (b) illustrates the case where $u_t \leq \hat{u}$.

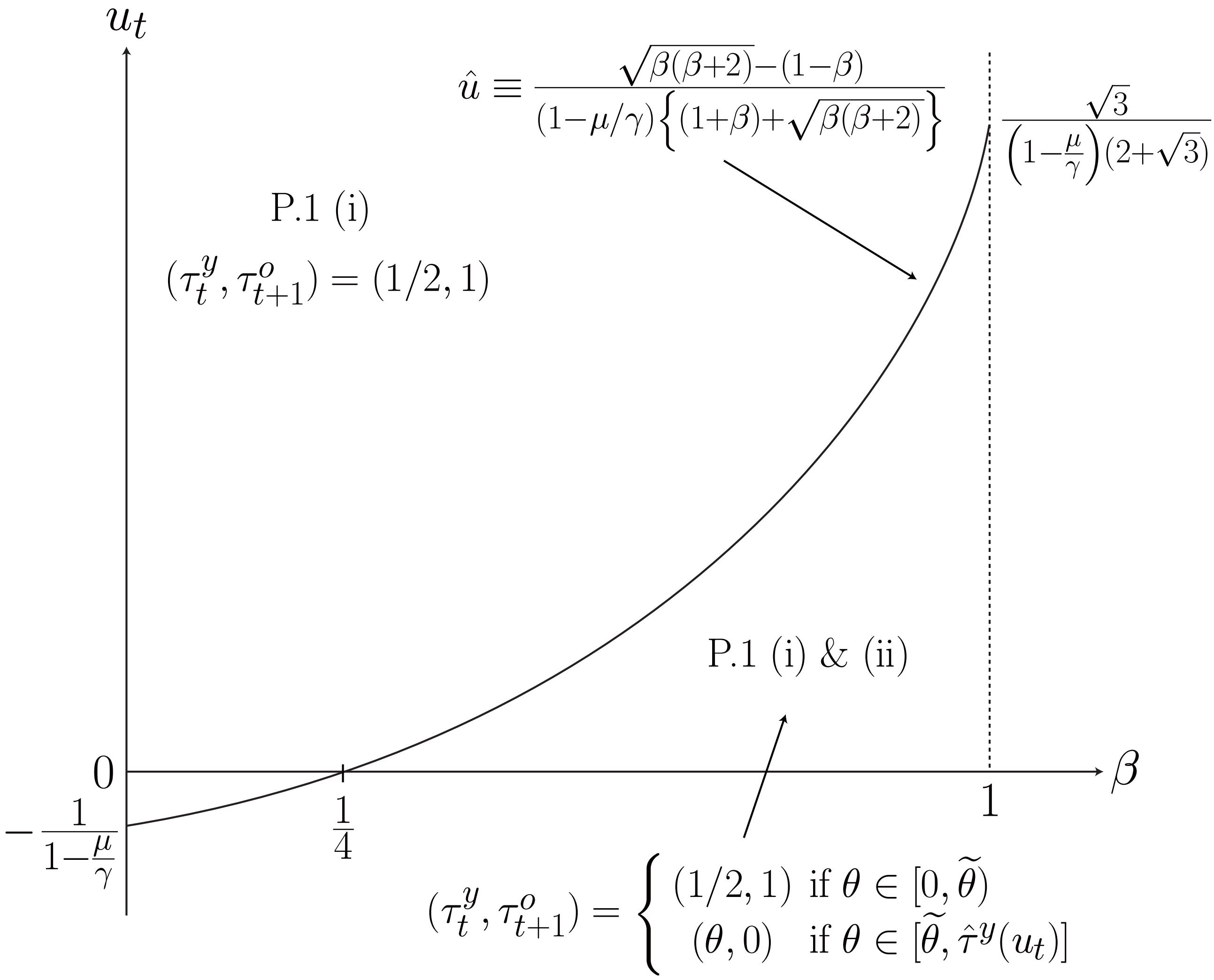

Figure 5: The set of (β, u_t) classified according to the characterization of period-t political equilibria.

