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Taxation, Growth and Fiscal Institutions

A Political and Economic Analysis

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In Memoriam

Anthony K.C. Lee.

"For that which you love most in him may be clearer in his absence,

as the mountain to the climber is clearer from the plain"

*Kahlil Gibran, Friendship (*in *The Prophet, 1923)*

Foreword

It was Thorstein Veblen who remarked that the motivator of academic research is "idle curiosity." One may well conclude that recent writings in the leading economic journals have moved increasingly in that direction. Of course, idle curiosity is no sin, but one expects more from those who contribute to the economic literature. That is, we can hope at least occasionally for the emergence of what Benjamin Franklin dubbed "useful knowledge." Although such contributions are not nonexistent or even strikingly rare, they are hardly common.

This book has succeeded in moving us toward both goals—the provision of observations that satisfy the innovator's curiosity and the presentation of knowledge that, indeed, can be useful. The topic is the vitally important relationship between inequality and growth and the role institutions play in this relationship. All of this is a matter that apparently works in (at least) two directions: The degree of inequality presumably affects an economy's growth rate, while growth, with its promise for reduction of poverty, is clearly the most powerful instrument for the purpose.

This study makes use of both theoretical analysis and empirical evidence and thereby can serve as a model for further work in the area for scholars with different orientations, in terms of preferred research methods. Moreover, it offers insights for the formulation of effective public policy. In short, it is a piece well worth study both by those whose primary scholarly concern is promotion of the public welfare and by those who seek to improve their mastery of sophisticated research instruments.

From the long-run point of view, it surely is arguable that there is no more important task for economic research than investigation of avenues for the promotion of growth. Here it has long been argued that the role of institutions is crucial, since they can either provide the necessary incentives or impose the most powerful impediments to the process. But formal analysis or systematic empirical investigation of the relationships understandably has proven difficult to carry out. Here, too, this book makes an invaluable contribution, using, as the author describes it, "a dynamic general equilibrium framework" and employing econometric techniques to adapt the analysis to the facts of reality. This, in itself, is surely a significant step forward and, as such, it is well worth careful study by my professional colleagues. In closing, let me remind the reader that my own recent research has focused on the microtheory of economic growth.[1] Consequently, I value the empirical contributions, such as those supplied in this book, for bringing more "reality" along with more evidence to the subject.

New York, USA William J. Baumol

[1]Some of his recent contributions to this literature are: Baumol, WJ, et al (2011) Innovative Entrepreneurship and Policy: Toward Initiation & Preservation of Growth, Contributions to Economics, Springer Publications, Baumol, WJ (2010) *The Microtheory of Innovative Entrepreneurship*. Princeton University Press, Baumol, WJ, Strom, RJ (2007) Entrepreneurship & Economic Growth, Strategic Ent J, 1(3–4), 233–237.

Preface

The causal relationship between growth and inequality is complex, and there have been many scholarly works to study this relationship since the seminal work of Kuznets (1955). Few recent studies in this field have shown that the nature of relationship is multifaceted and non-linear. In addition to the intrinsic non-linear nature of the relationship, government and institutions play a pivotal role in distributing the benefits of growth to reduce inequality. The responsiveness greatly depends upon a country's initial conditions in terms of inequality and the nature of democracy prevailing in that country. This book highlights the role of institutions in explaining the gulf between inequality and growth.

Our method for exploring the role of institutions uses a dynamic general equilibrium framework and econometric techniques. Econometrically, two important hypotheses are tested. First, holding fixed institutions, the growth rate increases as inequality decreases. Second, holding fixed inequality, improvement in the integrity of fiscal institutions results in higher economic growth.

This book examines the connections among taxation, growth, and fiscal institutions in an overlapping generations production economy. In this economy, agents with different productive abilities vote for a proportional tax rate on labor income to finance a lump sum welfare transfer. In equilibrium, the size of the transfer is inversely proportional to the median–mean ability ratio. Time–consistent fiscal policy yields a higher tax rate than that of a Ramsey equilibrium in which policy commitment is possible. Fiscal institutions are modeled as trigger mechanisms in a dynamic tax game, in order to support inter–generation cooperation. A simulation example quantifies the effectiveness of the fiscal institutions of 20 OECD countries. Cross-section growth regressions confirm the hypothesis that strong institutions are pro-growth.

This analysis will be useful to scholars and policymakers in the fields of economic growth and development, public policy and economic modeling.

Washington DC, USA Albert J. Lee

Acknowledgements

This book is based on my unpublished doctoral dissertation at the University of California, Los Angeles (Lee 1999). I thank Costas Azariadis for directing my attention to the importance of this growing literature. Many colleagues provided useful criticisms and insights. In particular, I thank Michael Akemann, William Baumol, John Fahr, Fabio Kanczuk, Konstantina Kiousis, Robert Plunkett, John Riley, Grant Taylor, Kam Ming Wan, and seminar participants at UCLA and University of Miami. During its revision, I received valuable assistance from Mark Cottrell, Charles Datta, Thomas Lee, Corey West, and Paras Sharma. I alone am responsible for any mistakes.

Contents

Chapter 1
Introduction

Abstract This chapter provides a recent survey of literature on inequality and economic growth. The contemporary literature suggests that there is a complex relationship between growth and inequality and that the level of initial inequality plays an important role in defining the nature of the causal relationship. The path of the causal relationship between inequality and growth, and vice-versa, remain an area of active research. This chapter summarizes the recent theoretical advancements in this literature and identifies the role of institutions to play in explaining the causal relationship between inequality and growth. It highlights the role of fiscal institutions and emphasizes that inequality by itself is not sufficient to cause slower growth. A dynamic general equilibrium model is developed in the subsequent chapters, and the role of fiscal institutions on growth is assessed using statistical techniques. A Markovian solution is imposed on the structure of the model to overcome the problem of multiple equilibria.

Keywords Dynamic general equilibrium • Fiscal policy • Growth • Inequality • Institutions • Multiple equilibria • Political economy • Tax game

The economic profession has expended much of its prodigious energy puzzling over the connections between inequality and growth. This inquiry traces back at least to Kuznets (1955), who observed that inequality first increases during the early stages of economic growth. However, as economic development takes hold, inequality generally decreases. This expression that inequality is non-linear in economic growth is known as the Kuznets hypothesis. The early thinking concerning the effects of inequality on growth suggested that greater inequality might be good for growth. Early research (Kuznets 1955; Kaldor 1957; Bourguignon 1981) suggests that the marginal propensity to save among the rich is higher than among the poor, implying that a higher degree of initial inequality will yield higher aggregate savings, capital accumulation, and growth. A number of empirical studies provide evidence supporting this hypothesis (Barro 2000).

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A growing literature has developed, evaluating the theoretical plausibility and empirical evidence for a reverse causality, holding that growth is a function of inequality. In an article entitled "Inequality is Harmful for Growth," Persson and Tabellini (1994) provided a modern foundation for this line of inquiry. In their seminal article, the two authors linked distribution of income with economic growth. Their conclusion that inequality is harmful to growth is based upon the hypothesis that in democracies an unequal distribution of income creates political pressure to redistribute wealth. Taxation that finances these welfare transfers also distorts investment and work incentives, which ultimately slows growth. Other earlier contributors to this literature include Alesina and Rodrik (1994) and Krusell et al. (1997).

The Persson and Tabellini article is hardly the last word on this important topic. Instead, it inspired a decade of vigorous debate covering both the theory and the evidence of causality between inequality and growth. This literature provides conflicting theories and evidence and requires careful reading. In terms of empirics, Deininger and Squire (1996) find no systematic evidence to support the claim that income inequality slows economic growth. Structural estimates reported by Perotti (1996) also do not support the assertion that inequality slows growth. In a cross-section panel, Barro (2000), too, fails to find any evidence that lends support to Persson and Tabellini's hypothesis. In short and medium terms, Forbes (2000) even concludes that income inequality has a significant positive relationship to economic growth.

A number of recent articles refine the understanding between inequality and growth. For example, in the empirical literature, non-linearity has emerged as a potential explanation for the causal disconnect. Iradian (2005) provides cross country evidence linking inequality, poverty, and growth. Her results from a panel regression suggest that in the short–to–medium–term, an increase in a country's level of income inequality may have a positive relationship with subsequent economic growth. In the long term, however, inequality has an adverse impact on growth. Echoing Iradian's long– and short–term distinctions, Lin et al. 2009 formally examine the non-linearity between inequality and growth. Using a switching regression model, they establish that increase in inequality slows growth in low-income countries but accelerates growth in high-income ones.[1]

Separately, the theoretical literature points to a missing link between inequality and growth that provides new insight to Persson and Tabellini's original contribution. In a literature best described as modern political economy, several recent

[1] The literature offers many other hypotheses. For example, using nonparametric regression, Frazer (2006) finds little evidence supporting the Kuznets hypothesis in a cross-country comparison. Banerjee and Duflo (2003) identify non-linearity as key in reconciling different estimates of the relationship between growth and inequality in the literature. Bandyopadhyay and Basu (2005) show that countries with skill-intensive technology, low barriers to knowledge spillovers, and high degrees of redistribution have a positive growth-inequality correlation. Lacking these characteristics, this correlation is negative. Voltchovsky (2005) argues that the shape of the income distribution matters and, moreover, that inequality at the top end of the distribution is positively associated with growth. Thus, the inequality at the lower end of the distribution is negatively related to growth.

papers begin to examine the roles of government in these arguments. Contrasting the US and the European countries, Alesina and Angeletos (2005) observe that different political systems may respond very differently to inequality. Consequently, these systems may lead to multiple equilibria and steady states, even if there are no intrinsic differences in economic fundamentals between the US and the European countries. Supporting this view, Bjørnskov (2005, 2008) offers evidence that inequality is negatively associated with growth under left-wing governments and positively associated with growth under right-wing governments. This is said to be so because left-wing governments' tolerance for inequality is less than that of right-wing governments. This difference in tolerances could lead to different redistributive policies with different growth implications.

This book attempts to design a model that captures these recent theoretical developments formally. It provides an institutional explanation of the inequality–growth nexus. It begins by providing a reexamination of Persson and Tabellini's seminal work. Specifically, it critically evaluates their controversial assumption that policies can be perfectly linked into future periods. This assumption oversimplifies the connection between income inequality and growth and therefore leads to conclusions that do not comport with the evidence. We will show that without the perfect commitment assumption, inequality by itself is insufficient to cause slower growth.[2] Instead, we introduce two new factors into redistributive politics: first, the mean–median ratio of asset distribution to quantify inequality; second, intertemporal cooperation to measure the degrees of policy commitment.[3] We argue that these two factors are necessary to specify correctly the connections between inequality and growth.

We first derive a dynamic general equilibrium model that describes the selection mechanism of redistributive tax rates. The equilibrium is a function that maps asset inequality and the level of intergenerational cooperation to fiscal policies. A calibrated metric, *institutional parameter*, is proposed to measure the level of intertemporal cooperation. By varying inequalities and this parameter, this function explains the variation of redistributive tax rates across economies.

Second, using the calibrated institutional parameter, the analysis quantitatively evaluates the impact of fiscal institutions on growth by way of growth regressions. While many others have included political variables in their growth regressions, these are usually subjective and not based on explicit theory.[4]

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[2] Alesina (1988) examines the importance of commitment of policy formation in a two-party system. Although the motivations are different, the format of his solution is similar to ours. See Chap. 2 "Environment and Equilibrium" for a comparison.

[3] Barro (2000) refers to this as countries' "tastes for redistribution."

[4] Barro (1991) established the tradition within the empirical growth literature of including policy variables. See, Knack and Keefer (1995) and Fedderke and Klitgaard (1998) for critical evaluations. Persson (2003) examines cross-sectional fiscal performance focusing upon individual countries' features of government, including presidentialism, majoritarianism, and proportional representation. The proposed institutional parameter is based upon a structural model and has demonstrated considerable explanatory power concerning long-run economic growth.

The modeling strategy and the equilibrium concepts in this book are standard in economics. To examine both the economic and the political equilibria, this analysis embeds a general equilibrium model in a dynamic tax game. The economic environment is a production economy with an infinite horizon, populated by overlapping generations of heterogeneous agents with two-period lives. These agents work and vote when young and only consume in old age. They are atomistic and lack bequest motives. As consumer–voters, these agents behave competitively and cooperate only when motivated by enlightened self-interest.[5]

In a dynamic tax game, a young agent with the median characteristics is chosen each period to determine the fiscal policy. The resulting tax receipts finance budget–balancing, lump–sum transfers to the young. Without policy commitment, voting decisions are sequentially optimal. This allows different generations to cooperate through the enforcement of trigger strategies. However, it is unclear how voters coordinate to select an equilibrium policy among a continuum of possibilities.

We overcome the problem of multiple equilibria by imposing a structural Markovian solution in a closed-loop equilibrium. The structural form serves as a metric in the policy space to measure the distance between the theoretically highest sustainable tax rate and the fiscal policy actually implemented. The difference is determined via the intergeneration cooperation attributable to fiscal institutions.

The reminder of the book begins with Chap. 2 "Environment and Equilibrium," which lays out the theory and solution methods for the dynamic tax game. Chapter 3 "A Parametric Example" parameterizes the model, chooses a Markovian solution, and discusses methods of calibration. Chapter 4 "An Empirical Appraisal" presents the results of a cross-sectional study. A brief summary concludes the discussions.

[5]In contrast to Alesina and Angeletos (2005), our agents do not care about distributive fairness.

Chapter 2
Environment and Equilibrium

Abstract This chapter models the connections between the redistributive tax rate and income inequality in a dynamic tax game embedded in an overlapping generation model with heterogeneous agents. In the first period, agents vote and work; in the second period, they consume. The source of heterogeneity within the same generation is endorsed due to differences in labor efficiency among the agents. The existence and stability of the political–economic equilibrium is shown to exist. In accordance to the wishes of the median voter, government redistributes the tax revenue completely to the young. This process is repeated in subsequent time periods. Each agent, based on his selection of policy, maximizes his lifetime indirect utility, subject to his personal constraints. Nash equilibria are sub optimal, under the assumption of sequential rationality. Hence, agents have an incentive to cooperate.

Keywords Cooperation • Coordination • Dynamic general equilibrium • Median voter • Nash equilibrium • Policy commitment • Ramsey equilibrium • Two-period overlapping generations model

In a two–period–lived overlapping generations model, we consider heterogeneous agents who vote and work when young and consume when they are old. Assuming no population growth, agents born in period t (superscript) maximize a time-separable utility function:

$$U(l_t^t) + \beta U(c_{t+1}^t), \tag{2.1}$$

where subscripts denote calendar time. Specifically, l_t^t and c_{t+1}^t denote, respectively, an individual agent's leisure at period t and his consumption at period $t+1$.

Agents have identical preferences. It is further assumed that the period utility function $U(\cdot)$ is continuous, twice differentiable, and strictly concave. Agents discount future utility by a subjective discount rate $\beta \in (0,1)$. Both consumption and leisure are normal goods. Moreover, we assume that the marginal utility of each argument tends to infinity as the limit of the argument tends to zero.

