The Distributional Consequences of Government Spending

Santanu Chatterjee*†
Department of Economics
University of Georgia

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Abstract

This paper examines the mechanism through which pro-growth policies such as government spending on infrastructure might affect the dynamics of inequality. We develop a model in which government-provided infrastructure is not only the engine of growth, but also a critical determinant of the distributions of wealth, income, and welfare. Government spending on infrastructure by itself is shown to be an ineffective tool of redistribution. It enhances economic growth, but leads to sharply contrasting effects on income inequality over time: inequality falls in the short run, but worsens in the long-run. For infrastructure investment to have a redistributive effect on the economy, it must be financed by an appropriate taxation policy. In this respect, the capital income tax serves as an effective redistributive tool if used as a financing instrument. The redistributive effects of the consumption tax as an alternative to the more conventional labor income tax are also highlighted.

Keywords: Infrastructure, Public investment, Inequality, Equity, Distribution, Economic Growth, Welfare, Fiscal Policy

JEL Classification: D31, D33, E25, H54, O15

*Department of Economics, Terry College of Business, University of Georgia, Athens, GA 30602 USA. Phone: +1-706-542-3696. Email: schatt@terry.uga.edu.

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1 Introduction

"The expressway network (in China) has...helped to promote a sharp increase in private car ownership...roads are sometimes built expressly for the purpose of converting countryside into revenue-generating urban land...For Beijing's airport expansion, 15 villages were flattened and their more than 10,000 residents resettled...but...former farmers...were barred from unemployment benefits and other welfare privileges."

The Economist (February 14, 2008)

Over the last three decades, income inequality has steadily risen across the world, in both the OECD and non-OECD countries. As the gap between the "haves" and the "have-nots" increases over time, the role of government in the alleviation of poverty and inequality has emerged as one of the most challenging aspects of public policy. At the heart of this issue is the relationship between government spending programs, specifically on productive public goods such as infrastructure, underlying taxation policies, and their effects on economic growth and inequality. Economists generally agree that government spending on an economy's infrastructure can have significant productivity and growth benefits, and this hypothesis has led to a large empirical and theoretical literature over the last two decades.\(^1\) However, the distributional consequences of such productive government spending have generally been ignored in this literature. This paper, therefore, takes a different track from earlier research by raising the following questions:

(i) What is the mechanism through which productive government spending (such as on infrastructure) affects the distributions of wealth, income, and welfare?

(ii) Do pro-growth policies also reduce inequality, both in the short run and the long-run? In other words, do public policies generate intertemporal trade-offs between growth and inequality?

(iii) Do the underlying taxation policies used for financing government spending on infrastructure affect the growth-inequality relationship?

This paper draws its main motivation from some recent empirical findings that attempt to relate public goods and infrastructure to inequality. For instance, Ferranti et al. (2004), Fan and Zhang (2004), and Calderon and Serven (2004) find that investment in physical infrastructure (such as roads, dams, and telecommunications) has contributed towards the alleviation of inequality and poverty in China and Latin America. On the other hand, Banerjee (2004) and Banerjee and Somanathan (2007) find that in India, access to critical infrastructure services and public goods in general is highly correlated with the distribution of income and social status: rich people tend to have more access to public goods than their poorer or less mobilized counterparts, even though the provision of public goods by the government is intended to benefit the poor. This finding has been corroborated in a World Bank (2006) report which finds that the quality and performance

\(^1\) Though the link between infrastructure and growth can be traced to Arrow and Kurz (1970), it was the findings of Aschauer (1989) that spawned a huge empirical literature on the impact of infrastructure on productivity and output; see Gramlich (1994) for a survey of the early findings. Notable theoretical contributions include Barro (1990), Glomm and Ravikumar (1994), and Fisher and Turnovsky (1996).
of state-provided infrastructure services tend to be the worst in India's poorest states. Khandker and Koolwal (2007) find that access to paved roads have had a limited distributional impact in rural Bangladesh. The quote from The Economist at the beginning of this section also highlights the uneven effects infrastructure investment across the income distribution scale. The ambiguity in these empirical findings underscore the need for a well-specified theoretical framework within which the link between infrastructure spending by the government, economic growth, and inequality can be studied. This is the central objective of this paper.