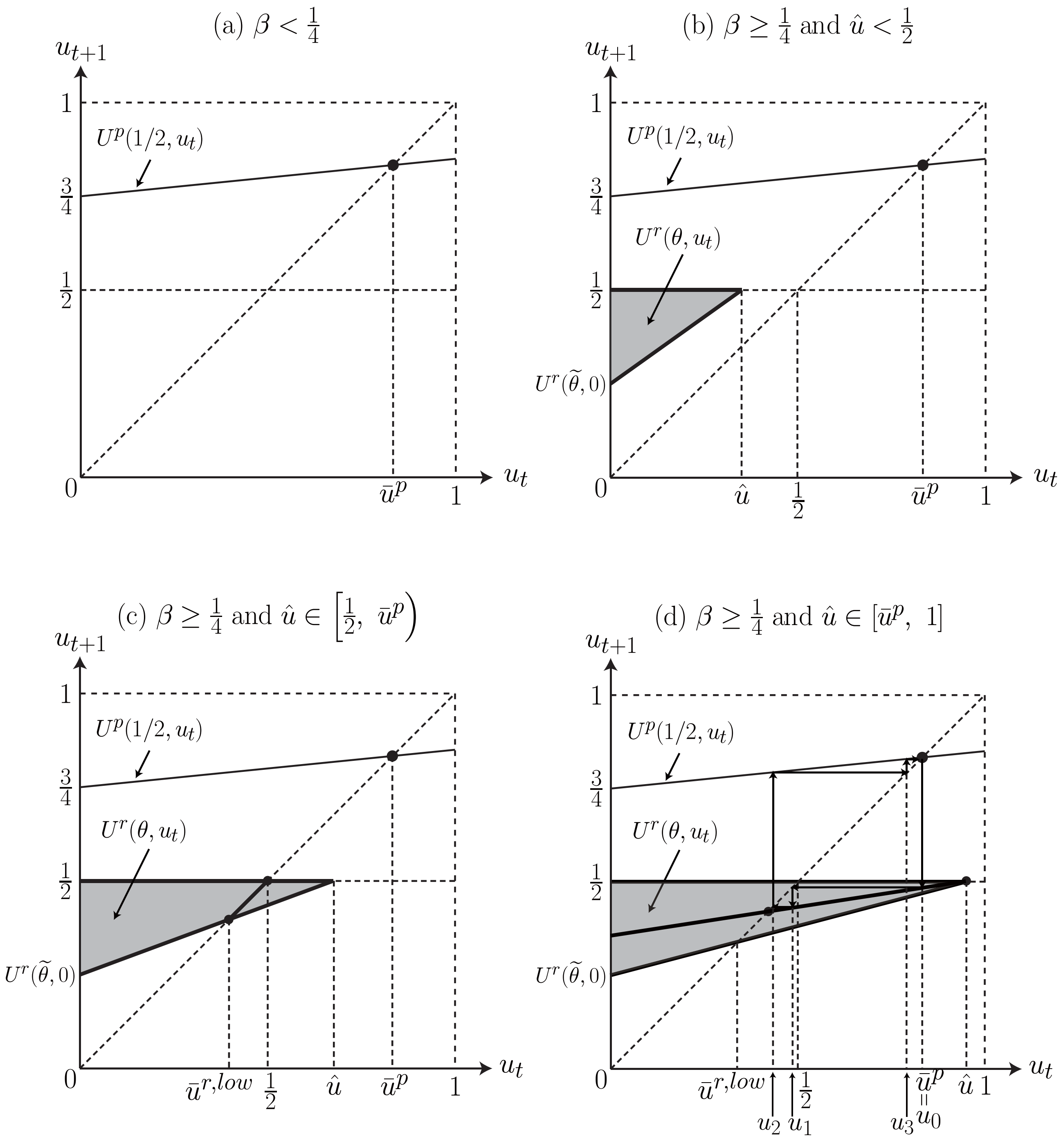

Figure 6: The characterization of dynamic political equilibria. Panel (a) illustrates the case of $\beta < 1/4$; panel (b) illustrates the case of $\beta \geq 1/4$ and $\hat{u} < 1/2$; panel (c) illustrates the case of $\beta \geq 1/4$ and $\hat{u} \in [1/2, \bar{u}^p)$; panel (d) illustrates the case of $\beta \geq 1/4$ and $\hat{u} \in [\bar{u}^p, 1]$.