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The only source of heterogeneity within the same generation is the index of agents' ability endowment of labor efficiency units, e. It is distributed in the population according to a known and time–invariant distribution, $\Gamma(e)$, which satisfies the assumptions noted next.

Assumption 2.1: Heterogeneity.

$$\int_{\underline{e}}^{\bar{e}} \mathrm{d}\Gamma(e) = 1,$$

$$\int_{\underline{e}}^{\bar{e}} e\mathrm{d}\Gamma(e) = 1,$$

$$\int_{\underline{e}}^{e^m} \mathrm{d}\Gamma(e) = 1/2,$$

where $e^m < 1$.

The first equation of Assumption 2.1 indicates that $\Gamma(e)$ is well–defined on the interval $[\underline{e}, \bar{e}]$, where $\underline{e} > 0$.[1] The second equation normalizes the mean of the distribution to one. The third equation restricts our attention to the class of distributions where the median is less than the mean.

Each agent is endowed with a normalized unit of time to be allocated between leisure, l_t^t, and work, n_t^t, in his first period of life. Depending on his ability endowment, e, each unit of n_t^t earns an effective wage rate, eW_t. The only store of value in this economy is capital investment in a competitive capital market. Each unit of consumption good invested yields a (pre-tax) factor rate, R_{t+1}. We note that there are no gains from trade between agents.[2] An agent's asset holding at date t is denoted by a_t^t. We write his time constraint, first–, and second–period budget constraints, respectively, as

$$\begin{aligned} &l_t^t + n_t^t \leq 1, \\ &a_t^t \leq eW_t n_t^t (1 - \tau_t) + T_t, \\ &c_{t+1}^t \leq a_t^t R_{t+1}(1 - \tau_{t+1}), \end{aligned} \tag{2.2}$$

where W_t, R_{t+1}, τ_t, and T_t are , respectively, the wage rate, the interest factor, income tax rate, and a lump–sum transfer—all suitably time–subscripted.

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[1]The support of the distribution need not be finite or bounded for our results to hold.

[2]Since young agents are identical up to endowment, it is clear that in an environment without uncertainty there are no gains from trade among agents of the same generation. We further assume that this is a classical economy, so there is no role for paper money.

There is a continuum of individuals in this economy. Factor markets are competitive. Capital, labor markets, and the political process determine interest, wage rates, and fiscal policies, respectively. Agents take prices and policies parametrically.

Firms possess a constant–returns–to–scale (CRS) production technology, specified as $F(K_t,N_t) = Y_t$. Without loss of generality, we assume that there is a continuum of firms, normalized to size one. These firms produce consumption goods by employing efficiency labor and capital. The two–factor aggregates are denoted as:

$$N_t = \int_{\underline{e}}^{\bar{e}} n_t^t e \mathrm{d}\Gamma(e),$$

and

$$K_t = \int_{\underline{e}}^{\bar{e}} k_t \mathrm{d}\Gamma(e).$$

We further assume that both the wage rate, $W_t = \frac{\partial F(\cdot)}{\partial N_t}$, and the interest factor for all t is given as $R_t = \frac{\partial F(\cdot)}{\partial K_t}$.

Government exists to implement the wishes of the pivotal voters. It only redistributes income, i.e., it issues neither debt nor provides any public goods. Government levies a proportional tax, τ_t, against output, Y_t. It balances its budget by providing a lump–sum transfer, T_t, to the existing young. We express the government's budget constraint as:

$$T_t = \tau_t Y_t. \tag{2.3}$$

Policies are said to be feasible if equation (2.3) holds.

2.1 The Political–Economic Equilibrium

A political–economic equilibrium satisfies three conditions:

1. *Competitive economic equilibrium:* Given any feasible policies and factor prices, economic decisions are optimal for agents; given feasible policies, prices are set to clear markets;
2. *Political equilibrium:* The policy implemented in each period is (weakly) preferred to any other feasible policy by a majority of the voters; and
3. *Rationality of expectations:* The expectations of individuals in their roles as economic agents and voters are fulfilled.

2.2 Competitive Economic Equilibrium

Since capital investment is the only asset in this economy, a perfect foresight competitive equilibrium is defined as follows:

Definition 2.1: A Competitive Equilibrium. Given a vector of policy, $\{\tau_t, T_t\}_{t=1}^{\infty}$, a competitive economic equilibrium consists of a vector of prices, $\{W_t, R_t\}_{t=1}^{\infty}$, and a vector of allocations, $\{l_{i,t}^t, n_{i,t}^t, c_{i,t+1}^t\}_{t=1}^{\infty}$, $i \in [\underline{e}, \bar{e}]$, such that (a) given the policy and price vectors, the vector of allocations maximizes both agents' utilities for all i and firms' profits, (b) the vector of prices is consistent with cleared goods and factor markets, and (c) the government budget is balanced in each period.

Assuming non-satiation, equation (2.2) hold as strict equalities in equilibrium. Taking parametrically the after–tax wage rate, $\tilde{W}_t \equiv W_t(1-\tau_t)$, the after–tax interest factor, $\tilde{R}_{t+1} \equiv R_{t+1}(1-\tau_{t+1})$, and transfer, T_t, the optimal labor supply is the solution to the first order condition,

$$U'(1-n_t^t) = \beta U'\left(\left(n_t^t e\tilde{W}_t + T_t\right)\tilde{R}_{t+1}\right) e\tilde{W}_t\tilde{R}_{t+1}.$$

The optimal labor–leisure and saving decisions are respectively described by two functions:

$$n_t^{*t} = \mathbf{n}\left(\tilde{R}_{t+1}, \tilde{W}_t, T_t\right),$$

and

$$a_t^{*t} = \mathbf{z}\left(\tilde{R}_{t+1}, \tilde{W}_t, T_t\right).$$

Because fiscal decisions distort labor supply decisions, there is a threshold ability, e_t° (below), which allows agents to subsist on welfare alone and provide zero hours of work, i.e.,

$$e_t^{\circ} = \frac{1}{\beta\tilde{W}_t\tilde{R}_{t+1}} \frac{U'(1)}{U'\left(T_t\tilde{R}_{t+1}\right)}.$$

We express $e_t^{\circ} = \mathbf{e}(\tilde{R}_{t+1}, \tilde{W}_t, T_t)$. The aggregate labor supply comes from the population that remains in the work force, given factor prices and polices, i.e.,

$$N_t = \int_{e^o}^{\bar{e}} n_t e \mathrm{d}\Gamma(e).$$

One additional equation, the capital market clearing condition, is necessary to complete the description of an economic equilibrium is the capital market clearing condition. Recall that a_t^t is the asset holding for an agent at time t. Thus, the aggregate saving at time t is denoted by:

$$A_t \equiv \int_{\underline{e}}^{\bar{e}} a_t^t \mathrm{d}\Gamma(e).$$

Capital market clearing implies that today's aggregate saving equals tomorrow's aggregate capital stock, K_{t+1}—i.e.,

$$K_{t+1} = A_t. \tag{2.4}$$

2.3 A Perfect Foresight Political Equilibrium

This section considers any voting rule that allows a pivotal individual to choose a tax rate τ_t for $t > 0$. Before the definition of an equilibrium policy, we describe the policy choice problem confronting young voters. In an environment where future decisions and allocations cannot be committed, these policy choices and allocations must be individually optimal at each period. The sequentially optimal nature of the equilibrium makes the timing of the actions of agents and the government crucial to this analysis. Events unfold thus: Once all young agents in period t have made their allocation decisions, the government, according to the wishes of the pivotal voter in the same period, will impose tax τ_t upon the current output, Y_t. The tax revenue, T_t, is instantaneously redistributed wholly to the young, while the existing old consume. In period $t+1$ the game repeats.[3] The policy voted by each agent is individually optimal, in the sense that such a policy maximizes his lifetime (indirect) utility subject to his personal constraints and the feasibility of policy.

We first examine an open-loop rational expectations policy equilibrium. In this equilibrium, voters take the policy decisions of their predecessors as given. In addition, voters at period t will limit their voting decisions to those they *perceive* to be consistent with their expectations of future policies.[4]

Definition 2.2: An Open-Loop Rational Expectations Equilibrium. Given a record of all the previous policies, and the rational expectations of future policies, an agent chooses $\tau_{i,t}$, $\forall i \in [\underline{e}, \bar{e}]$, $t = 1, 2, \ldots$ such that his lifetime utility is maximized and $\tau_{i,t}$ is feasible.

We introduce several key accounting notations. Recall that at each date, t, there exists a continuum of voters, defined on a closed interval $[\underline{e}, \bar{e}]$. Let i be an individual index, i.e., $i \in [\underline{e}, \bar{e}]$. Each young agent i at date t chooses a tax rate between zero and one. Let us denote an individual voter's strategy set as the closed interval $I_{i,t} \equiv [0, 1]$. Let $I_t \equiv \prod_{i \in [\underline{e}, \bar{e}]} I_{i,t}$ be the joint strategy set of all voters at time t, and likewise let $I \equiv \prod_{t=1,2,\ldots} I_t$ be the product of these joint strategy sets across the infinite horizon. The dynamic tax game is defined by four elements.

[3]The games played at period t and $t+1$ are not identical, in that the payoffs are different. That is, this super-game is dynamic, not just repeating.

[4]To derive the policy decisions in this equilibrium, we make use of the language of dynamic game theory. In particular, we employ the notation devised by Friedman (1990).

Definition 2.3: A Dynamic Tax Game.

$$G = ([\underline{e},\bar{e}], I, P, \beta).$$

Denote an agent's subjective discount factor as β, and the lifetime payoff function as P. Before the definition of P, recall that in the two–period, overlapping generations model, agents maximize a utility function of the following form:

$$U(l_t^t) + \beta U(c_{t+1}^t),$$

subject to equation (2.2). In the most general version of the game, an agent's single-period payoff functions, defined over strategies, take all previous actions as arguments. Denote a vector of all previous actions at date t as a history of the game, $h_t = \{\tau_0, \tau_1, \ldots, \tau_{t-1}\}$, where $\tau_s \in I_s$, and $s = 0, \ldots, t-1$. Correspondingly, we define the single–period payoff function of voter i at date t as:

$$\pi_{i,t}(\tau_t, h_t),\ \forall i \in [\underline{e},\bar{e}],\ t = 1, 2, \ldots, \tag{2.5}$$

where $\pi_{i,t}(\tau_t, h_t)$ is assumed to be increasing and concave in $\tau_{i,t}$ for all i and t. Equation (2.5) signifies that an agent's period payoff is a function of his cohort's actions and *all* the actions taken in the past.

2.4 Capital Stock as a State Variable

Next, we provide a sufficient condition under which the single-period payoff function for voters can be specialized to one which takes the level of current capital stock, K_t, as a summary statistic for the history of the game. This restriction substantially reduces the dimensionality of the single-period payoff function.

Consider a version of the payoff functions that take as arguments today's and yesterday's policy decisions. Replacing h_t by its last element, the payoff functions in equation (2.5) can be expressed as:

$$\pi_{i,t}(\tau_t, \tau_{t-1}),\ \forall i \in [\underline{e},\bar{e}],\ t = 1, 2, \ldots. \tag{2.6}$$

We define the super–game payoff, P, as a discounted stream of these restricted single–period payoffs.

Definition 2.4: Game Payoff Function. Let $P_{i,t}(\tau_{t-1}, \tau_t, \tau_{t+1}) = \pi_{i,t}(\tau_\mathbf{t}, \tau_{t-1}) + \beta \pi_{i,t+1}(\tau_{t+1}, \tau_t)$ be the dynamic game payoff function, $\forall i \in [\underline{e},\bar{e}]$, $\forall t = 1, 2, \ldots$.

The following stationarity assumption further simplifies the super–game payoff:

Assumption 2.2: Stationarity. Individual preferences, $U(\cdot)$, and the distribution of abilities, $\Gamma(e)$, are stationary.

These stationarity assumptions and the hypothesis of the uniqueness of the pivotal individual enable us to drop both the individual index and the time subscripts, which are associated with the super–game payoff, i.e.,

$$P(\tau_{t+1}, \tau_t, \tau_{t-1}),$$

where $\tau_t \in [0,1]$.[5]

The following statement characterizes the nature of an open–loop, non–cooperative equilibrium for this dynamic tax game:[6]

Proposition 2.1: A Characterization Theorem. $\{\tau_0^*, \tau_1^*, \tau_2^*, \ldots\} \in \tau_0^* \times \prod_{t=1,2,\ldots} I_t$ *is an open-loop non-cooperative equilibrium for a game satisfying Assumption 2.2 if and only if*

$$P(\tau_{t+1}^*, \tau_t^*, \tau_{t-1}^*) = \mathrm{Max}_{\tau_t \in [0,1]} P(\tau_{t+1}^*, \tau_t, \tau_{t-1}^*),\ \forall t = 1, 2, \ldots. \tag{2.7}$$

In addition to providing an algorithm to compute the optimal tax rate for the pivotal voter, Proposition 2.1 asserts that his individually optimal tax rate is a function of two arguments: the tax rate decided in the last period, τ_{t-1}, and the equilibrium tax rate to be selected in the succeeding period, τ_{t+1}. Therefore, the subset of open–loop, non–cooperative solutions of the game G with payoff function P has the form:

$$\Psi(\tau_{t+1}, \tau_{t-1}) \subset [0,1].$$

In particular, a solution to a sequence of tax rates is an element of the above correspondence,

$$\tau_t^* \in \Psi(\tau_{t+1}^*, \tau_{t-1}^*),\ \forall t = 1, 2, \ldots. \tag{2.8}$$

Since we are ultimately concerned with such a political economy in the steady state, the dynamic properties of the open–loop, non–cooperative equilibrium sequence are important for our analysis. We adopt the following technical assumption, which ensures the existence of a uniquely stable steady state for equation (2.8).

Assumption 2.3: The Lipschitz Condition. $\Psi(\tau', \tau'')$ is a single–value function that obeys the following:

$$\|\Psi(\tau_{t+1}, \tau_{t-1}) - \Psi(\tau'_{t+1}, \tau''_{t-1})\| \le \lambda_1 \|\tau_{t-1} - \tau''_{t-1}\| + \lambda_2 \|\tau_{t+1} - \tau'_{t+1}\|,$$

where $\lambda_1 + \lambda_2 < 1$, $\forall \tau_{t-1}, \tau''_{t-1}, \tau_{t+1}, \tau'_{t+1} \in [0,1]$.

---

[5] The arguments of P are now scalars, which are policy decisions of the next period, the current period, and the last period, respectively. Since it is understood that only the pivotal individual's decision matters to the policy choice, we suppress his individual subscripts. Also, the pivotal voter's characteristics are stationary, as the distribution of abilities is stationary. Hence, the time–subscripts are irrelevant.

[6] The proofs of the following Proposition 2.1 and other propositions are in Appendix A.

Heuristically, Assumption 2.3 requires that the changes in the equilibrium policy cannot be too rapid.

The following proposition guarantees the existence of an open–loop, non–cooperative equilibrium.