To analyze the issues under consideration, this paper develops an analytical framework wherein public infrastructure spending is not only the engine of growth, but also a critical determinant of the distributions of wealth, income, and welfare, all of which are major indicators of inequality. The source of inequality in our model is the unequal distribution of initial private capital (wealth) endowments, as in Caselli and Ventura (2000) and Sorger (2000). Indeed, recent evidence points to the importance of returns to capital as a critical determinant of inequality; see Atkinson (2003) and Checchi and Garcia-Penalosa (2005). Further, labor supply is endogenously determined in the resource allocation process, and when combined with an unequal distribution of initial wealth, it generates a distribution of income endogenously in equilibrium. The stock of government-provided infrastructure is introduced as a non-rival and non-excludable public good which serves as a complementary factor to private capital and labor supply in the production process. This specification therefore yields an equilibrium where both growth and inequality are endogenously determined.

The evolution of the aggregate economy is independent of the distributional characteristics, but the distributions of wealth and income in turn track the evolution of the aggregate variables such as infrastructure, private capital, and the average labor-leisure allocation along the transition path. This feature of the model enables a tractable examination of the effects of various government spending and taxation policies on growth and the various distributions. The study of the public policy-growth-inequality relationship in the context of a fully specified dynamic model represents an important deviation from previous work, which have generally ignored the role of the government and have been restricted to the steady-state equilibrium path.

Another important contribution of this paper is that it synthesizes two independent strands of literature: on the one hand, the theoretical literature on growth and inequality, which has extended Caselli and Ventura's (2000) insights on the distributional properties of the representative consumer

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2 Various other and potentially important sources of inequality have also been studied in the literature, such as capital market imperfections, the ability to invest in human or physical capital, the unequal distribution of natural resources, socio-economic stratification, and technological progress; see Banerjee and Newman (1993), Galor and Zeira (1993), Benabou (1996), Galor and Tsiddon (1997), Aghion and Bolton (1997), Bhattacharya (1998), and Gylfason and Zoega (2003).

3 A number of recent papers, by Garcia-Penalosa and Turnovsky (2006, 2007) explore the growth-inequality relationship in the context of a linear endogenous growth model. These papers study only the balanced growth path and abstract from dynamic issues and public goods. More recently, Garcia-Penalosa and Turnovsky (2008) explore the dynamic properties of wealth and income distributions in a neoclassical growth model. However, by construction, their model does not yield a long-run growth inequality relationship. Their analysis is also restricted to structural shocks such as productivity changes and population growth, and again, abstracts away from the government.
model, has not dealt with issues related to public investment and its financing. On the other hand, the extensive theoretical literature on growth and public investment has ignored distributional questions. This paper, by exploring the public investment-growth-distribution relationship in the context of the representative consumer theory of distribution, represents the first attempt (to our knowledge) in the literature that combines both these strands of literature into a unified framework.

The evolution of inequality in our model is determined by two factors: (i) the distribution of labor supply generated by the endogenous labor-leisure choice in response to the initial distribution of private capital, and (ii) the gradual accumulation of the stock of public infrastructure in the economy, which affects relative returns of the private factors of production (capital and labor) and their dispersion, by serving as a complementary input in production. In the short run, therefore, the dynamics of income inequality are determined primarily by the initial response of the labor-leisure choice, while its transition and long-run adjustment are influenced by the evolution of the aggregate stocks of private capital and public infrastructure. The model is analyzed numerically, by conducting several policy experiments. A number of interesting hypotheses emerge:

(i) A lumpsum tax-financed increase in government spending on infrastructure capital, while being growth-enhancing, can have sharply contrasting effects on inequality over time. In the short run, the government expenditure shock reduces income inequality, but this trend is reversed along the transition path, and the long-run is characterized by an increase in the inequality of wealth, income, and welfare. This is a surprising result, since lumpsum taxes are a non-distortionary source of financing government spending. However, it is consistent with recent trends in OECD countries, where both infrastructure spending and inequality have steadily risen over time. The key to understanding this result lies in the dual role played by infrastructure in influencing the marginal return from private capital and the productivity of labor. Being a complementary input in production, infrastructure increases the productivity of labor in the short run, since the stock of private capital cannot be changed instantaneously in response to the favorable government spending shock. Since labor income is more equally distributed than capital to begin with, the short run dispersion of income narrows. However, the higher government spending also raises the long-run return to private capital, which is the source of inequality in the economy. As a result, wealth inequality increases over time as richer agents gain disproportionately relative to poorer agents from the infrastructure investment. In equilibrium, this more than offsets any productivity benefits that might accrue to labor. Additionally, this pro-growth policy also lowers equity by increasing the dispersion of welfare. Therefore, a central conclusion of this paper is that growth-enhancing government investment policies may actually contribute to the worsening of both inequality and equity in the long-run.