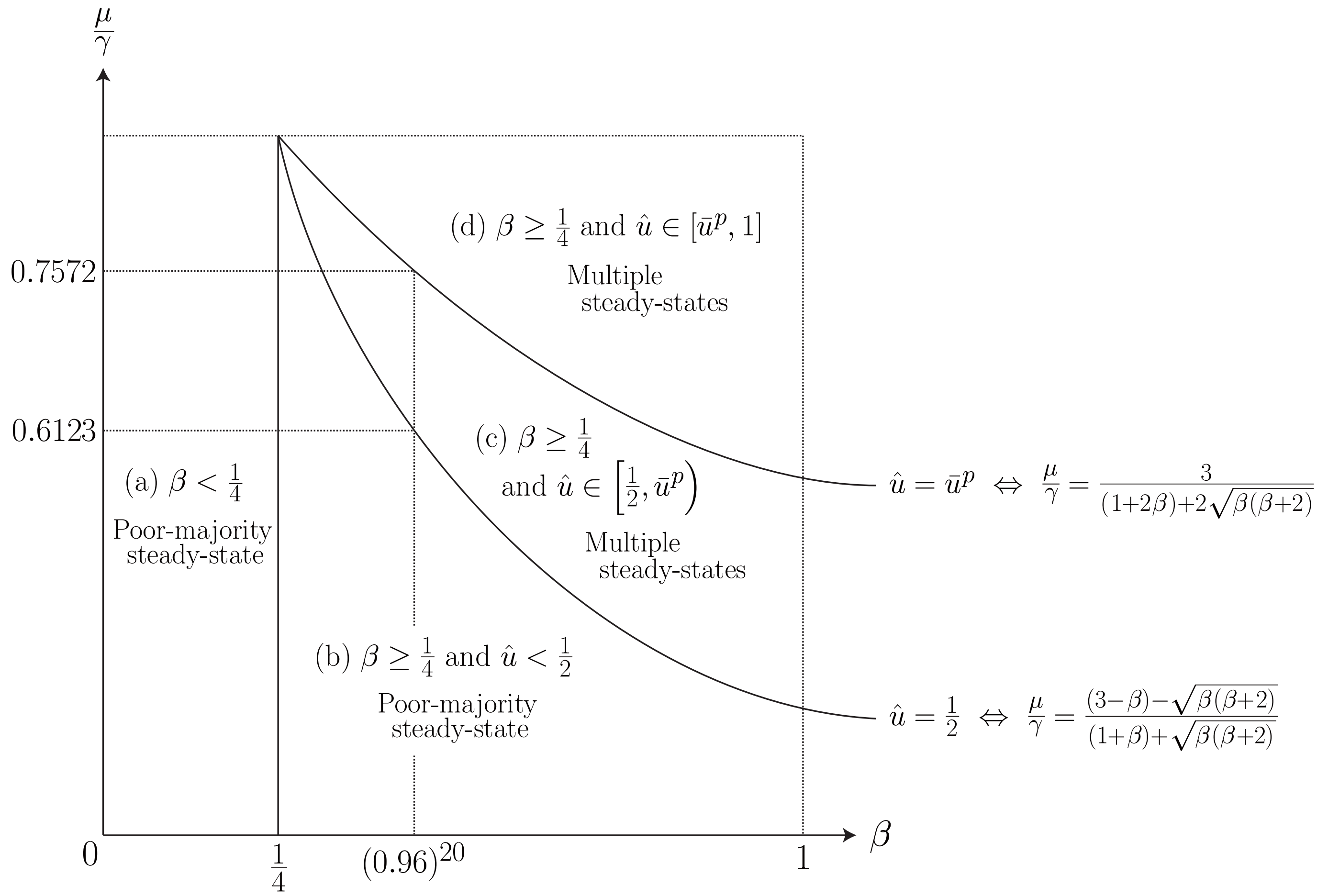

Figure 7: The set of parameters $(\mu/\gamma, \beta)$ classified according to the characterization of the steady states.