Proposition 2.2: An Existence Theorem.

$$\Psi(\tau_{t+1},\tau_{t-1}) \neq \emptyset,\ \tau_{t+1},\tau_{t-1} \in [0,1],\ \forall t = 1,2,\ldots.$$

The next statement, which characterizes the dynamic properties of the open–loop equilibrium, is due to Friedman (1990).[7]

Proposition 2.3: The Existence of a Uniquely Stable Steady State. *If the equilibrium correspondence of a dynamic game G satisfies the Assumption 2.3, then there exists a unique, steady–state equilibrium. In particular, there exists a unique* $\tau' \in [0,1]$ *such that if* $\tau_0 = \tau'$, *then* $\{\tau',\tau',\ldots\}$ *is an open–loop, non–cooperative equilibrium. Moreover, given any initial tax rate,* $\tau_0 \in [0,1]$,

$$\lim_{t\to\infty} \tau_t^* = \tau'.$$

The steady–state tax rate is the solution to the following fixed–point problem:

$$\tau' = \Psi(\tau'). \tag{2.9}$$

If equation (2.9) satisfies the Lipschitz condition, then the equilibrium correspondence under consideration constitutes a contraction mapping, which maps from the closed interval [0,1] to itself. It is well known that a uniquely stable fixed point exists for this type of contraction mapping.[8,9]

Once the existence and the dynamic properties of an open–loop, non–cooperative tax sequence of this simpler version of the tax game are ascertained, we turn to the issue of the decision aggregating mechanism at each stage of game t. In particular, we identify the characteristics of the pivotal voter.

Given the knowledge of τ_{t-1}^*, and a perfect foresight of τ_{t+1}^*, an agent i at date t will vote for a tax rate to maximize his lifetime payoffs—i.e.,

$$\tau_{i,t}^* = \text{ArgMax}_{\tau_t\in[0,1]} P_{i,t}.$$

[7]See Friedman (1990), page 165, Theorem 5.1.

[8]See, for example, Stokey and Lucas (2005). The existence and stability of a long–run equilibrium tax rate confine our focus to the consideration of the steady–state tax rate.

[9]The existence, uniqueness, and stability of the steady state equilibrium enable us to calibrate a parameterized version of this model to match long–run features of actual economies.

By a modified version of the Median Voter Theorem, we infer that the pivotal voter is at the median of the distribution of abilities.[10] This result is stated formally as follows:

Proposition 2.4: A Median Voter Theorem. *At each period t, given τ^*_{t-1}, a perfect foresight value for τ^*_{t+1}, and a distribution of productivity, $\Gamma(e)$, satisfying Assumptions 2.1 and 2.2,*

$$\tau^*_t = \tau^*_{m,t} > 0, \; \forall t = 1, 2, \ldots,$$

where $\tau^*_{m,t}$ denotes the individually optimal choice of the voter endowed with the median ability.

As in Meltzer and Richard (1981), we have established that in the open–loop equilibrium the relevant measure of inequality is the mean–median ratio. Therefore, an economy endowed with a positively skewed distribution of abilities suffers from a higher equilibrium tax rate than a symmetric economy.

2.5 Markovian Payoff Functions

This section shows that the restricted model is identical to single–period payoff functions that take K_t as a state variable. Before the reintroduction of the unrestricted, single–period payoff function for agent i at date t, recall that h_t is the history of the game at date t, h_t. In this environment, an agent's payoff is a function of the current decision, as well as all of the past pivotal, which are summarized in h_t. Consider the pivotal voters' payoff functions,

$$P = \pi_t(\tau_t, h_t) + \beta \pi_{t+1}(\tau_{t+1}, h_{t+1}), \; \forall t = 1, 2, \ldots.$$

Recall that at each date, t, capital stock, K_t, is a state variable with an associated law of motion, $\Phi(\cdot)$, where

$$\Phi: \; \kappa \times [0,1] \mapsto \kappa,$$
$$\Phi(K_t, \tau_t) \mapsto K_{t+1},$$

with $\kappa \subset \Re_+$. Therefore, it is assumed to be compact and convex.

With the inelastic saving assumption, in conjunction with a linear CRS production function, the law of motion can be specialized as:

Proposition 2.5: The Law of Motion of Capital.

$$\Phi(K_t, \tau_t) \equiv K_{t+1} = WN_t(K_t, \tau_t) + \tau_t K_t R. \tag{2.10}$$

[10] See Meltzer and Richard (1981) and Roberts (1975).

Equation (2.10) describes the nature of capital accumulation in this economy. Since agents save their entire share of after–tax income plus the lump sum welfare transfers, and because these transfers are financed by a redistributive tax rate levied against the total output, the capital stock next period is the sum of the aggregate wage payment and the fraction of welfare transfers that is financed by the old–to–young redistribution. Therefore, this form of redistributive taxation behaves like a reverse social security program that subsidizes the saving of the young.

Assumption 2.4: Invertibility. Φ is continuously invertible with respect to τ_t. The inverse is written as:

$$\tau_t = \Phi^{-1}(K_t, K_{t+1}).$$

Given equation (2.10), a sequence of tax rates, $\{\tau_1, \tau_2, \ldots, \tau_T\}$, and the initial conditions $\{K_0, \tau_0\}$, by iterating the law of motion forward, we obtain K_1 and, recursively, $\{K_2, \ldots, K_{T+1}\}$.

Since the inverse of the law of motion is assumed to hold, given the same pair of initial conditions and a sequence of capital stocks, $\{K_1, \ldots, K_{T+1}\}$, we obtain the sequence of tax rates, $\{\tau_0, \tau_1, \ldots, \tau_T\}$, by iterating the inverse mapping. Therefore, given these initial conditions—the law of motion and its inverse mapping—the two sequences contain the same information. In particular, K_t and τ_{t-1} are informationally equivalent for all $t = 1, 2, \ldots$.

Assumption 2.4 and the law of motion of capital establishes a correspondence between the history of the game and the history of capital stocks. Under the restriction that replaces h_t with τ_{t-1} in the single–period payoff functions, it is equivalent to consider single-period payoff functions that use the capital stock as a state variable. We summarize the preceding discussion in Proposition 2.6:

Proposition 2.6: The Equivalence of Payoff Functions.

$$\pi_{i,t}(\tau_{t-1}, \tau_{i,t}) = \pi_{i,t}(K_t, \tau_{i,t}), \ \forall i \in [\underline{e}, \bar{e}], t = 1, 2, \ldots$$

Since the restriction sets are equivalences, it follows:

Corollary 2.1: Single Period Payoff Function. *The single–period payoff functions, $\pi_{i,t}(K_t, \tau_{i,t})$, are continuous, increasing, and concave in $(K_t, \tau_{i,t})$, $\forall i \in [\underline{e}, \bar{e}]$, $\forall t = 1, 2, \ldots$.*

Since the restrictions on the sets and the functional forms are identical in the two cases, equilibrium and its dynamic properties are preserved, and the two formulations of the payoff functions are identical. Given such a restriction, it therefore is legitimate to express the single–period (Markovian) payoff at date t as $\pi(K_t, \tau_t)$.

2.6 Static Versus Dynamic

The dynamic tax game, which we have considered thus far, is analogous to a dynamic infinite Prisoners' Dilemma problem. Here we recall that the equilibrium correspondence is a function of the tax rates of the prior and the next periods. In an environment where there is no policy commitment, this equilibrium correspondence essentially requires the period decisions to be subgame perfect. In other words, the equilibrium tax rate chosen at period t must satisfy rationality restrictions imposed by *all* subsequent periods. Typically, an infinite Nash equilibrium delivers the lowest possible utility.[11]

This last point highlights the importance of policy commitment in this type of tax game. Persson and Tabellini (2000, 2003, 2004) study endogenous taxation is an overlapping generations model with parametric factor prices and policy commitment. These two assumptions jointly eliminate a subset of equilibrium policies that can be supported by trigger–type strategies. In particular, because of these assumptions the individually optimal decisions by the median voters are repeating (up to the level of existing capital stock) but not dynamic, in that subgame perfection of policy choices is irrelevant. That is, for Persson and Tabellini (2000, 2003, 2004) future decisions are of no concern to the formulation of today's policy.

2.7 A Ramsey Solution

Because of sequential rationality, infinite Nash equilibria are typically sub optimal. This gives agents incentives to cooperate. To illustrate, let us consider an analogous economy where policy commitments are possible. Following Chari et al. (1989), we model policy commitments by allowing the government to set the tax rates once and for all, after which private agents make their economic decisions accordingly. We adopt the following definition of Ramsey equilibrium for our economy:

Definition 2.5: A Ramsey Equilibrium. A Ramsey Equilibrium is a vector of policies, $\{\tau_t, T_t\}_{t=0}^{\infty}$, and a vector of allocations, $\{l_{i,t}^t, n_{i,t}^t, c_{i,t+1}^t\}_{t=0}^{\infty}$, $i \in [\underline{e}, \bar{e}]$, such that:

1. Given a vector of policies, individual allocations maximize each agent's utility subject to his budget constraints;
2. The vector of policies maximize $\sum_{t=0}^{\infty} \beta^t V(\tau_t, K_t)$, where $V(\tau_t, K_t)$ is the indirect utility function of the median voter at period t; and
3. The vector of policies is feasible at each period t.

[11] See Abreu (1988).

In particular, government solves the following policy programming problem for the steady state policy,

$$\mathrm{MAX}_{\tau\in[0,1]} \sum_{t=0}^{\infty} \beta^t V(\tau, K_t),$$

subject to

$$N_t = \mathbf{N}(\tau, K_t), \tag{2.11}$$

$$T_t = \mathbf{T}(\tau, K_t), \tag{2.12}$$

$$K_{t+1} = \boldsymbol{\Phi}(\tau, K_t). \tag{2.13}$$

$V(\tau, K_t)$ is as defined above.[12] Boldface capital letters denote the aggregate reduced forms that determine, in the order of appearance, the aggregate labor participation, the lump sum transfers (or alternatively, the government budget constraint at date t), and the law of motion for the capital stock.

This policy programming with a commitment technology essentially requires median voters of different generations to both cooperate *and* coordinate to achieve the best stationary policy.[13] Let the solution of the preceding program be denoted by τ^R. By construction, we note the following:

Lemma 2.1: The Sustainability of the Open–Loop Equilibrium. *The open-loop non-cooperative equilibrium, τ^*, is sustainable.*

This non–cooperation equilibrium is analogous to an infinite Nash equilibrium, which offers the lowest utility for median voters.

Recall that $V(\cdot)$ denotes the indirect utility of median voters.

Proposition 2.7: An Inequality. *For a given level of capital stock, $K_t > 0$, any sustainable steady–state equilibrium τ must have a utility level $V(\tau, K_t)$ greater than or equal to the utility level $V(\tau^*, K_t)$ of the non–cooperation equilibrium, i.e.,*

$$V(\tau, K_t) \geq V(\tau^*, K_t).$$

Corollary 2.2 addresses the essential difference between the Ramsey solution and the open-loop equilibrium. In an environment where a commitment technology is unavailable, the Ramsey solution is not credible. In another words, there exists at least one binding, sequentially rational restriction that rules the Ramsey solution inadmissible for the set of subgame perfect solutions. Consider Propositions 2.7 and 2.4 jointly. Immediately apparent is the following corollary:

Corollary 2.2: Inequality Condition. $\tau^* > \tau^R$*, which induces an inequality in utility $V(\tau^*, K_t) < V(\tau^R, K_t)$ for any $K_t > 0$.*

---

[12] Since we assume stationarity of $\Gamma(e)$, the indirect utility functions of each generation's median voter are identical. Therefore, the associated reduced–form function is time–subscript free.

[13] We could have considered tax sequences that are not stationary. However, in economies with constant growth rates, it has been shown that optimal policies are stationary. See Krusell et al. (1997).

Recall that h_t is a record of tax rates selected from date 0 up to date t, i.e., $h_t = \{\tau_s\}_{s=0}^{t-1}$. Following Chari et al. (1989), we define a set of revert–to–non–cooperation plans, τ^r. These plans specify the continuation of an existing policy if it has been consistently chosen in the past. Otherwise the plans specify reversion to the non–cooperation equilibrium, τ^*. Exploiting this folk–like strategy, the inequality discussed in the following section characterizes the entire set of time–consistent equilibria.

Proposition 2.8: A Folk Theorem. *As long as agents at each date t behave competitively given h_t, an arbitrary tax rate τ is a time–consistent equilibrium if and only if their lifetime utility under the arbitrary τ is higher than their lifetime utility under the non–cooperation equilibrium for any level of capital stock, i.e., $V(\tau, K_t) > V(\tau^*, K_t)$.*

Following from Proposition 2.8 is the observation that if agents care enough about their second period consumption, the Ramsey solution can be supported as a sustainable equilibrium. Formally, we state:

Corollary 2.3: Time Consistent Equilibrium. *There exists a $\bar{\beta} \in (0,1)$ such that for all $\beta \geq \bar{\beta}$ the Ramsey solution can be supported as a time–consistent equilibrium.*

Assuming the discount factor is large enough to support Ramsey equilibrium, a more substantive issue remains in the implementation of a trigger strategy. On the one hand, it has been shown that there is a great potential for fiscal institutions to foster inter–generational cooperation and thereby improve welfare. On the other hand, the theory is completely silent on the issue of coordination. Proposition 2.8 describes a large subset of possible equilibrium policies. Along with its corollaries, Proposition 2.8 specifies only the lower and upper bounds for supportable equilibrium policies, i.e., $\tau^r \in [\tau^*, \tau^R]$. These trigger–type strategies provide little practical guidance as to which policy to select.

Figure 2.1 summarizes the theoretical results by giving a graphical example of two hypothetical economies, A and B. In this depiction, economy A is endowed with a more skewed distribution of abilities. As a consequence, the Nash threat (A) renders the lifetime utility level of median voters closer to the origin. The upper right hand area bounded between the threat point (A) and the Ramsey frontier denotes all other sustainable equilibria, should the appropriate trigger strategies be applied. Let $\tau(a)$ denote the level of lifetime utility corresponding to the implemented tax policy, which is observed from data. The improvement from the threat point (A) to the actual policy,$\tau(a)$, is measured by the effectiveness of intergenerational cooperation, C(a). Similar notations describe economy B, which is endowed with a more symmetric distribution of abilities. Consequently, its threat point (B) is closer to the Ramsey frontier.

Generally, C(·) is not fixed. Given any threat point, the equilibrium, $\tau(.)$, is indeterminate. Thus, without knowing the extent of intergenerational cooperation, the connection between inequality and equilibrium tax rates is undefined in the absence of a commitment technology.