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4This literature has explored the determinants of the interdependency between growth and inequality, focusing mainly on the productivity of private capital (Bertola, 1993), differences in individual propensities to save (Chatterjee, 1994), structural characteristics of an economy, such as civil liberty and openness (Lundberg and Squire, 2003), and the endogeneity of labor supply when initial wealth endowments are unequally distributed (Sorger, 2000).

5Government investment in the OECD countries has increased steadily, from an average of about 21 percent of GDP in 1972 to about 26 percent in 1999 (source: Government Financial Statistics Database). On the other hand, income inequality increased in most of the major OECD countries during this time; see Smeeding (2002).
(ii) The above result raises the question: does the mode of financing infrastructure investment matter for the inequality? Our results indicate an important redistributive role for the capital income tax as a financing instrument: infrastructure spending financed by a tax on capital income not only increases growth, but also reduces income and welfare inequality, thereby promoting both growth and equity. By comparison, government spending financed by labor income or consumption taxes turn out to be inferior policies, with respect to their redistributive effects.

(iii) Finally, the effects of various taxation policies on growth and inequality, for a given level of government spending, are examined. This experiment has the advantage of decoupling the redistributive effects of taxes from those of government spending. Our results reveal that while raising the capital income and consumption tax rates can have a redistributive effect on the economy, they come at the cost of lower growth and welfare. We also consider the case where the labor income tax is replaced by a consumption tax as a means of financing a given level of government spending, which has been a topical issue in political circles in countries such as the United States. We find that the switch from a labor income tax to a consumption tax is beneficial for the economy at both the aggregate and the distributional levels: growth increases in the long-run, while the major indicators of inequality decline. Therefore, replacing the labor income tax with a consumption tax, as a means of financing productive government spending, raises both efficiency and equity in equilibrium.

The wide array of results generated by our numerical experiments show that there is no definitive relationship between growth and inequality, both in the short run as well as the long run. This relationship depends critically on the underlying government spending or taxation policy and, more significantly, can change over time, leading to sharp intertemporal trade-offs. In this sense, our results are consistent with the ambiguous relationship between growth and inequality that is documented in a voluminous empirical literature.⁶

The rest of the paper is organized as follows. Section 2 lays down the analytical framework and derives the aggregate relationships describing the evolution of the economy. Section 3 derives the distributional relationships and demonstrates how they are interdependent with the evolution of the aggregate economy. Section 4 conducts several numerical policy experiments and discusses their predictions. Finally, Section 5 concludes.

2 Analytical Framework

Consumers

⁶Empirical studies that have explored the causality between growth and income inequality have generally yielded ambiguous results. For example, while Alesina and Rodrik (1994), Persson and Tabellini (1994), and Perotti (1998) find an inverse relationship, studies by Li and Zou (1998), Barro (2000), and Forbes (2000) have documented the possibilities for a positive link between the two.
There is a continuum of infinitely lived consumers, indexed by $i$, who are identical in all respects except for their initial endowment of private capital, $K_{i,0}$. Private capital is defined as an amalgam of physical and human capital, as in Romer (1986). Each consumer is also endowed with one unit of time which can be allocated to either leisure, $l_i$, or work, $L_i = 1 - l_i$. A consumer $i$ maximizes lifetime utility over an infinite horizon from its flow of consumption and leisure, using an isoelastic utility function:

$$U_i = \int_0^\infty \frac{1}{\gamma} (C_i t_i) e^{-\beta t} dt, \quad -\infty < \gamma < 1, \quad \theta > 0, \quad \gamma(1 + \theta) < 1$$

(1)

where $C_i$ is the $i$-th consumer’s flow of consumption and $\theta$ is the relative importance of leisure in utility. Each consumer’s optimization is subject to the following flow budget constraint

$$\dot{K}_i = (1 - \tau_k)rK_i + (1 - \tau_w)w(1 - l_i) - (1 + \tau_c)C_i - T$$

(2)

where $\tau_k$, $\tau_w$, and $\tau_c$ represent the tax rates on the agent’s capital income, labor income, and consumption expenditures, respectively and $T$ represents a lump-sum tax levied by the government on all $i$ individuals. The interest earned on private capital investment is given by $r$ and $w$ is the wage income from work.