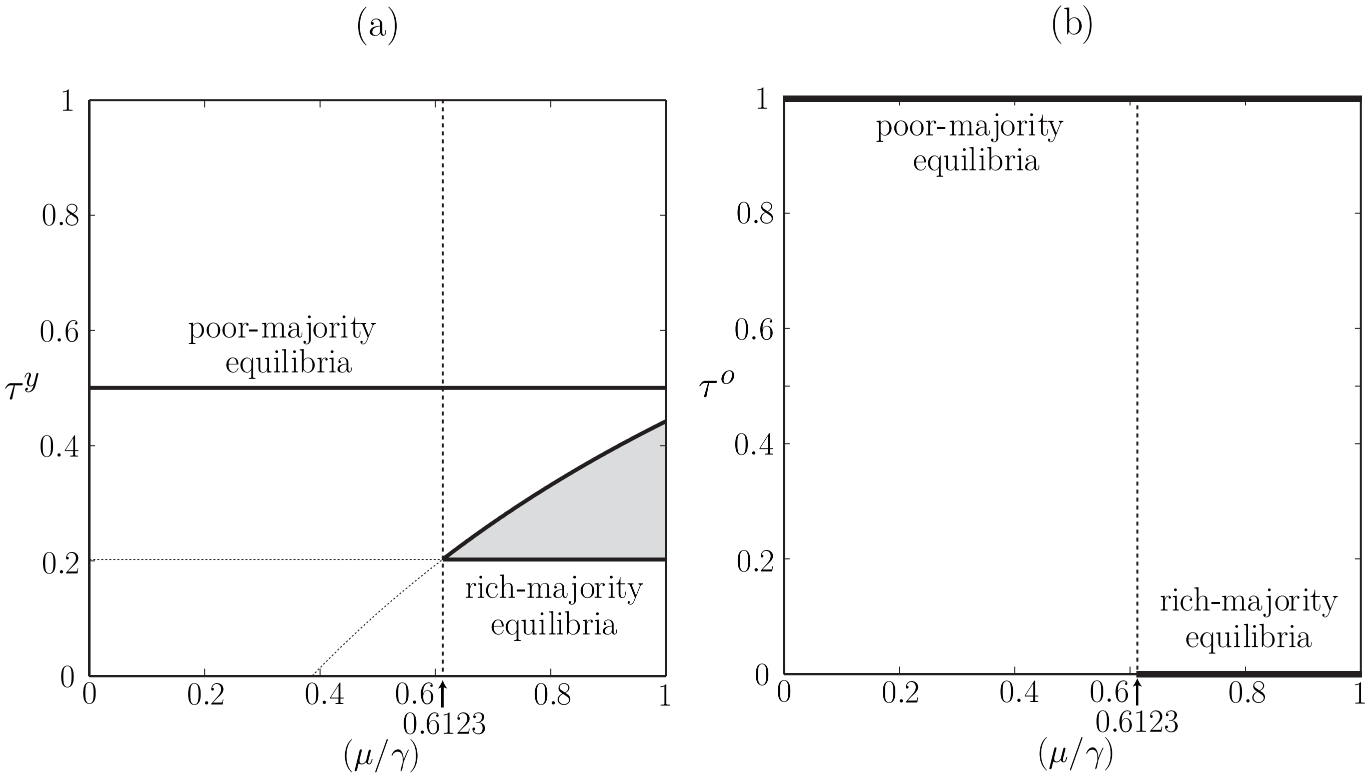

Figure 8: The tax rate on the young (panel (a)) and the tax rate on the old (panel (b)).