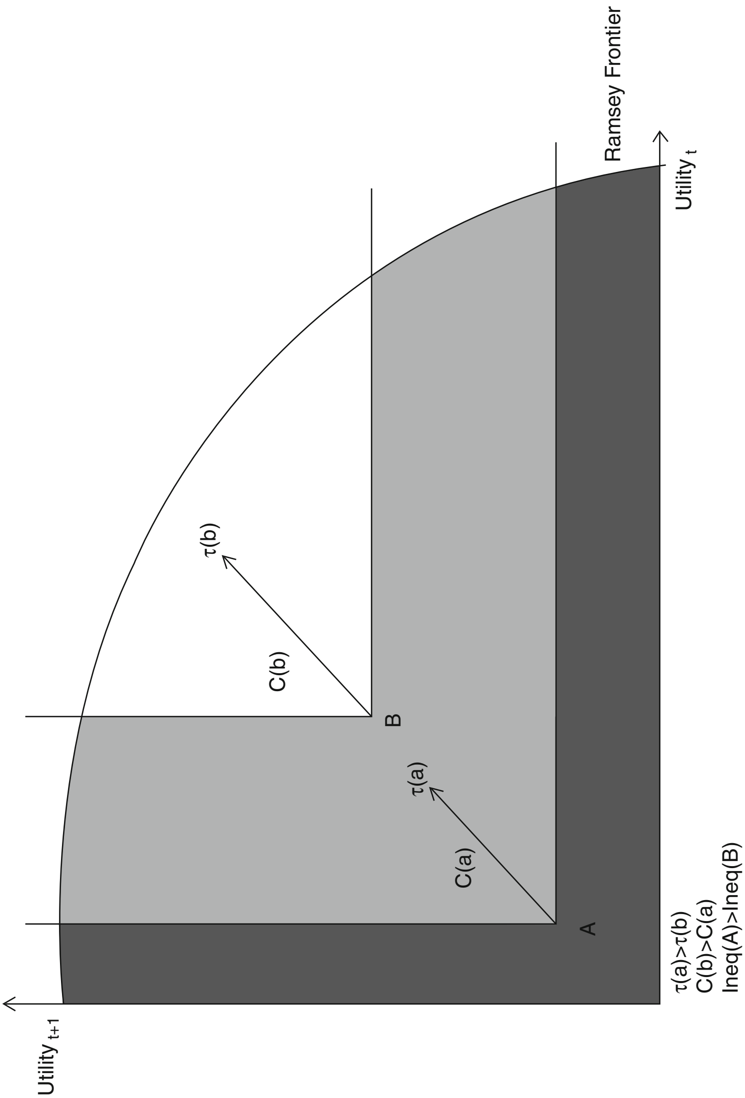

Fig. 2.1 Graphical description of two hypothetical economies

2.8 Inter–Versus Intra–Generation Interactions

There is an interesting correspondence between our model and the model in Alesina (1988). Similar to our framework, Alesina examines equilibrium policies in a dynamic environment in which commitment is unavailable. In a one–shot electoral game, rational voters expect and vote for a political party that will implement its ideological “bliss” policy without comprise. Because different political parties have different bliss points, equilibrium policies oscillate, depending on who holds power. In other words, the lack of commitment eliminates policy convergence—complete or partial—across periods in one–shot elections. However, in a repeated game, policy convergence is subgame perfect, depending on parties’ discount rates and the distance between their respective bliss points. Alesina outlines conditions under which policy convergence can occur.

Similar to our model, Alesina also shows that in repeated games, efficient, first–best, and stable policy can be a time-consistent equilibrium in a bargaining game using one–shot Nash equilibria as threats. Like ours, the enforcement mechanism is folk–like: Any observed deviation from agreed–upon policies triggers permanent non–cooperation, whereby parties revert back to the one–shot Nash equilibria forever. Therefore, this mechanism produces credible policy if the discount factor is sufficiently close to one. Moreover, given that electoral victory is probabilistic, Alesina shows that the more equal the victory probabilities (i.e., 50% in a two–party system) the more likely cooperation and policy convergence are *ceteris paribus*. In fact, so long as each party’s winning probability is positive, Pareto–improved policies (relative to one–shot Nash) are possible.

Despite these similarities, there are some obvious differences between our model and that of Alesina, particularly in the format and possible outcomes of elections. For example, the voting assumption of our model makes the young median voters pivotal in each period. It therefore could appear that these certain winners have no incentive to cooperate with the certain losers. In other words, it would seem unnecessary for the young pivotal voters to compromise with the contemporaneous old. Furthermore, in our model cooperation and coordination occur among different sets of winners *across* time periods.

These differences are stylistic and do not fundamentally alter the nature of the solution. This is because within a given generation the fraction of time a pivotal voter wins with certainty is 50%. These victories occur only when the pivotal voters are young. However, they lose with certainty the other 50% of their lives, when they are old. Probabilistically, this election framework is equivalent to Alesina’s, since political parties within the same period have equal probability of electoral victory. In other words, the effects of inter–generational cooperation can be approximated by intra–generational bargaining, and vice versa.

Chapter 3
A Parametric Example

Abstract The current this chapter provides a parametric example based on the theory developed in the previous chapter. The impact of changes in the tax rate on the desire to work is assessed. The agents maximize their lifetime, indirectly utilizing the function based upon the changes in the tax rate. It is shown that the optimal choice of tax rate is stationary and the tax rates chosen in a closed–loop regime are lower than those of open–loop equilibria. Four equations are derived to completely describe the political economy in a Markovian equilibrium. The existence of uniquely stable, steady–state equivalence relationship of the restricted payoff function provides a solution to the Markovian equilibrium, which is unique and stable. The parameters from the four equations—namely the discount factor, the ratio of median–mean ability, and the institutional parameter—are calibrated; then iterative computer simulation is performed. The simulation determines the steady–state equilibrium distribution of assets and the tax rate. The convergence and stability of the simulation are found to be consistent with the assumptions of the model.

Keywords Calibrations and simulations • Equilibrium tax rate • Institutional technology and parameter • Median-mean ability ratio

This chapter presents a parametric example that exploits the theoretical results established in the previous chapter. In particular, we exploit the existence of a uniquely stable steady state for calibration. We also make use of the equivalence relationship of a restricted payoff function to compute the Markovian equilibrium.

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3.1 The Economics

Assuming logarithmic preferences for both periods, agents' maximization problems can be written as:

$$\text{MAX}\left\{\log(1-n_t^t)+\beta\log(c_{t+1}^t)\right\}$$
subject to
$$c_{t+1}^t=\tilde{R}_{t+1}(n_t^t e\tilde{W}_t+T_t).$$

The first order condition for the optimal labor supply n_t^{*t} can be expressed as:

$$n_t^{*t}=\frac{\beta}{1+\beta}-\frac{T_t}{(1+\beta)e\tilde{W}_t}. \tag{3.1}$$

A zero tax rate implies zero transfers—in which case, (3.1) implies that all agents supply a $\frac{\beta}{1+\beta}$ fraction of their time endowment.

The second fraction of equation (3.1) has the interpretation of a tax–induced distortion of the work–leisure decision. Moreover, we note that hours worked is a positive function of ability and a negative function of transfers. Therefore, there exists a threshold ability e_t°, below which agents supply no work hours. This threshold is derived by setting $n_t^{*t}\leq 0$. In the present parameterization, the following relationship obtains:

$$e_t^\circ\beta\tilde{W}_t\leq T_t.$$

In other words, if an agent's share of endowment in present value earns him an after–tax wage rate that is less than transfers, then the optimal decision for this agent is to subsist on welfare by choosing not to work. The monotonicity of equation (3.1) in e leads to a partitioning of the population into two subsets according to ability. Recall that $[\underline{e},\bar{e}]$ denotes the support of the distribution of abilities. Thus, the expression can be stated as $[\underline{e},\bar{e}]=[\underline{e},e_t^\circ]\bigcup(e_t^\circ,\bar{e}]$, where the first subset measures the number of those who are unemployed.

We notice that tax rates have two effects on the desire to work. First, at the macro level, tax rates determine the (voluntary) unemployment level by changing the threshold level. Second, at the micro level, tax rates determine the work effort for those who remain in the work force.

Suppose the underlying distribution of abilities is an exponential distribution—i.e.,

$$\mathrm{d}\Gamma(x)=\lambda\exp\{-\lambda x\},$$

which is supported on the interval $[0,\infty)$. Normalizing the mean of the distribution to one—i.e., $\lambda=1$, we note that the median is less than the mean.[1]

Recall the government's budget constraint,

$$T_t=\tau_t(WN_t+RK_t), \tag{3.2}$$

[1]The median is approximately 0.7.

where we assume linear, constant returns to scale production technology. Then the aggregate labor supply is the solution to the following nonlinear equation:

$$N_t = \frac{\beta}{1+\beta} \exp\left\{ -\frac{\tau_t}{1-\tau_t} \frac{WN_t + RK_t}{\beta W} \right\}. \tag{3.3}$$

We write the solution as $N_t = N(\tau_t, K_t)$. It can be shown that:

Proposition 3.1: Comparative Statics of $\mathbf{N}(\tau_\mathbf{t}, \mathbf{K_t})$.

$$\frac{\partial N_t}{\partial \tau_t} < 0, \text{and } \frac{\partial N_t}{\partial K_t} < 0.$$

The logic of the first inequality is clear. The higher the tax rate, the more agents will substitute leisure for work. Also, a higher tax rate implies a higher threshold ability to participate in the work force, and thus, a greater portion of the population will choose to remain unemployed. These two facts jointly imply lower aggregate labor participation.

The second inequality stems from the property that at a given tax rate τ_t, a higher level of capital stock, K_t, implies a higher transfer, T_t (cf: equation (3.2)). Specifically, the share of transfers that is financed by an inter–generational redistribution from the old to the young increases as K_t increases. Therefore, this income effect distorts labor participation decisions.

3.2 The Politics

For the voter's problem, let V be the indirect utility function—i.e.,

$$V = \log(1 - n_t^{*t}) + \beta \log(c_{t+1}^{*t}),$$

where

$$c_{t+1}^{*t} = \tilde{R}_{t+1}(n_t^{*t} e\tilde{W}_t + T_t).$$

Applying the envelope theorem, the optimal tax rate is chosen according to the following equation,

$$\frac{\mathrm{d}V}{\mathrm{d}\tau_t} = \frac{\beta \tilde{R}_{t+1}}{c_{t+1}^{*t}} \left\{ \frac{\mathrm{d}T_t}{\mathrm{d}\tau_t} - n_t^{*t} eW \right\} = 0.$$

This first order condition implies:

$$\frac{\mathrm{d}T_t}{\mathrm{d}\tau_t} = n_t^{*t} eW. \tag{3.4}$$

Equation (3.4) identifies two cases for the open–loop solution. Consider the first case where $n_t^{*t} = 0$. The class of agents who have ability endowments less than the threshold level choose a tax rate to maximize the lump–sum welfare transfer. That is, their optimal tax rate is the solution to the following equation:

$$\frac{\mathrm{d}T_t}{\mathrm{d}\tau_t} = 0. \tag{3.5}$$

Let $\Pi^U(K_t)$ denote the optimal tax rates for the unemployed.

Agents who work will choose a tax rate that balances the marginal gain of higher welfare transfers with the marginal loss of a lower after–tax income, which is due to the higher tax rates. Let $\Pi^E(K_t)$ denote the choice of optimal tax rates for the employed.

3.3 A Markovian Solution

Let us suppose that the functional form of the optimal choice of tax rate is stationary, — i.e.,

$$\tau_t = \Pi(K_t),\ \forall t > 0.$$

By rewriting agents' indirect utility function as:

$$V = \log(1 - n_t^{*t}) + \beta \log(c_{t+1}^{*t}),$$

where

$$c_{t+1}^{*t} = R_{t+1}\left\{1 - \Pi(K_{t+1})\right\}\left\{n_t^{*t} eW(1 - \Pi(K_t)) + T_t\right\},$$

the maximal tax rate under a Markovian strategy is the solution to the following first order condition:

$$\frac{\mathrm{d}V}{\mathrm{d}\Pi(K_t)} = 0. \tag{3.6}$$

The solution to (3.6) is given next.

Proposition 3.2: The Institutional Technology.

$$\tau_{t+1} = 1 - C \times \exp\left\{-\tilde{\phi} K_{t+1}\right\},\ t = 1, 2, \ldots, \tag{3.7}$$

where $\tilde{\phi} = \frac{A_1}{A_2 A_3}$ *with*

$$A_1 \equiv \frac{\mathrm{d}T_t}{\mathrm{d}\Pi(K_t)} - n_t^{*t} eW, \tag{3.8}$$

$$A_2 \equiv n_t^{*t} eW(1 - \Pi(K_t)) + T_t = k_{t+1}, \tag{3.9}$$

$$A_3 \equiv \frac{\mathrm{d}K_{t+1}}{\mathrm{d}\Pi(K_t)}, \tag{3.10}$$

and C is a constant of integration.

Since (3.7) determines the tax rates, we refer to this function as the *institutional technology*, while and C is the *institutional parameter*.

Denote the equilibrium tax rates generated by the institutional technology as $\Pi^M(K_t)$, $\forall t = 1, 2, \ldots$. Equations (3.4) through (3.6) yield the inequalities given in the next section.

Proposition 3.3: A Ranking of Tax Rates.

$$\Pi^U(K_t) > \Pi^E(K_t) > \Pi^M(K_t).$$

This proposition asserts that, all things equal, tax rates that are chosen in a closed–loop regime are lower than those of an open–loop equilibrium. Moreover, in an open–loop equilibrium, the unemployed voters choose a tax rate that is higher than one that an employed voter will choose.

3.4 A Simulation Exercise

The political economy in a Markovian equilibrium is completely described by the following system of equations:

$$N_t = \frac{\beta}{1+\beta} \exp\left\{ -\frac{\tau_t}{1-\tau_t} \frac{WN_t + RK_t}{\beta W} \right\}, \tag{3.11}$$

$$T_t = \tau_t (WN_t + RK_t), \tag{3.12}$$

$$K_{t+1} = N_t W + \tau_t K_t R, \tag{3.13}$$

$$\tau_{t+1} = 1 - C \exp\left\{ -\tilde{\phi} K_{t+1} \right\}, \tag{3.14}$$

where $\tilde{\phi} = \frac{A_1}{A_2 A_3}$.

Equation (3.11) determines the aggregate labor participation, (3.12) equation is the government budget constraint, (3.13) equation is the law of motion of capital, and (3.14) equation, which is the institutional technology, determines the next period's tax rate, given the next period's state variable.

Essentially, these four equations describe a function that, for a given value of the institutional parameter, C, maps a space of distributions of abilities to a space of equilibrium tax rates. This mapping can be carried out by an iterative computer program using the steps given next.

1. Guess an initial tax rate $\tau^{(0)}$. Given a time-invariant distribution of abilities, $\Gamma(e)$, and an initial level of aggregate capital, $K^{(0)}$, compute the corresponding distribution of assets—say $G^{(1)}(k)$. In particular, compute the distributional characteristics relevant to the determination of the next period's tax rate, $(\tilde{\phi}K)^{(1)}$. Given a value of the institutional parameter, C, equation (3.14) yields $\tau^{(1)}$.
2. If $|\tau^{(1)} - \tau^{(0)}| \leq \delta$ for some small $\delta > 0$, then $\tau^{(1)}$ is the steady–state value of the equilibrium tax rate. Otherwise, repeat step (1) by setting $\tau^{(1)} = \tau^{(0)}$, and $K^{(1)} = K^{(0)}$.