Firms and Technology

Firms are indexed by $j$ and produce output using (i) private capital, borrowed from consumers, (ii) labor supply, purchased from consumers, and (iii) the economy-wide aggregate stock of infrastructure, or "public capital", $K_g$, provided by the government. Output is produced using a Cobb-Douglas production function:

$$Y_j = A(L_j K_g)^\eta K_j^{1-\eta}, \quad 0 < \eta < 1, \quad A > 0$$

(3)

In the above production function, it is assumed that "raw" labor, $L_j$, is combined with public capital to yield "labor efficiency" units, which in turn interacts with private capital to produce output. Note that since all firms face identical production conditions (same $A$, $K_g$, and $\eta$), they will choose exactly the same level of employment of labor and private capital, i.e., $K_j = K$ and $L_j = L$, $\forall j$, where $K$ and $L$ are the average economy-wide levels of private capital and labor employment, respectively. Therefore, the individual and aggregate marginal products of labor and capital are related by

$$\frac{\partial Y_j}{\partial L_j} = \frac{\partial Y}{\partial L} = \frac{\eta A z^\eta}{(1 - l)^{1-\eta}} K \equiv w(z, l)K$$

(3a)

$$\frac{\partial Y_j}{\partial K_j} = \frac{\partial Y}{\partial K} = (1 - \eta) A[(1 - l)z]^\eta \equiv r(z, l)$$

(3b)

where, $z = K_g / K$ denotes the ratio of infrastructure to private capital in the economy, while we
have used the fact that $L = 1 - l$. Since firms are all identical and competitive, the relationships in (3a) and (3b) pin down the the economy-wide real wage rate and the marginal product of capital, respectively. These, in turn, depend on the aggregate ratio of infrastructure to private capital and the average allocation of time to work (or leisure).

**Government**

The government provides the aggregate stock of non-excludable public capital, whose evolution is given by

$$\dot{K}_g = G = gY, \quad 0 < g < 1$$

where $G$ is the flow of new investment in public capital, which in turn is tied to the scale of the economy, given by aggregate output $Y$. Therefore, $g$ represents the fraction of aggregate output allocated to public investment by the government. The government finances this allocation through its tax revenues and maintains a balanced budget at all points of time:

$$G = \tau_k r K + \tau_w w(1 - l) + \tau_c C + T$$

In order to maintain an equilibrium of sustained growth, we assume that lump-sum tax revenues represent a fixed proportion of aggregate output

$$T = \phi Y, \quad 0 < \phi < 1$$

### 2.1 Resource Allocation in the Private Sector

Each consumer $i$ chooses their rate of consumption, labor supply (or leisure), and investment in private capital to maximize (1), subject to (2) and their initial endowment of private capital, $K_{i,0}$. Since the labor and capital markets are competitive, the real wage rate and return on private investment is determined by (3a) and (3b) respectively, and is therefore taken as given by the individual consumer. The representative consumer also treats all tax and policy variables as exogenously given.

The optimality conditions for a generic consumer $i$ are given by

$$C_i^{\gamma - 1}l_i^{\beta\gamma} = \lambda_i (1 + \tau_c)$$

$$\theta C_i^{\gamma} l_i^{\beta\gamma - 1} = \lambda_i (1 - \tau_w) w(z, l) K$$

$$(1 - \tau_k) r(z, l) = \beta - \frac{\dot{\lambda}_i}{\lambda_i}$$

$$\lim_{t \to \infty} \lambda_i K_i e^{-\beta t} = 0$$

The interpretation of the optimality conditions is standard. Equation (5a) equates the marginal utility of consumption for the $i$-th consumer to their consumption tax-adjusted marginal utility of
private wealth. Similarly, (5b) equates the marginal utility of leisure to its opportunity cost, which is the after-tax wage income foregone, priced by the marginal utility of wealth. The after-tax rate of return on private capital investment is equated to that on consumption in (5c), while (5d) states the transversality condition for the private capital stock.

Dividing (5b) by (5a) gives the marginal rate of substitution between consumption and leisure

$$\frac{\theta C_i}{l_i} = \frac{(1 - \tau_w)}{(1 + \tau_c)} w(z, l) K$$

Substituting (6) in (2), while taking note of (3a), (3b), and (4c), we can derive the evolution of the \(i\)-th consumers' private capital stock

$$\psi_{K_i} \equiv \frac{\dot{K}_i}{K_i} = (1 - \tau_k)r(z, l) + (1 - \tau_w)w(z, l)[(1 - l_i) - \frac{l_i}{\theta}(\frac{K}{\dot{K}}) - \phi_y(\frac{K}{\dot{K}})]$$

where, \(y = Y/K = A[(1 - l)z]^\eta\), is the average product of aggregate private capital.