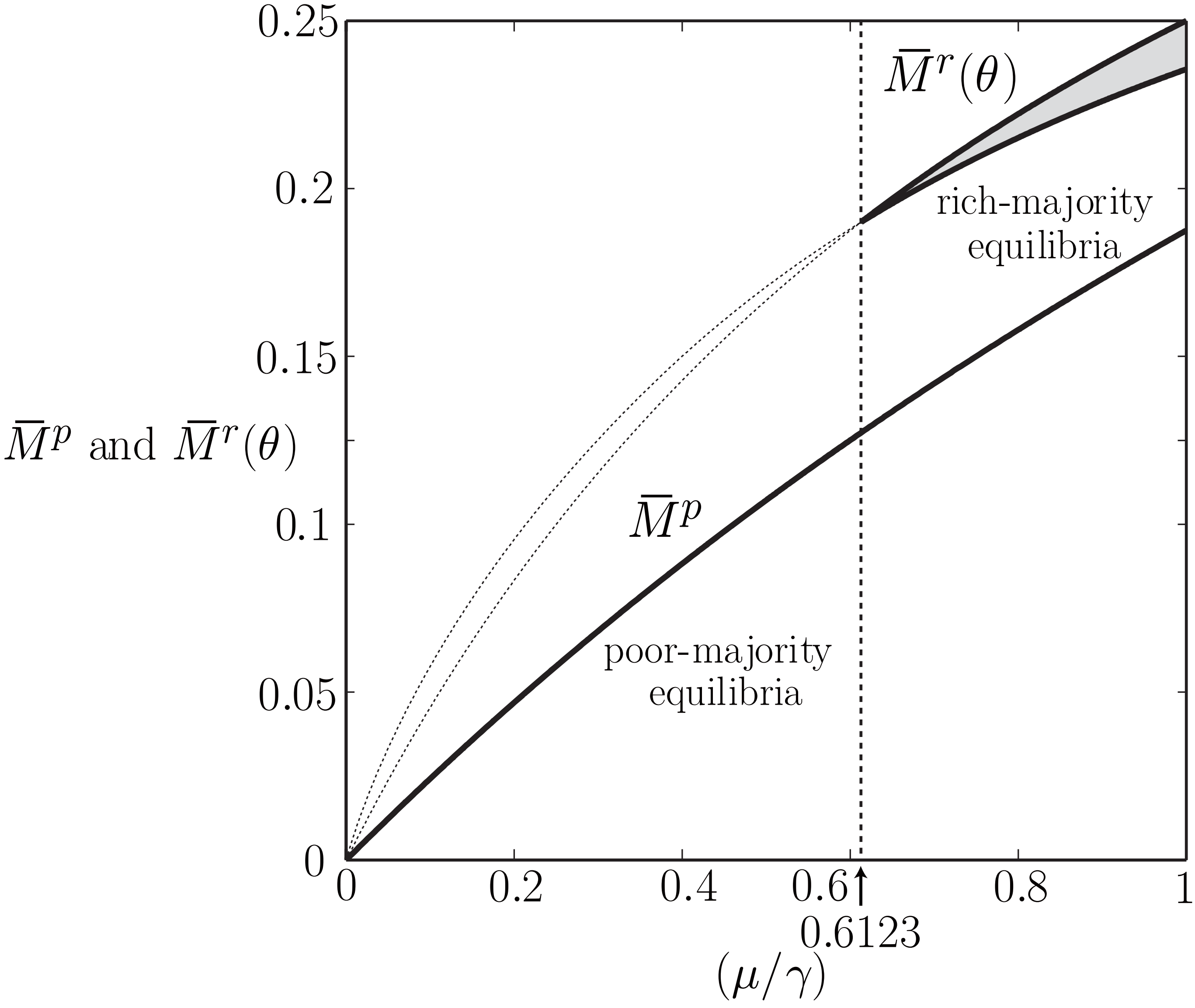

Figure 9: Intergenerational mobility in the steady state.