This iterative program, among other macro aggregates, determines the steady–state equilibrium distribution of assets, $G^*(k)$, and the steady–state equilibrium tax rate, τ^*.

3.5 A Calibration Exercise

There are three unknown variables that need to be parameterized before we can proceed with our simulation exercise. They are: the discount factor, β; the ratio of median–mean ability—denoted as $\frac{e^m}{e^M}$; and the institutional parameter, C. They are calibrated to match the observed labor participation, pre-tax income distributions, and government consumption, as shares of national income, respectively.

From (3.7) we note that one of the parameters that influences the Markovian tax rates is $\tilde{\phi}K_{t+1}$. We can express $\tilde{\phi}K_{t+1}$ as $\phi\frac{K_{t+1}}{k_{t+1}}$, where $\phi = \frac{A_1}{A_3}$ (cf: (A.8) through (A.10)). This change of notations eases the task of calibration. This substitution allows us to break down $\tilde{\phi}K_{t+1}$ into two parts: $\frac{K_{t+1}}{k_{t+1}}$, which can be calibrated to match after-tax income inequalities; and ϕ, which measures the elasticities of savings to a change of tax rate. This change of variables also gives $\phi\frac{K_{t+1}}{k_{t+1}}$ an intuitive meaning that the Markovian tax rate is a function of the elasticity–adjusted asset inequality.

The ratio of mean and median asset holding can be expressed as:

$$\begin{aligned}\frac{K_{t+1}}{k_{t+1}} &= \frac{N_t^t W(1-\tau_t)+T_t}{n_t^t e^m W(1-\tau_t)+T_t}\\ &= \frac{\theta Y_t(1-\tau_t)+\tau_t Y_t}{(\frac{e^m}{e^M})\underbrace{\theta Y_t}_{(I)}(1-\tau_t)+\underbrace{\tau_t Y_t}_{(II)}}\\ &= \frac{\theta(1-\tau_t)+\tau_t}{(\frac{e^m}{e^M})\theta(1-\tau_t)+\tau_t},\end{aligned} \tag{3.15}$$

where $\theta \in (0,1)$ is the labor share of total income. Respectively, we substitute in under–braces (I) and (II) the labor share of income and the government budget constraint.

From the micro data, we observe that a typical worker works about one–third of his hours. We therefore aim to match the hours worked by an average agent to about one–third. In the case of the US data, $\beta = 0.95$ implies $n_t^t = 0.34$.[2]

The steady–state value for τ is taken to be the some long–run average of government consumption as a percentage of national income. In particular, we

[2] This calibration implies that in the absence of tax distortions, agents with the average endowment of ability work about 48% of their hours.

Table 3.1 Summary of US data

Data	Calibrated parameters
$N = 0.35$	$\beta = 0.95$
$\frac{K}{k} = 1.113$	$\frac{e^m}{e^M} = 0.787$
$\tau = 0.122$	$C = 1.769$
$\theta = 2/3$	$\phi = 0.629$

Sources: Government subsidies and transfers data are from IMF (1975–1993). The income distribution data are from Deininger and Squire (1996).

calibrate the size of taxation to match the long–run averages of governmental transfers and subsidies, which are expressed as percentages of national incomes.

The institutional parameter can be obtained from:

$$C = \text{Exp}\left\{ ln(1-\tau) + \phi \frac{K}{k} \right\}. \tag{3.16}$$

Most of the elements in equation (3.16) can be calibrated from data, except the elasticity parameter, ϕ. This parameter is determined by the structural assumptions of preferences and the distribution of abilities. We therefore calibrate ϕ by a method of iterations.[3] The steps to calibrate ϕ are given next.

1. Guess a value of C—say C^1. Equation (3.16) implies the corresponding value of ϕ—say ϕ^1.
2. Given C^1, ϕ^1 and starting values, iterate (3.11) through (3.14) until convergence. This process yields a new value of ϕ—say $\phi^{'}$.
3. Check if $|\phi^{'} - \phi^1| < \delta$ for some small $\delta > 0$. If not, update ϕ by a linear combination of the old and new values—i.e.,

$$\phi^2 = \lambda\phi^1 + (1-\lambda)\phi^{'},$$

   where $\lambda \in (0,1)$. This process produces a new value for C–say C^2. Repeat step (1).
4. Stop if $|C^n - C^{n+1}| < \delta^*$ for some small $\delta^* > 0$.

In our experience, step sizes of one–half, i.e., $\lambda = 0.5$, work well with this iterative process. We set $\delta^* = 6 \times 10^{-6}$. All observations converge with $n \leq 20$. The stability properties of this iterative process are robust to the changes of starting values and step size.

For illustrative purposes, Table 3.1 summarizes the US data.[4]

[3] See, for example, Rios-Rull (1997).

[4] Sources: Data sources are collected in Appendix B.

Table 3.2 Summary statistics for the OECD sample

	τ	$\hat{\tau}$	$\frac{K}{k}$	$\frac{\hat{K}}{k}$	$\frac{e^m}{e^M}$	C
Max	0.386	0.448	1.61	1.63	0.951	3.08
Min	0.065	0.082	1.03	1.07	0.582	1.49
Mean	0.213	0.239	1.12	1.17	0.863	1.76
Std. dev.	0.078	0.089	0.133	0.130	0.093	0.367

Correlation matrix:

Variables	τ	$\hat{\tau}$	$\frac{K}{k}$	$\frac{\hat{K}}{k}$	$\frac{e^m}{e^M}$	C
τ	1	0.996	−0.582	−0.408	0.506	−0.649
$\hat{\tau}$		1	−0.523	−0.342	0.436	−0.593
$\frac{K}{k}$			1	0.979	0.966	0.996
$\frac{\hat{K}}{k}$				1	0.969	0.957
$\frac{e^m}{e^M}$					1	−0.953
C						1

Sources: See Appendix B.
Legend: τ: Government subsidies and transfers as percentage of GDP;
$\frac{K}{k}$: Mean-median asset ratio;
e^m/e^M: Pre-tax inequality; C: Calibrated institutional parameter.
Note: Quantities with a "ˆ" are calibrated parameters implied by the model.

Table 3.3 Calibrated parameters for OECD countries (by ascending order of calibrated parameter (C))

	Data			Calibrated parameters		
Country	τ	$\frac{K}{k}$	$\frac{e^m}{e^M}$	C	$\hat{\tau}$	$\widehat{\frac{K}{k}}$
Sweden	0.30343	1.0389	0.93807	1.4890	0.33772	1.1080
Netherlands	0.38637	1.0582	0.89300	1.4951	0.44829	1.1846
Norway	0.28346	1.0382	0.94133	1.5010	0.31327	1.0979
Belgium	0.29942	1.0471	0.92617	1.5115	0.33433	1.1167
Denmark	0.24610	1.0342	0.95067	1.5187	0.26812	1.0780
Finland	0.20293	1.0413	0.94525	1.5654	0.21873	1.0721
Italy	0.26016	1.0716	0.89800	1.5948	0.29029	1.1296
Austria	0.22725	1.0696	0.90625	1.6105	0.25031	1.1137
UK	0.20562	1.0803	0.89683	1.6481	0.22588	1.1185
Germany	0.17059	1.0811	0.90190	1.6719	0.18509	1.1083
Canada	0.13535	1.0782	0.91048	1.6888	0.14485	1.0960
Ireland	0.26929	1.1270	0.82500	1.7307	0.31072	1.2033
France	0.27995	1.1315	0.81600	1.7396	0.32531	1.2150
Australia	0.17382	1.1187	0.86036	1.7527	0.19204	1.1519
USA	0.12190	1.1135	0.87680	1.7699	0.13169	1.1314
Spain	0.15565	1.1260	0.85717	1.7784	0.17128	1.1542
Portugal	0.17433	1.1335	0.84496	1.7861	0.19393	1.1688
Switzerland	0.12795	1.1731	0.82000	1.8966	0.14202	1.1976
Greece	0.17284	1.3424	0.66500	2.3451	0.21086	1.4030
Turkey	0.06533	1.6086	0.58200	3.0846	0.08169	1.6324

Sources: See Appendix B.
Legend: τ: Government subsidies and transfers as percentage of GDP;
$\frac{K}{k}$: Mean–median asset ratio;
e^m/e^M: Pre-tax Inequality;
C: Calibrated institutional parameter
Note: Quantities with a "^" are calibrated parameters implied by the model.

Chapter 4
An Empirical Appraisal

Abstract In this chapter two hypotheses are empirically tested. First, controlling for institutions, the growth rate increases as inequality decreases. Second, holding inequality fixed, a strengthening of the integrity of fiscal institutions results in increased economic growth. It is empirically shown that in the subset of democratic countries, the growth rates are negatively related to inequality and positively related to the strength of fiscal institutions. World Bank data on distribution of income are employed to test these hypotheses. Three empirical measures of government consumption—namely average government consumption as a percentage of GDP, average government consumption excluding public education and defense as a percentage of GDP, and average government transfers and subsidies as a percentage of GDP—are defined to calibrate the institutional parameters and to explain the average growth rate from 1974 to 1989 in a cross-country sample. Heteroscedasticity issues are identified and corrected using standard procedures. The regressions provide strong support for the β-convergence hypothesis. Other control variables in the regression are found to have right signs and are statistically significant. Our results suggest that after controlling for regional variations, government transfers and subsidies are harmful to growth. However, once other economic variables are controlled for, institutional arrangements in democracies that promote intergenerational cooperation positively affect long–term economic growth.

Keywords Beta-convergence • Democracy • Economic growth regressions • Income and asset inequality • Institutional parameter

Before we report the testable implications, it is instructive to recap the basic mechanisms of the model. Holding institutions fixed, in an environment where a proportional tax rate is chosen to finance lump–sum transfers, the majority vote rule implies that the equilibrium tax rate is inversely related to the median ability. In particular, the model specifies that the relevant measure of inequality is the median–mean asset ratio, or, equivalently the asymmetry of the distribution of assets. That is,

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the farther is the median asset level is below the mean level, holding institutions fixed, the higher equilibrium redistributive tax rates will be. We refer to this logical component of the theory as the Political Mechanism (I).

At a given level of inequality, an increase in inter–generational cooperation, which is engendered in stronger institutional arrangements, tempers the redistributive instinct of the median voter, resulting in a smaller redistribution from the rich to the poor. We refer to this part of the theory as the Political Mechanism (II).

Redistributive taxation reduces the steady–state income level. Hence, given a starting level of income, the theory of conditional convergence holds that the larger the size of redistribution, the slower the growth rate will be. This is referred to as the Economic Mechanism.

Therefore, two testable implications follow: First, controlling for institutions, the growth rate increases as inequality decreases; second holding inequality fixed, strengthening the integrity of fiscal institutions results in increased economic growth.

4.1 Democracy as an Identifying Assumption

The theoretical discussion, assumes that a connection exists between the will of the majority and the equilibrium. In our empirical evaluations, the inclusion of institutions may lead to ambiguities. Consider, for example, two fundamentally identically economies, say A and B. Economy A may choose a lower redistributive tax rate than economy B for one of the two reasons: Economy A is not a functioning democracy, and therefore, the median voter theorem breaks down, which implies that the connection between inequality and the equilibrium tax rate does not no long exist; or as a genuine democracy, economy A has superior fiscal institutions that promote better inter–generational cooperation than in economy B. As an identifying assumption, we include interactive terms to take into explicit consideration the nature of the individual country's political system. As a testable implication, in the subset of democratic countries we expect growth rates to be negatively related to inequality and positively related to the strength of fiscal institutions.

That said, the same relationship may exist for non–democracies, albeit at a lesser extent. Excessive inequality can indirectly affect growth though other adverse channels outside the endogenous fiscal policy paradigm. Sociopolitical instability, for example, is another way in which inequality slows economic growth.[1] Also, the institutional parameters generated for the non–democracies in our sample may correlate with other variables that enhance growth. Rule of law, government contract enforcement, and the lack of corruption, for example, are important for economic growth and are found in both democratic and non-democratic societies. Therefore, we expect the same signs in the structural equations in the subset of non-democratic

[1] See, for example, Alesina and Perotti (1992) and Benhabib and Rustichini (1996).

countries, though the coefficients of interest should be weaker in both economic and statistical significance, as compared to their democratic counterparts.

4.2 Structural and Reduced–Form Equations

For the reasons just stated, the endogenous fiscal policy with institutions approach can be summarized in the following results given next.

- *Political Mechanism (I):* Holding institutions fixed, the redistributive tax rate increases as inequality increases.
- *Political Mechanism (II):* Holding inequality fixed, the redistributive tax rate decreases as institutions strengthen.
- *Economic Mechanism:* The growth rate decreases as redistributive tax increases.
- *Reduced Form:* The growth rate increases as (1) inequality decreases and/or as (2) institutions strengthen.
- *Identification Restriction:* In particular, the reduced–form relationship should be stronger in democracies than in non–democracies.

4.3 Income Distribution Data

As is typical of empirical studies of the distribution of income, the lack of reliable data limits the scope of the present investigation. Data on the distribution of wealth do not exist for a sufficient number of countries, and the distribution of income must be used as a proxy. Consistent with the assumptions of the model, we adopt the pre-tax income distribution as a proxy for the distributions of ability. Since agents are assumed to save inelastically, we impute the wealth distributions by the after-tax income distributions.

In our structural model, inequality is synonymous with asymmetry. We construct these inequality measures from an income distribution data set, which was recently reported by the World Bank (Deininger and Squire 1996). We further approximate long–run, pre-tax inequality by averaging time series data on inequality for each individual country. To ensure the exogeneity of the fundamental inequality, these time series are taken from dates going as far back as the data allow. These measures of pre-tax inequality do not fluctuate excessively against their long-run averages.

For 15% of the sample, only the Gini coefficients are provided. Fortunately, the Gini coefficients and the ratio of the relevant quintiles are correlated. For these countries we imputed their median–mean ratios, $\frac{e^m}{e^M}$, by the following linear equation:

$$\left(\widehat{\frac{e^m}{e^M}}\right) = \hat{\alpha} + \hat{\beta}(\text{Gini Coefficient}), \tag{4.1}$$

Table 4.1 Regression coefficients for (4.1)

$\hat{\alpha}$	$\hat{\beta}$	Nobs	R^2
119.92	−1.12	100	0.53
(27.97)	(−10.64)		

where $\hat{\alpha}$ and $\hat{\beta}$ are the regression coefficients from the rest of the sample where both the symmetry measures and the Gini coefficients are available. The regression estimates, and parenthetically, the t-statistics, are summarized in Table 4.1.[2]

4.4 Heteroscedasticity

There are two sources of heteroscedasticity that plague the final data set. The first source of heteroscedasticity is empirical in nature. As pointed out by Perotti (1996), the accuracy of data from poor countries is always in doubt. In similar growth regressions, the author Perotti shows that the variance of the residuals from the basic regressions falls as the per capita income increases.