(a)

	Per capita after tax-and-transfer income	Population	Total after tax-and-transfer income
Young rich agents	$(1-\tau_t^y)+s_t$	$(1-u_t)e_t^r+u_t\mu e_t^p$	$\{(1-u_t)e_t^r+u_t\mu e_t^p\} \times\{(1-\tau_t^y)+s_t\}$
Young poor agents	s_t	$(1-u_t)(1-e_t^r) + u_t\mu(1-e_t^p) + u_t(1-\mu)$	$\{(1-u_t)(1-e_t^r)+u_t\mu(1-e_t^p) + u_t(1-\mu)\}\cdot s_t$

(b)

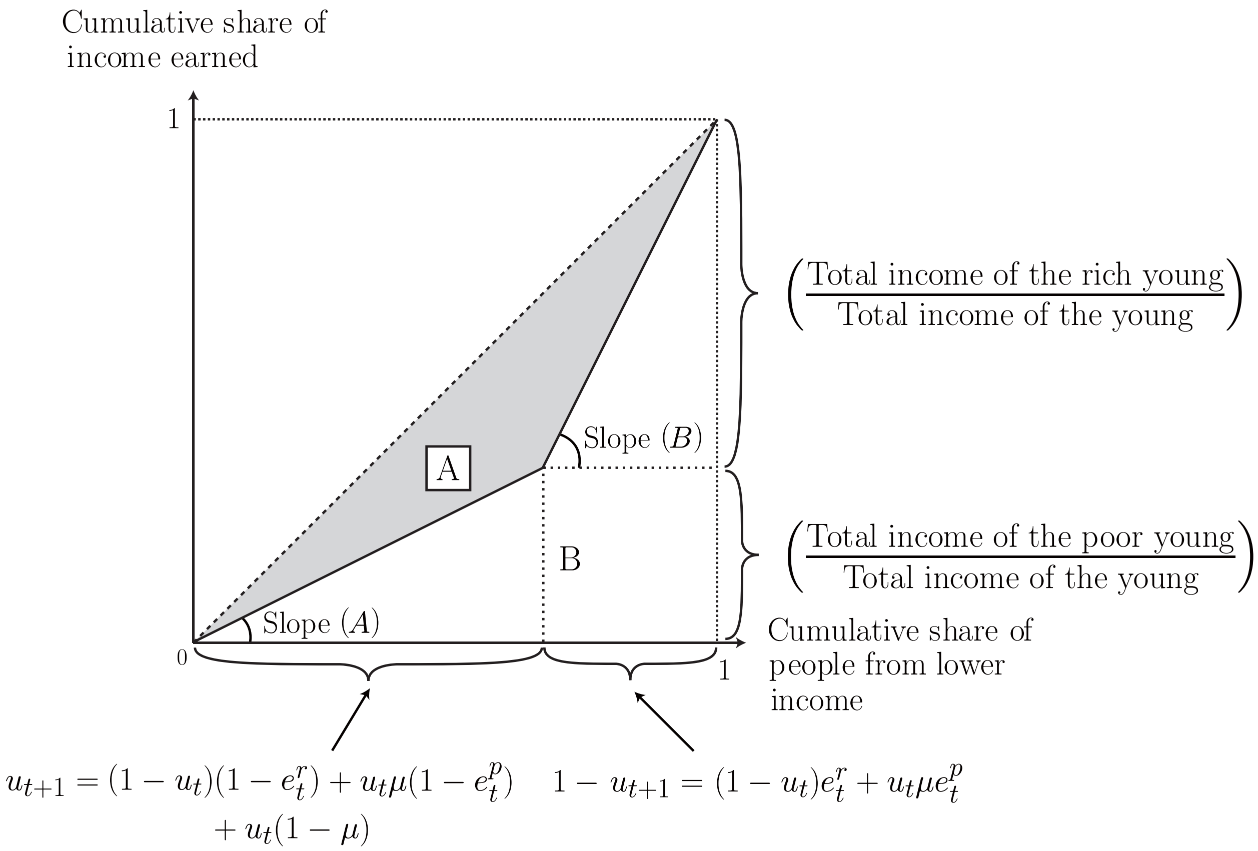

Figure 10: Information about per capita income, the size of the population and total income for each type of young agent (panel (a)) and the Lorenz curve (panel (b)).

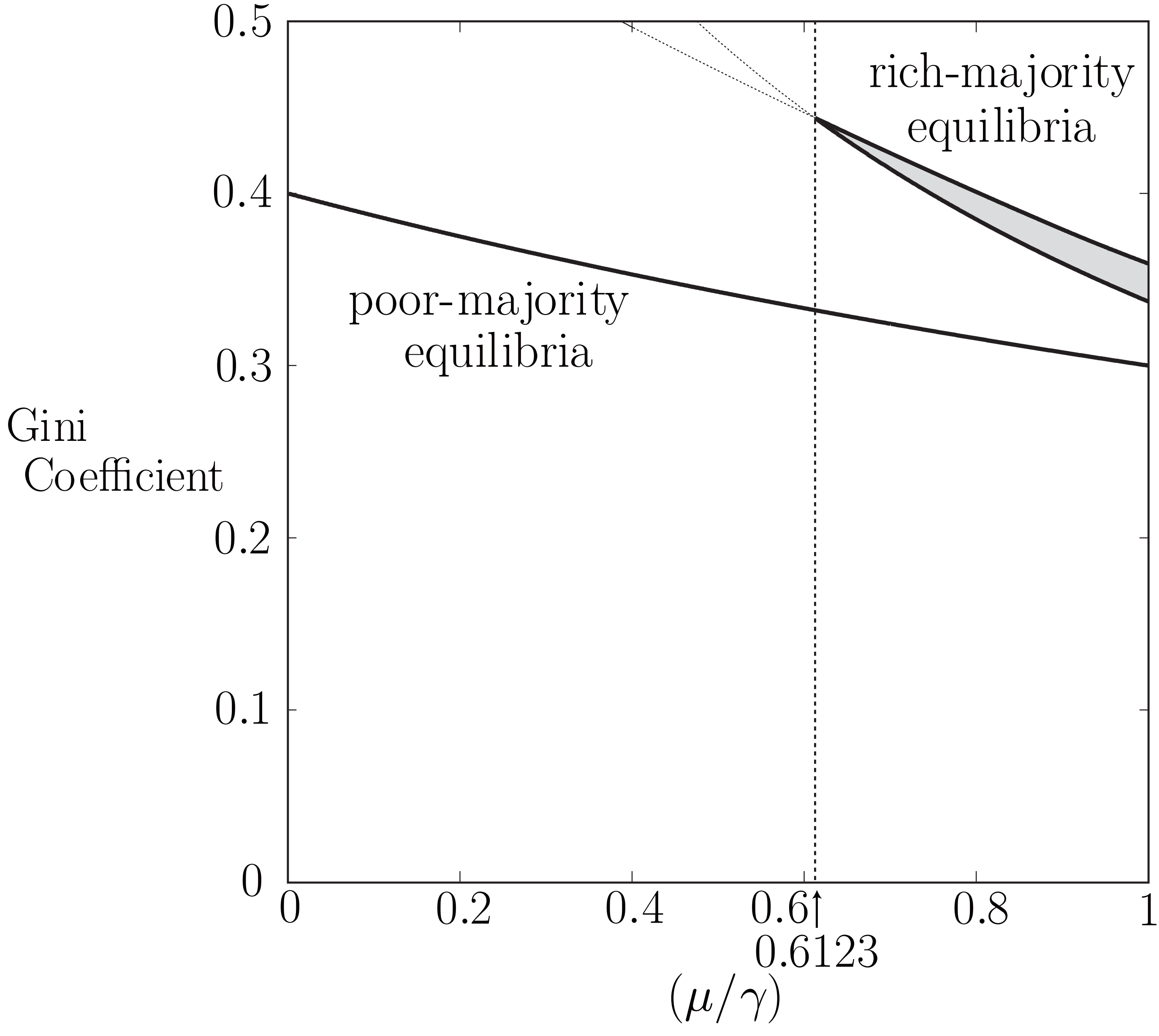

Figure 11: Gini coefficients among young agents.