In addition to the empirical unreliability of the data, the manner in which our institutional parameters are calibrated introduces another subtle source of heteroscedasticity. In the model, economies are assumed to be identical up to the measure of fundamental inequality and institutional arrangements. That is, an individual economy faces the same Ramsey frontier, which is defined by technology and preferences, in the first– and second–period utility space. Depending on the underlying distribution of ability, each economy is assigned a position in this space according to its Nash equilibrium. Typically, these Nash positions are located anywhere between the origin and the Ramsey frontier. The more symmetric the distribution of abilities, the closer the Nash equilibrium will be to the frontier, which leaves little space for additional improvement (cf: Fig. 2.1).

The effects of institutions are modeled as an improvement from the Nash equilibrium. If the effects of institutions were to be distributed between the Nash equilibrium and any point on the Ramsey frontier, an economy with a relatively unequal distribution of abilities could have a larger variance in the distribution of its institutions than an economy with a relative more symmetric distribution of abilities (see Fig. 2.1). In this way, the distribution of institutions suffers from heteroscedasticity. For these two reasons, the regression coefficients reported in the subsequent tables are corrected for heteroscedasticity using methods suggested by White (1982).

[2] Data are from the same World Bank study. National gross household data are used.

4.5 The Size of Redistribution

We calibrate our institutional parameters to match three aspects of government consumption. The first data set measures the average government consumption as a percentage of Gross Domestic Product (GDP) between 1974 and 1989, (*Gov*). A negative sign associated with this variable indicates that the overall government consumption—redistributive or otherwise—is distortive. This interpretation originated in Meltzer and Richard (1981), who use similar modeling strategies to investigate the size of government consumption.

The second set of data measures the average government consumption exclusive of public education and defense, as a percentage of GDP, *GovX*, between 1974 and 1989. These data are a proxy for the non-productive government consumption.

The third data set is the average of governmental transfers and subsidies as a share of GDP between 1977 and 1993, *GovTS*. This data set, which quantifies the total resources that are redistributed, represents the narrowest concept of the three measures of the size of redistribution.

To ensure the comparability across these three definitions of the size of redistribution, the final data set only admits countries that provide all three averages and the relevant measure of inequality. The intersection contains 55 observations, 32 of which are designated as democracies by the literature.[3] Table 4.2 reports the identities of the final data set, the various definitions of redistribution as share of GDP, and the corresponding sets of institutional parameters.

4.6 Growth Regressions

Table 4.3 presents the regression coefficients and, parenthetically, the t-statistic, of a cross-sectional study. The dependent variable is the average growth rate between 1974 and 1989, and the size of redistribution is taken to be the average total government consumption as a percentage of GDP, *Gov*. Table 4.3 includes the results of four reduced–form regressions and two structural regressions. We note immediately that the conditional convergence hypothesis is strongly supported in all four reduced–form regressions: Since the coefficients associated with the real per capita GDP in 1960 (RGDP (60)) are negative and statistically significant. That is, controlling for other determinants of growth, the higher the starting value of per capital income, the slower the growth rate will be. These regressions give strong support for a β-convergence of per capita income.

[3]See Perotti (1996), Persson and Tabellini (1994), and Barro and Lee (1993) for the criteria used to designate democracies.

Table 4.2 The final data set

Country	*Gov*	*GovX*	*GovTS*	C_G	C_X	C_{TS}	Demo = 1
Argentina	0.11754	0.08336	0.07242	2.5031	2.5748	2.5984	0
Australia	0.18185	0.10589	0.17382	1.7445	1.8226	1.7527	1
Austria	0.18188	0.13383	0.22725	1.6530	1.6984	1.6105	1
Barbados	0.16869	0.09938	0.10187	2.2248	2.3405	2.3362	1
Belgium	0.16792	0.07028	0.29942	1.6297	1.7187	1.5115	1
Bolivia	0.12916	0.08032	0.02176	2.7697	2.9054	3.0859	0
Brazil	0.10063	0.06018	0.11879	3.2982	3.4725	3.2261	0
Canada	0.19863	0.10834	0.13535	1.6295	1.7141	1.6888	1
Chad	0.18409	0.12925	0.00787	1.9645	2.0346	2.1953	0
Chile	0.13562	0.05533	0.14636	2.3382	2.4861	2.3193	1
Colombia	0.09712	0.05604	0.06562	2.8512	2.9710	2.9422	0
Costa Rica	0.15549	0.09759	0.06680	2.5012	2.6279	2.6997	1
Cote d'Ivoire	0.16511	0.09343	0.04264	2.6776	2.8678	3.0191	0
Denmark	0.25107	0.14912	0.24610	1.5143	1.6042	1.5187	1
Dom. Rep.	0.07353	0.03893	0.01964	2.5500	2.6233	2.6654	1
Egypt	0.18514	0.06111	0.14190	1.8484	1.9906	1.8975	0
Finland	0.19347	0.13724	0.20293	1.5738	1.6239	1.5654	1
France	0.18636	0.12279	0.27995	1.8409	1.9128	1.7396	1
Germany	0.20258	0.13203	0.17059	1.6416	1.7086	1.6719	1
Greece	0.17548	0.09242	0.17284	2.3403	2.4989	2.3451	1
India	0.10387	0.04397	0.06719	1.9653	2.0364	2.0088	1
Indonesia	0.10064	0.04229	0.03984	1.9422	2.0095	2.0124	0
Iran	0.19060	0.08041	0.04595	2.7832	3.1252	3.2512	0
Ireland	0.18737	0.11052	0.26929	1.8182	1.9034	1.7307	1
Israel	0.34877	0.03492	0.19300	1.5797	1.8901	1.7285	1
Italy	0.15752	0.10363	0.26016	1.6918	1.7435	1.5948	1
Korea	0.10522	0.02737	0.06373	1.9430	2.0334	1.9912	1
Liberia	0.15914	0.09837	0.01967	2.1618	2.2557	2.3832	0
Madagascar	0.10337	0.06450	0.01393	3.0876	3.2279	3.4320	0
Malaysia	0.15934	0.06313	0.04793	2.5703	2.8038	2.8441	1
Mauritius	0.12171	0.08231	0.07311	1.5698	1.6028	1.6105	0
Mexico	0.09704	0.06313	0.04783	2.6034	2.6808	2.7169	1
Netherlands	0.17927	0.08140	0.38637	1.6807	1.7751	1.4951	1
Norway	0.18333	0.11802	0.28346	1.5894	1.6479	1.5010	1
Pakistan	0.11570	0.05100	0.03907	1.9532	2.0300	2.0442	0
Panama	0.20473	0.13412	0.05963	2.7769	2.9854	3.2464	0
Portugal	0.14191	0.07230	0.17433	1.8204	1.8946	1.7861	0
Senegal	0.18189	0.10640	0.04877	3.3165	3.6745	4.0172	0
Seychelles	0.20649	0.02782	0.08681	2.2105	2.5293	2.4176	0
Singapore	0.11064	0.01933	0.01613	2.2675	2.4200	2.4256	0
Spain	0.12992	0.09831	0.15565	1.8050	1.8378	1.7784	1
Sri Lanka	0.09165	0.05312	0.07086	2.2394	2.2996	2.2717	1
Sweden	0.25982	0.18947	0.30343	1.5268	1.5895	1.4890	1
Switzerland	0.13074	0.05747	0.12795	1.8935	1.9766	1.8966	1

(continued)

Table 4.2 (continued)

Country	*Gov*	*GovX*	*GovTS*	C_G	C_X	C_{TS}	Demo = 1
Tanzania	0.14901	0.07709	0.01779	2.4249	2.5711	2.7018	0
Thailand	0.11962	0.04937	0.01794	2.4849	2.6332	2.7038	0
Togo	0.18661	0.10302	0.03991	1.7916	1.8819	1.9505	0
Trinidad	0.15722	0.11185	0.09988	1.8969	1.9498	1.9639	0
Tunisia	0.15779	0.07297	0.10451	2.5270	2.7217	2.6464	0
Turkey	0.11064	0.03979	0.06533	2.9394	3.1730	3.0846	1
UK	0.21743	0.15575	0.20562	1.6369	1.6958	1.6481	1
USA	0.20355	0.14475	0.12190	1.6889	1.7472	1.7699	1
Uruguay	0.13277	0.08427	0.12326	2.2377	2.3166	2.2529	1
Venezuela	0.11300	0.05674	0.06470	2.0141	2.0851	2.0750	1
Zimbabwe	0.19583	0.06935	0.12118	3.0530	3.5734	3.3369	1

Sources: See Appendix B.
Legend: *Gov*: Total government consumption as % of GDP (1974–1989);
GovX: Government consumption excluding public education and defense as % of GDP (1974–1989);
GovTS: Government transfer and subsidies as % of GDP (1977–1993);
$C_\bullet$: Corresponding calibrated institutional parameters;
Demo: A binary indicator for democracy

Population growth rates, used as a proxy for fertility rates, have the right sign and are statistically significant in all four regressions.[4]

Since economic growth takes place when there is a fresh transfer of technology, the potential of new technology can be best harnessed in societies that already have a large stock of human capital. These regressions include the percentage of secondary school enrollment in 1960 as a proxy for the initial stock of human capital. These cross–sectional studies show that a one standard deviation increase from the mean of the human capital stock implies a positive growth differential between 0.3% and 0.6% (cf: regressions (1) through (4) in Table 4.3).[5]

The interaction between the size of redistribution, inequality, and institutions is central to this study. To this end, regression (1) in Table 4.3 shows that government consumption is negatively related to growth rate, confirming the economic mechanism hypothesis. In our sample, our regressions show that a one standard deviation increase from the mean of government consumption implies a 0.5% decrease in the long–term growth rate. Regression (2), which examines the hypothesis that inequality is bad for growth, shows that equality has the right sign but is statistically insignificant. Regressions (1) and (2), taken together, demonstrate that there are missing variables in the inequality–harm–growth literature. Regression (3) substitutes government spending by a linearized, institutional technology calibrated to match total government consumption. This theoretical decomposition attempts to explain government consumption in terms of two components. One of these

[4]See Barro (1997) for reasons to include this variable.

[5]For a more detailed discussion on how human capital affects growth, see Barro and Lee (1993).

Table 4.3 Reduced and structural regressions ($\tau = Gov$)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Gth. Rate	Gth. Rate	Gth. Rate	Gth. Rate	τ	τ
Sample	All	All	All	All	NonDemo	Demo
Intercep	3.77	4.28	3.74	3.50	−0.160	−0.032
	(6.34)	(5.94)	(5.88)	(4.25)	(−2.19)	(−0.522)
RGDP (60)	−0.754	−0.785	−0.800	−7.87		
	(−4.29)	(−4.32)	(−4.43)	(−3.88)		
PoP. Growth	−0.791	−0.866	−0.620	−0.564		
	(−3.52)	(−3.19)	(−2.44)	(−2.00)		
Sec. School Enrollment (60)	0.618	0.356	0.529	0.545		
	(3.13)	(2.00)	(2.43)	(2.37)		
τ	−0.511					
	(−2.18)					
Inequality ($\frac{e}{E}$)		0.432				
		(1.43)				
Std. Inst. Para.			1.59	1.66	−2.78	−4.16
			(1.80)	(1.09)	(−9.64)	(18.35)
$\theta * \frac{K}{k}$			−2.01	−2.21	2.70	3.67
			(−2.53)	(1.62)	(9.63)	(15.93)
Latin America						
Africa						
Demo				0.297		
				(0.433)		
Demo*Inst. Para				0.012		
				(0.007)		
Demo*$\theta \frac{K}{k}$				0.3877		
				(0.238)		
R^2	0.4171	0.3976	0.3193	0.4539	0.8177	0.9289
No. of Obs.	55	55	55	55	24	31

Sources: See Appendix B.
Legend: *Gov*: Total government consumption as % of GDP (1974–1989);
Gth. Rate: Average growth rate
Regression models: (1) Economic mechanism; (2) Inequality; (3) Reduced form; (4) Identification restruction; (5) and (6) Political mechanism

components is driven by the asset–holding inequality, which is denoted by $\theta * \frac{K}{k}$. The other one, which is driven by institutional arrangements, is denoted by Std. Inst. Para. Both the standardized institutional parameter, Std. Inst. Para. and the elasticity–adjusted asset holding inequality, $\theta * \frac{K}{k}$, have the predicted signs and are statistically significant at the 10% level, affirming the reduced–form hypothesis.[6] In particular, Regression (3) shows that one standard deviation increase from the mean of the institutional parameter improves the long-term growth rate by 1.6%.

[6]The p-value associated with Std. Inst. Para. is 7%.

Regressions (2) and (3) assume that all the observations in the sample are democracies. To confirm that these desired properties of the model are chiefly derived from the subset democratic countries in our sample, Regression (4) includes two interactive terms, Demo*Inst. Para. and Demo*$\theta\frac{K}{k}$, as well as a democracy dummy, Demo, which takes on the value one in the case of democracy. In this regression, the values of the first four economic regressors are basically unchanged. However, both Demo*Inst. Para. and Demo*$\theta\frac{K}{k}$ are not significant. In other words, the results in Regression (3) that institutions are beneficial for growth are not driven by the democratic institutions. Since Regression (4) fails this identification restriction, we cannot claim that our theory of institutions explains total government consumption.

Regressions (5) and (6) report structural estimates for non–democracies and democracies, respectively. In both of these partitioned samples, the coefficients have the right signs and are statistically significant. We note that for both variables, the coefficients from the subset of democracies are larger both in terms of magnitude and are statistically significant. Moreover, the R^2 that is associated with the democracies is notably higher when compared with that of the non–democracies. These two regressions suggest that our theoretical decomposition offers a better fit with democracies than with non–democracies.[7]

Table 4.4 considers a narrower definition of government spending. It uses a data set that is designed to match the average non-productive share of government consumption, *GovX*. Column (1) in Table 4.4 regresses growth rates on a standard set of economic variables, using the narrower definition of government consumption. We note that this proxy for the non-productive share of government consumption has the right sign and is statistically significant (p-value $<0.01\%$). In particular, this regression shows that one standard deviation increase above mean spending costs as much as 0.9% of long–term growth. The linear decomposition of government non-productive spending continues to do well. Regression (3) shows that the institutional parameter has the right sign and is statistically significant. Once again, we test the identification restriction by including the same set of interactive terms used in Table 4.3. Column (4) shows that the effect on growth from democratic institutions is insignificant. The regression coefficients associated with Demo*Inst. Para. and Demo*$\theta\frac{K}{k}$ reject the hypothesis that the results from Regression (3) are due to the democratic institutions. Again, institutions, which are calibrated to match the non-productive share of government consumption, fail to satisfy the identification restriction.

Regressions (5) and (6) in Table 4.4 are structural regressions, which share similar characteristic of the corresponding regressions in Table 4.3. Again there seems to be evidence to support the conclusion that the institutional technology provides a better explanation of government spending in democracies than in non–democracies. Finally, Table 4.5 examines governmental transfers and subsidies and their impact on long term economic growth. Column (2) reports regression estimates

[7]The F-values for Regressions (5) and (6) are 47.11 and 182.87, respectively.