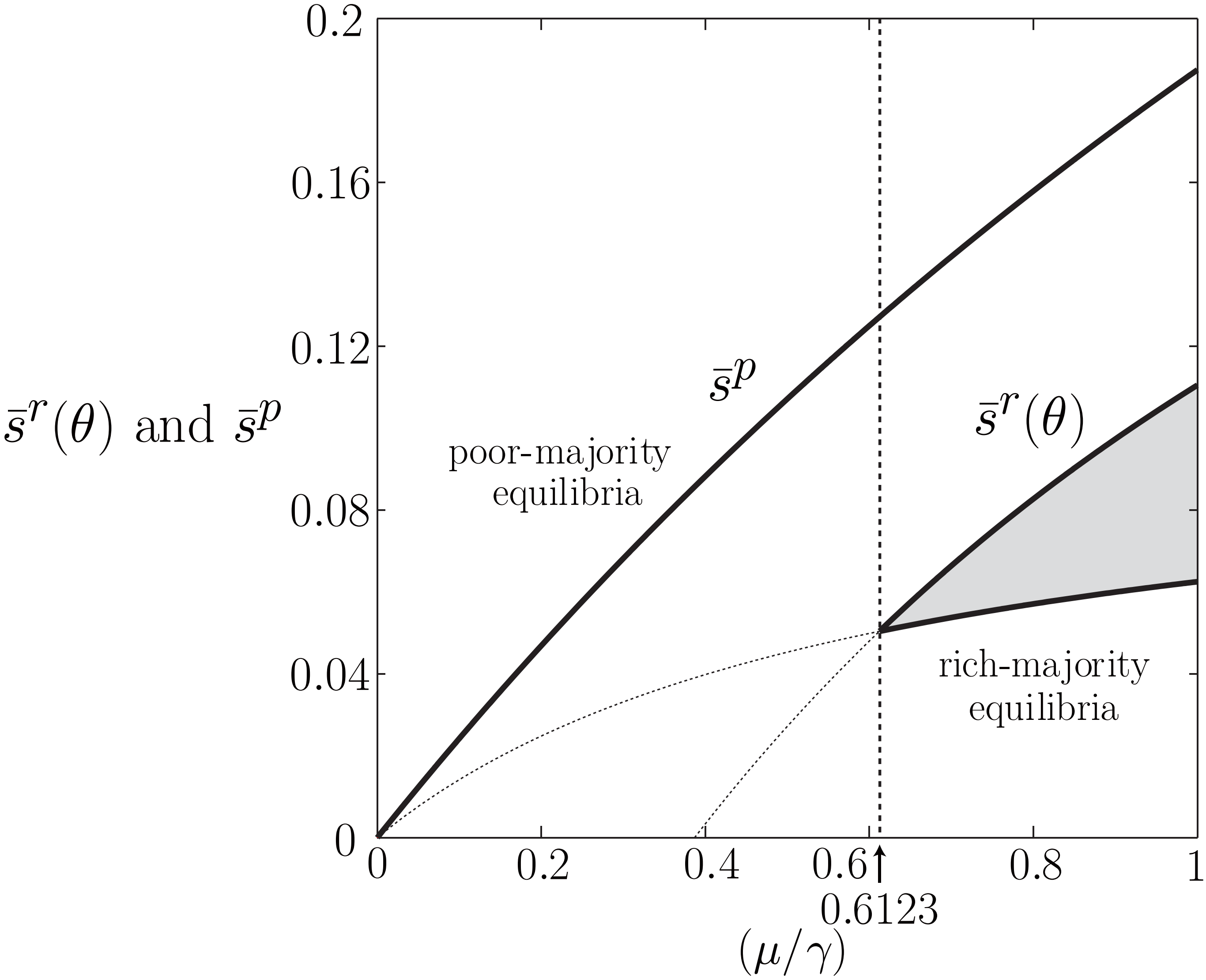

Figure 12: Size of transfer in the steady state.