Table 4.4 Reduced and structural regressions ($\tau = GovX$)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Gth. Rate	Gth. Rate	Gth. Rate	Gth. Rate	τ	τ
Sample	All	All	All	All	NonDemo	Demo
Intercep	4.12	4.28	4.22	3.86	−0.239	0.0009
	(6.90)	(5.93)	(6.70)	(4.76)	(−1.90)	(0.078)
RGDP (60)	−0.640	−0.785	−0.724	−0.697		
	(−5.12)	(−4.32)	(−5.35)	(−4.02)		
PoP. Growth	−1.07	−0.866	−0.897	0.7486		
	(−5.07)	(−3.19)	(−3.79)	(−2.93)		
Sec. School	0.522	0.356	0.392	0.393		
Enrollment (60)	(3.24)	(2.00)	(2.27)	(2.14)		
τ	−0.927					
	(−3.82)					
Inequality ($\frac{e}{E}$)		0.432				
		(1.43)				
Std. Inst. Para.			4.42	6.37	−3.63	−5.44
			(2.86)	(2.73)	(−4.97)	(6.95)
$\theta * \frac{K}{k}$			−4.73	−6.78	3.62	4.91
			(−3.11)	(2.86)	(5.07)	(6.09)
Latin America						
Africa						
Demo				0.201		
				(0.327)		
Demo*Inst. Para.				−4.24		
				(1.21)		
Demo*$\theta \frac{K}{k}$				4.48		
				(1.26)		
R^2	0.5214	0.3976	0.5126	0.539	0.5507	0.7158
No. of Obs.	55	55	55	55	24	31

Sources: See Appendix B.
Legend: *GovX*: Government consumption excluding public education and defense as % of GDP (1974–1989);
Gth. Rate: Average growth rate
Regression models: (1) Economic mechanism; (2) Inequality; (3) Reduced form; (4) Identification restruction; (5) and (6) Political mechanism

on government consumption, which is taken to be the share of national income devoted to transfers and subsidies. After controlling for regional variations, e.g., in Latin America and Africa, governmental transfers and subsidies are shown to be harmful to growth. In particular, one standard deviation increase from the mean slows long–term economic growth by as much as 0.5% (t-statistic = −2.12). This regression suggests that there are important elements in the Latin American and the African growth experiences that are left unexplained by our specification. In fact, we note that these regional variations correlate significantly with the secondary school enrollment ratio in 1960 and the population growth rate.

Table 4.5 Reduced and structural regressions ($\tau = GovTS$)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Gth. Rate	Gth. Rate	Gth. Rate	Gth. Rate	τ	τ
Sample	All	All	All	All	NonDemo	Demo
Intercep	4.53	5.33	5.22	4.83	−0.235	−0.042
	(6.07)	(7.00)	(7.68)	(5.10)	(−2.65)	(−0.939)
RGDP (60)	−0.742	−0.663	−0.720	−0.829		
	(−4.31)	(−4.88)	(−5.20)	(−4.68)		
PoP. Growth	−1.13	−0.950	−0.822	−0.952		
	(−3.87)	(−3.64)	(−3.78)	(−3.06)		
Sec. School	0.488	0.240	0.217	0.420		
Enrollment (60)	(3.14)	(1.99)	(1.68)	(2.34)		
τ	−0.419	−0.563				
	(−1.28)	(−2.12)				
Inequality ($\frac{e}{E}$)						
Std. Inst. Para.			1.32	−1.73	−1.86	−2.73
			(1.89)	(−1.07)	(−6.30)	(−22.76)
$\theta * \frac{K}{k}$			−1.38	1.03	1.55	2.02
			(−2.32)	(0.732)	(5.95)	(16.82)
Latin America		−1.79	−1.46			
		(−3.58)	(−2.76)			
Africa		−2.80	−2.88			
		(−3.66)	(−3.79)			
Demo				0.104		
				(0.149)		
Demo*Inst. Para.				3.61		
				(2.02)		
Demo*$\theta \frac{K}{k}$				−3.04		
				(−1.87)		
R^2	0.3920	0.5951	0.3193	0.4825	0.6601	0.9561
No. of Obs.	55	55	55	55	24	31

Sources: See Appendix B.
Legend:*GOVTS*: Government transfer and subsidies as % of GDP (1977–1993);
Gth. Rate: Average growth rate
Regression models: (1) and (2) Economic mechanism; (3) Reduced form; (4) Identification restruction; (5) and (6) Political mechanism

Regression (3) deconstructs government spending into its two explanatory components. Assuming that the entire sample is democratic, the associated coefficients indicate that one standard deviation from the mean institution increases the long-term growth rate by 1.3% (t-statistic = 1.89). Regression (4) imposes the identification restriction. In this case, we find that the positive institutional effect on economic growth is driven by democratic institutions. In particular, one standard deviation difference e.g., that of the United Kingdom to Malaysia implies a remarkable 3.6% (t-statistic = 2.02) growth differential.

In addition, it is worth noting that the coefficient associated with the starting level of income, RGDP (60), in absolute magnitude is the largest in Regression (3): -0.829 (t-statistic = -4.68). Assuming that the theory of conditional convergence accurately describes the per capita income convergence mechanism, then the regression with the largest coefficient associated with the starting level of income signifies the inclusion of most relevant variables. The central message of this cross–sectional study is that once we control for other economic variables, the institutional arrangements in democracies that promote intergeneration cooperation positively affect long–term economic growth.

Regressions (5) and (6) report structural estimates. Note that the R^2 associated with the democratic subset of the sample is notably higher than in the non-democratic subset of the sample.[8] These two regressions also explain why governmental transfers and subsidies are significant only after the inclusion of regional dummies of Latin America and Africa, two regions that have higher concentrations of non–democracies. Once they are controlled for, Regression (2) in Table 4.5 identifies the effects of governmental transfers and subsidies on the long–term growth rates of countries that are more likely to be democratic.

[8]The F-values that are associated with Regression (5) and (6) are 20.38 and 304.96, respectively.

Chapter 5
Conclusion

Abstract This chapter summarizes the findings and highlights the possible limitations and extensions to the analysis presented here. Unequal distribution of abilities results in distortionary taxes, but their effect could be minimized by institutional arrangements that promote inter–generational cooperation. This book provides both theoretical and empirical justification for the idea that omitting the role of institutions results in misspecification of the causal link between inequality and growth. The book contributes to the existing literature by highlighting the role of fiscal institutions in enhancing economic welfare. The possible limitations of this analysis are the effects of the fiscal institutions, which are treated as exogenous, and the level of inter–generational cooperation, which depends on institutional features.

Keywords Age requirements in bicameralism • Dynamic inefficiency of policy • Features of fiscal institutions

Economists identify causes of market failure by showing a lack of correspondence between optimality and (competitive) equilibrium. Assuming complete markets, economists attribute the failure of the First Welfare Theorem to externalities. Our research has identified political or institutional failures by demonstrating discrepancies between the planner solutions—i.e., the Ramsey solution—and the non-cooperative median voter equilibrium.[1] Further, it has quantified the connections between political and market pathologies. Distortionary taxation accounts for the market pathology in the analysis, though it is a direct consequence of two different but related elements within the realm of politics. These are the unequal distribution of abilities, which is fundamental to an economy, and the political institutions through which dynamic inefficiency of policies is magnified. Simply put distortionary taxes exist because of the unequal distribution of abilities (cf: Proposition 2.4). However, they could be minimized by institutional arrangements

[1] See Besley and Coate (1998) for a discussion of political failure in a dynamic context.

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that promote inter–generational cooperation. Thus, by introducing of roles of institutions, this book has corrected the mis-specification that is prevalent in the inequality-harms-growth literature.

5.1 Extension

We have modeled fiscal institutions as an integral part of the economic and political decision-making process. In particular, it has provided a microeconomic foundation for fiscal institutions to enhance welfare. However, our model treats the effect of fiscal institutions as exogenous and provides no specifics about which institutional features determine the extent of inter–generational cooperation. Recently, Persson (2003) and Persson and Tabellini (2000, 2003, 2004) have begun some important investigations along these lines. These authors have identified specific electoral rules and forms of government that influence fiscal policy. They find that presidential regimes induce smaller governments than parliamentary democracies, and majoritarian elections lead to smaller welfare programs than proportional elections. If government expenditures and welfare programs are financed by distortive taxation, it follows that presidential and majoritarian regimes are more conducive to economic growth.

For institutions that promote inter–generational cooperation, it is interesting to note that the United States US Constitution stipulates different age requirements for different federal offices. Specifically, it requires members of the House of Representatives to be at least 25 years old and members of the Senate to be at least 30.[2] The US Constitution is by no means alone in these age requirements. At last count, 17 out of 38 constitutional bicameral governments in different countries have different age requirements for different assemblies.[3] Chile and the Czech Republic have the largest age requirement differential between different legislative assemblies. Citizens of these countries have to be 40 years old to qualify for the upper house, whereas the minimum age requirement for the lower house is only 21.[4] By deliberately engineering different age requirement in the two assemblies, these provisions seemingly attempt to maximize the cooperation among different age groups in policy formulation. As Alesina (1998) points out, these two-party bargaining settings are conducive to policy convergence that approximates the effect of inter–generation cooperation described here. These conjectures require careful empirical examination in future research.

[2]For the Senate age requirement, see Article I, Section 3 of the Constitution; for the House of Representatives, see Article I, Section 2.

[3]For other aspects of bicameralism, see Tsebelis and Money (1997).

[4]See Maddex (1995).

Chapter 6
Appendix A

This appendix presents proofs for some of the statements in Chap. 2 "Environment and Equilibrium."

Proposition 2.1: A Characterization Theorem. *For the "if" direction, let* $\bar{\tau}^* = \{\tau_0^*, \tau_1^*, \tau_2^*, \ldots\}$ *be an open-loop equilibrium for the dynamic game G. We show this part of the proposition by a contradiction. Suppose that* $\bar{\tau}^*$ *does not satisfy (2.7) for some period* t'. *Then it follows that at period* t', *the pivotal voter will choose* $\tau_{t'}' \neq \tau_{t'}^*$ *to increase his payoff. That is,*

$$\pi(\tau_{t'-1}^*, \tau_{t'}^{'}) + \beta\pi(\tau_{t'}^{'}, \tau_{t'+1}^*) > \pi(\tau_{t'-1}^*, \tau_{t'}^*) + \beta\pi(\tau_{t'}^*, \tau_{t'+1}^*)\ \tau_{t'}^*, \tau_{t'}^{'} \in [0,1].$$

That is to say that at period t' *the pivotal voter's payoff can be increased, but at periods* $t \neq t'$, *pivotal voters' payoffs remain unchanged—i.e.,* $\bar{\tau}^*$ *is not an open-loop equilibrium sequence.*

The "only if" direction is trivial. Suppose that τ_t^* *is a solution of equation (2.7) at period* t. *Then* τ_t^* *is the best response for pivotal voters at period,* t *given the policy made a period ago and next period's policy. Then* $\bar{\tau}^* = \{\tau_0^*, \tau_1^*, \tau_2^*, \ldots\}$ *is a collection of such best responses, which necessarily is an equilibrium point of G.* ∎

Proposition 2.2: An Existence Theorem. *Proposition 2.1 breaks down the infinitely dynamic game G into a sequence of smaller games—one for each period,* t. *Each game in period* t *involves only the policy chosen at period* $t-1\backslash$, *and the policy that will be chosen in period* $t+1$. *Therefore to demonstrate the existence of equilibrium, it suffices to show that an open–loop equilibrium exists for each one of these smaller games. Take the game at period* t, *for example.* τ_t^* *is a best response, given* τ_{t+1} *and* τ_{t-1}. *In particular, if the equilibrium correspondence satisfies the Lipschitz conditions, then (2.7) is written as follows:*

$$P : [0,1] \times [0,1] \longmapsto [0,1]$$
$$P(\tau_{t+1}, \tau_{t-1}) \longmapsto \tau_t^*,$$

is continuous, and the domain is convex and compact. Then the maximum of P, τ_t^* *exists for all* t. ∎

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Proposition 2.3: The Existence of the Uniquely Stable Steady State. *See Friedman (1986), Theorem 5.1.* ∎

Proposition 2.4: A Median Voter Theorem. *The main goal of this proof is to show a median voter is pivotal in an open–loop equilibrium, where agents at period t take as given K_t and τ^*_{t+1} for all t. We state without proof that*

Lemma A.1: Independence. *According to Roberts (1977), if the ordering of individual income is independent of the choice of T_t and τ_t, individual choice of the tax rate is inversely ordered by income. Moreover, with universal suffrage, the voter with median ability is pivotal.*

We prove Proposition 2.4 in steps. First we show that for each τ_t there is a unique T_t. Therefore, we reduce the dimension of the policy space by one. Second, we will show that the ordering of individual incomes is independent of the choice of τ_t for all t. We begin with the following observations:

Lemma A.2: Redistribution. *An increase in redistribution increases consumption.*

Proof. By equation (2.2), we show the above lemma by substituting the asset constraint into the second–period consumption constraint. That is,

$$\begin{aligned} c^t_{t+1} &\leq \tilde{R}_{t+1}[e\tilde{W}_t n^t_t + T_t] \\ &\leq \tilde{R}_{t+1}[y_t(1-\tau_t) + T_t], \end{aligned}$$

where $y_t = eWn_t$ denotes pre-tax income. By the choice of the utility function, these constraints hold in equality in equilibrium. Holding all things equal, it is trivial to show that consumption is a positive function of transfers. ∎

By applying the envelop theorem to the first order condition of the labor–leisure choice, it is easy to show that labor decision is positively monotonic in ability. Hence, Lemma A.3 follows:

Lemma A.3: Consumption. *Since consumption is a normal good, pre–tax income is non–decreasing with productivity.*

The following lemma shows the existence of a one–to–one relationship between the tax rate and the transfers.

Lemma A.4: Leisure. *Since leisure is a normal good, for every tax rate τ_t there is a unique per capital transfer, T_t.*

Proof. Recall the government's budget constraint,

$$\tau_t Y_t = T_t, \tag{A.1}$$

where

$$Y_t = WN_t + RK_t.$$

Since leisure is a normal good, $\frac{\partial l_t}{\partial T_t} = \frac{\partial l_t}{\partial n_t}\frac{\partial n_t}{\partial T_t} > 0$. But $\frac{\partial l_t}{\partial n_t} = -1$, which implies that $\frac{\partial n_t}{\partial T_t} < 0$. It follows that,

$$\frac{\partial Y_t}{\partial T_t} = W \int_{e_t^o}^{\bar{e}} e \frac{\partial n_t}{\partial T_t} \mathrm{d}\Gamma(e) < 0.$$

Therefore, it is established that the left side of equation (A.1) is a strictly decreasing, continuous function of T_t. At the same time, we note that the right side of the same equation is strictly increasing with T_t. We therefore conclude that there is a unique value of T_t that satisfies the government budget constraint. ∎

Recall that in an open–loop equilibrium, agents take future decisions and aggregate level of capital stock parametrically.

Lemma A.5: Income and Asset. *The ordering of individual incomes and asset holdings are independent of the choice of T_t and τ_t.*

Proof. Since the ranking of asset holdings is identical to that of income, given τ_t and T_t, the ranking of asset holding is identical to that of income. To prove this lemma, it is sufficient to demonstrate that income ranking is invariant to proportional taxation and lump–sum transfers. We first note that, by Lemma A.4, once τ_t is determined, so is T_t. Denote the pre-tax income for the pivotal voter by $y_t^d = We^d n_t(K_t, \tau_t)$. Therefore, given an aggregate level of capital, K_t, the individually optimal policy, which maximizes the pivotal voter's pre-tax income, is a function of his productivity—i.e., $\tau_t(K_t, e^d)$. Therefore, the agents' pre-tax income, y, is a function of the pivotal voter's productivity, e^d, and the aggregate level of capital, K_t.

Recall Lemma A.3, which states that pre-tax income is non-decreasing with productivity for those who do not work and strictly increasing for those who work. Given some tax rate, say τ_t^d, let $e_1 > e_2 > \cdots > e_j$ be a ranking of ability, where $e_1 > e_t^\circ$ for all t. Such a ranking induces a corresponding, positive pre–tax income ordering as follows:

$$We_1 n_t(K_t, \tau_t^d) > We_2 n_t(K_t, \tau_t^d) > \cdots > We_j n_t(K_t, \tau_t^d).$$

Suppose now that a new tax rate, τ_t^0, is chosen. Without loss of generality, we assume that $\tau_t^0 > \tau_t^d$. Holding K_t fixed, the income ordering is unaltered since $\frac{\partial n_t^i(\tau_t)}{\partial \tau_t} = \frac{\partial n_t^j(\tau_t)}{\partial \tau_t}$ for all $i \neq j$. The last line is true, since preference and, hence, the reduced form of $n_t(K_t, \tau_t)$ are identical across agents up to individual ability. Therefore:

$$We_1 n_t(K_t, \tau_t^o) > We_2 n_t(K_t, \tau_t^o) > \cdots > We_j n_t(K_t, \tau_t^o).$$

∎

The conditions for Lemma A.1 are satisfied, and it follows from the statement that individual choice of the tax rate is inversely ordered by income, $\frac{\partial \tau_t}{\partial y_t} \leq 0$. Furthermore, we note that

$$\frac{\partial \tau_t}{\partial e} = \frac{\partial \tau_t}{\partial y_t}\frac{\partial y_t}{\partial e} \leq 0.$$

The first partial in the second equality is non-positive by Lemma A.4. The second partial is non-negative by Lemma A.3. Thus, it is shown that individual choice of tax rate is inversely related to ability. Under universal suffrage, the wishes of agents endowed with median ability would prevail. ∎

Proposition 2.5: The Law of Motion of Capital. *Recall the following identity,*

$$A_{t+1} = \int_{\underline{e}}^{\bar{e}} a_t^t \mathrm{d}\Gamma(e).$$

Since agents save their entire share of after–tax income and the lump–sum transfers, individual asset holding is

$$a_t^t = eWn_t^t(1-\tau_t) + T_t, \tag{A.2}$$

where

$$T_t = \tau_t N_t W + \tau_t RK_t.$$

Integrating equation (A.2) across the population, we obtain:

$$\begin{aligned}\int_{\underline{e}}^{\bar{e}} a_t^t \mathrm{d}\Gamma(e) &= WN_t(1-\tau_t) + T_t \\ &= WN_t(1-\tau_t) + \tau_t N_t W + \tau_t RK_t \\ &= WN_t + \tau_t RK_t.\end{aligned}$$

Since taxation is redistributive in nature and the government balances its budget by a lump–sum transfer, the young save their entire labor share of income. But since the proportional tax rate applies equally to capital income, a τ_t fraction of the capital income of the old is redistributed to the young for all $t = 1, 2, \ldots$.

Applying the market clearing condition to the last line of these equalities, then

$$K_{t+1} = A_t = WN_t + \tau_t RK_t.$$

∎

Lemma A.6: The Sustainability of τ^*. *Two additional elements are required to demonstrate that the steady–state policy, τ^*, is sustainable in the sense of Chari and Kehoe (1990).*[1] *These elements include (1) the economic allocations are*

[1]This is a much less comprehensive statement than that of Chari and Kehoe (1990) or Chang (1998), who demonstrate the sustainability of the entire sequence of policies in the presence and absence of Markovian equilibria. Since we focus on the steady state of the economy, only the steady state of the policy sequence is considered here. In principle, using the same arguments as in

competitive, given τ^* *and its continuation; and (2) at any level of capital stock* K_t *and economic allocations,* τ^* *maximizes the median voter's indirect utility function, given the continuation of* τ^* *as a policy for the future.*

Since we restrict our attention to a Markovian equilibrium, the set of history at any period t is reduced to a singleton—i.e., the policy chosen in the most recent period, τ^**. Implicit in the maximization of the payoff function, P, are the requirements of a competitive economic equilibrium and the feasibility of policies at each period t, subsequent to the entering of the steady state. By Proposition 2.4,* τ^* *maximizes the welfare of the median voter.* τ^* *being a fixed point of the equilibrium correspondence ensures the continuation of the same policy in all future periods.* ∎

Proposition 2.6: Characterization of Other Sustainable Equilibria. *We show this statement by a contradiction. Suppose that there exists another sustainable equilibrium,* $\hat{\tau}^* \geq \tau^*$*. First we note that* $\hat{\tau}^*$ *cannot be an steady–state open–loop equilibrium for* τ^**, which is the uniquely stable, steady state for the open–loop equilibrium sequence.*

Then it remains to be shown that no folk–like strategy, Σ, can exist to support such $\hat{\tau}^*$ *as an equilibrium. At any level of* K_t*,* $\hat{\tau}^* \geq \tau^*$ *implies that* $V(K_t, \hat{\tau}^*) \leq V(K_t, \tau^*)$*. But this cannot be an equilibrium, since each median voter to whom this strategy is supposed to apply can and will defect to choosing* τ^**, which he knows with certainty is a sustainable equilibrium. Therefore,* τ^* *will be continued, which yields a higher utility for the median voter.* ∎

Proposition 2.7: A Folk Theorem. *Let us reiterate the trigger strategy of the revert–to–non–cooperation plan:*

- *(Compliance) Choose* τ^R *if* τ^R *is consistently chosen in the past;*
- *(Deviation) Otherwise choose* τ^**, which corresponds to the open–loop equilibrium.*

Consider the indirect utility function under the compliance regime,

$$V(K^R, \tau^R) = U(l_t(K^R, \tau^R)) + \beta U(c_{t+1}(K^R, \tau^R)), \tag{A.3}$$

where

$$K^R = WN(K^R, \tau^R) + \tau^R K^R R, \tag{A.4}$$

is the steady state level of capital, if τ^R *is the steady–state policy. This indirect utility function describes the situation where* τ^R *was consistently chosen in the past. The median voter will continue the same plan by choosing* τ^R*, with the rational expectations that the next period's policy will be* τ^R*.*

Chari and Kehoe (1990), we can show that the entire open–loop equilibrium sequence is sustainable, and the steady state is a special case.

Likewise, the indirect utility function under the deviation regime,

$$V(K^R, \tau^d) = U(l_t(K^R, \tau^d)) + \beta U(c_{t+1}(K^d, \tau^*)), \tag{A.5}$$

where

$$K^d = WN(K^R, \tau^d) + \tau^* K^R R, \tag{A.6}$$

is the capital stock after the first deviation. This indirect utility function describes the utility consequence for deviation under the revert–to–non–cooperation plan. Moreover, we note that for any given K_t *and* τ^* *as the next period policy, the best deviation is to choose* $\tau^d = \tau^*$*.*

For instance, if a deviation occurred in the immediate past period, it is the best response to play τ^**—i.e., to enforce the punishment. Given that the next period's policy choice will be* τ^* *and the previous play was* τ^**, the individually optimal policy is defined by* $\tau^* \in ArgMax_{\tau^* \in [0,1]} P(\tau^*, \tau^*)$*. Therefore the statement of the proposition follows.* ∎

Corollary A.1: The Sustainability of the Ramsey Solution. *A reinterpretation of the proof of Proposition 2.7 will demonstrate the statement of this corollary. Proposition 2.7 establishes that as long as* $V(K_t, \tau^R) \geq V(K_t, \tau^*)$*, where* τ^R *solves the Ramsey problem, then* τ^R *can be supported as a sustainable equilibrium. Equations (A.3) and (A.5), along with the inequality, imply*

$$\bar{\beta} = \frac{U(l_t(K^R, \tau^*)) - U(l_t(K^R, \tau^R))}{U(c_{t+1}(K^R, \tau^R)) - U(c_{t+1}(K^d, \tau^*))}, \tag{A.7}$$

where equations (A.4) and (A.6) hold. By inspection, we note that the numerator and the denominator of equation (A.7) are both positive.

We note $\bar{\beta}$ *is less than 1 if and only if*

$$U(l_t(K^R, \tau^*)) + U(c_{t+1}(K^*, \tau^*)) < U(l_t(K^R, \tau^R)) + U(c_{t+1}(K^R, \tau^R)),$$

where equations (A.4) and (A.6) hold.

The above inequality holds good since the right–hand side is the solution of the limiting case of a Ramsey problem, where β *approaches unity. By definition,* τ^R *globally maximizes the infinite sum of indirect utility functions of median voters. Strict concavity of period utility functions implies that* τ^R *is also a local maximum. Therefore* $0 < \bar{\beta} < 1$. ∎

Proposition 3.1: Comparative Statics of $N(\tau_t, K_t)$.

Recall that

$$N_t = \frac{\beta}{1+\beta} \exp\left\{ -\frac{\tau_t}{1-\tau_t} \frac{WN_t + RK_t}{\beta W} \right\}.$$

Then by implicit differentiation,

$$\frac{\partial N_t}{\partial \tau_t} = -\frac{\frac{WN_t + RK_t}{\beta W}\frac{N_t}{(1-\tau_t)^2}}{1 + \frac{\tau_t}{1-\tau_t}\frac{N}{\beta}}.$$

Therefore, $\frac{\partial N}{\partial \tau} < 0$ *and by inspection,* $\frac{\partial N_t}{\partial K_t} < 0$. ∎

Proposition 3.2: The Institutional Technology.

Remark. The following result is general, in that in a two-period overlapping generations model, solving for individually optimal fiscal policy in a Markovian equilibrium, which use capital as a state variable, the resulting equilibrium policy is always a solution to a first order differential equation, and therefore, involves one degree of freedom. See Azariadis and Galasso (1997).

Equation (3.6) implies

$$(1 - \Pi(K_{t+1}))\left(\frac{\mathrm{d}T_t}{\mathrm{d}\Pi(K_t)} - n_t^{*t}eW\right) = \underbrace{\frac{\mathrm{d}\Pi(K_{t+1})}{\mathrm{d}\Pi(K_t)}}_{(III)}(n_t^{*t}eW(1 - \Pi(K_t)) + T_t),$$

which can be further expended by an application of the chain rule at underbrace (III). Specifically, underbrace (III) can be written as $\frac{\mathrm{d}\Pi(K_{t+1})}{\mathrm{d}K_{t+1}}\frac{\mathrm{d}K_{t+1}}{\mathrm{d}\Pi(K_t)}$.

Recall the market–clearing condition where the aggregate assets accumulated at date t are set to equal the capital stock at date $t+1$—i.e.,

$$K_{t+1} = A_t = WN_t + \Pi(K_t)K_tR.$$

Since the young do not consume and the lump–sum transfers are financed by redistributive taxation, the aggregate asset, A_t, is the sum of the entire wage bill and the portion of the welfare transfers financed by redistribution from the old to the young.[2]

For the ease of subsequent expositions, we adopt the following changes to the variables:

$$A_1 \equiv \frac{\mathrm{d}T_t}{\mathrm{d}\Pi(K_t)} - n_t^{*t}eW, \tag{A.8}$$

$$A_2 \equiv n_t^{*t}eW(1 - \Pi(K_t)) + T_t = k_{t+1}, \tag{A.9}$$

$$A_3 \equiv \frac{\mathrm{d}K_{t+1}}{\mathrm{d}\Pi(K_t)}. \tag{A.10}$$

[2] Therefore, the old consume the after-tax interest payment, i.e., $C_t^{t-1} = K_t\tilde{R}_t, \forall t = 1, 2, \ldots$.

Then the first order condition for the voter at date $t+1$ is the following differential equation, which uses equation (A.8) through (A.10):

$$\frac{A_1}{A_2 A_3} - \frac{A_1}{A_2 A_3}\Pi(K_{t+1}) = \Pi'(K_{t+1}). \tag{A.11}$$

∎

Proposition 3.3: A Ranking of Tax Rates. *Recall the first order condition for the Markovian equilibrium,*

$$\left(\frac{\mathrm{d}T_t}{\mathrm{d}\Pi(K_t)} - n_t^{*t} eW\right) = \frac{\mathrm{d}\Pi(K_{t+1})}{\mathrm{d}\Pi(K_t)} \frac{n_t^{*t} eW(1-\Pi(K_t)) + T_t}{1-\Pi(K_{t+1})}.$$

By rearranging terms, this equation can be written as:

$$\frac{\mathrm{d}T_t}{\mathrm{d}\pi(K_t)} = \lambda_1(n_t^{*t} eW) + \lambda_2 \left\{ \frac{\mathrm{d}\Pi(K_{t+1})}{\mathrm{d}\Pi(K_t)} \frac{n_t^{*t} eW(1-\Pi(K_t)) + T_t}{1-\Pi(K_{t+1})} \right\},$$

which is a constraint maximization, with λ_1 being the "shadow price" for being employed and λ_2 being the "shadow price" for being in a Markovian equilibrium. According to the above formulation, $\lambda_1 = 1$ for the employed; and $\lambda_2 = 1$ for the Markovian equilibrium. Since those are binding constraints, the inequalities stated in Proposition 3.3 follow. ∎

Chapter 7
Appendix B

Unless otherwise indicated, data are provided by Levine and Renelt (1992).

Variable	**Definition and Source**
Gwth. rate	Growth rate, 1974–1989
RGDP (60)	Real GDP, 1960
PoP. growth	Population growth, 1974–1989
Sec. school enrollment (60)	Percentage of secondary school enrollment, 1960
$\tau = Gov$	Government consumption as a share of GDP, 1974–1989
$\tau = GovX$	Government consumption less public education and defense as a share of GDP, 1974–1989
$\tau = GovTS$	Governmental transfers and subsidies, 1977–1993 (source: IMF (1975–1993))
$\frac{e}{E}$	Median–mean income ratio (source: Deininger and Squire (1996))
Std. Inst. Para.	Standardized institutional parameter (source: Our calibration)
$\theta * \frac{K}{k}$	Elasticity adjusted mean–median asset holding ratio (source: Deininger and Squire (1996) and our calibration)
Latin America	Latin America indicator
Africa	Sub-Saharan Africa indicator
Demo (D)	Democracy indicator
N/D	Non–democracy (source: Perotti (1996))

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