Differentiating (5a) with respect to time and combining with (5c), we get

$$\gamma - 1 \frac{C_i}{C} + \theta \gamma \frac{\dot{l}_i}{l_i} = \beta - (1 - \tau_k)r(z, l)$$

From (8) it is evident that each consumer will choose the same rate of growth of consumption and leisure, i.e.,

$$\frac{\dot{C}_i}{C_i} = \dot{C} / C, \frac{\dot{l}_i}{l_i} = \dot{l} / l, \forall i$$

### 2.2 Macroeconomic Equilibrium

The macroeconomic equilibrium is derived in two stages. First, we derive the dynamic equilibrium for the aggregate economy and demonstrate that it is independent of the distribution of wealth and income. Second, given the aggregate equilibrium, we derive the distribution of income and wealth and show their correspondence to the dynamic evolution of the economy.

#### 2.2.1 Aggregate Dynamics and Steady-State

The economy’s aggregate dynamics will be described in terms of the evolution of the private and public capital stocks, consumption, and the leisure-labor allocation. We begin by aggregating (6), the marginal rate of substitution between consumption and leisure, over all \(i\) consumers

$$\theta \frac{C}{K} = \frac{(1 - \tau_w)}{(1 + \tau_c)} w(z, l)$$
Aggregating (7) over \(i\) consumers and applying Euler’s theorem to the aggregate production function, the evolution of the aggregate stock of private capital can be expressed as

\[
\psi_K \equiv \frac{\dot{K}}{K} = (1 - g)y - \frac{(1 - \tau_w)}{\theta(1 + \tau_c)}w(z, l)l
\]  

(10)

Differentiating (6) with respect to time, and using (8) and (10), we can derive the evolution of average leisure in the economy

\[
\dot{l} = \frac{F(z, l)}{G(z, l)}
\]  

(11)

where,

\[
F(z, l) = l[\beta - (1 - \tau_k)r(z, l) + (1 - \gamma)[\eta g(y/z) + (1 - \eta)\psi_K]] \\
G(z, l) = \theta\gamma - (1 - \gamma)[1 + (1 - \eta)l/(1 - l)]
\]

The growth rate of aggregate consumption is the given by

\[
\psi_C = \frac{\dot{C}}{C} = \frac{1}{(1 - \gamma)}[(1 - \tau_k)r(z, l) + \theta\gamma F(z, l)/lG(z, l) - \beta]
\]

(12)

The stock of the government-provided public capital evolves according to

\[
\psi_g = \frac{\dot{K}_g}{K_g} = g(y/z) = \frac{gA[(1 - l)z]^{\eta}}{z} 
\]

(13)

Finally, the growth rate of aggregate aggregate output is given by

\[
\psi_Y = \frac{\dot{Y}}{Y} = \eta[\psi_g - \frac{F(z, l)/G(z, l)}{1 - l}] + (1 - \eta)\psi_K
\]

(14)

The equilibrium dynamics can be represented by the evolution of the stationary variables \(z\) (the ratio of infrastructure to private capital) and \(l\) (leisure):

\[
\frac{\dot{z}}{z} = g(y/z) - (1 - g)y + \frac{(1 - \tau_w)}{\theta(1 + \tau_c)}w(z, l)l 
\]

(15a)

\[
\dot{l} = \frac{l[\beta - (1 - \tau_k)r(z, l) + (1 - \gamma)[\eta \psi_g + (1 - \eta)\psi_K]]}{\theta\gamma - (1 - \gamma)[1 + (1 - \eta)l/(1 - l)]}
\]

(15b)

The steady-state equilibrium is attained when \(\dot{z} = \dot{l} = 0\). Imposing this restriction on (15a) and (15b), we can solve for the steady-state ratio of infrastructure to private capital, \(\tilde{z}\), and the equilibrium allocation of time to leisure, \(\tilde{l}\). Given \(\tilde{z}\) and \(\tilde{l}\), (9) can be used to solve for the steady-state consumption-private capital ratio, \(\tilde{c}\):

\[
\tilde{c} = \frac{(1 - \tau_w)}{\theta(1 + \tau_c)}w(\tilde{z}, \tilde{l})\tilde{l}
\]

(15c)
The linearized dynamics around the steady-state \((\bar{z}, \bar{l})\) can be expressed as

\[
\begin{bmatrix}
\dot{z} \\
\dot{l}
\end{bmatrix} =
\begin{bmatrix}
a_{11} & a_{12} \\
a_{21} & a_{22}
\end{bmatrix}
\begin{bmatrix}
z - \bar{z} \\
l - \bar{l}
\end{bmatrix}
\]

(16)

where \(a_{ij} (i, j = 1, 2)\) represent the coefficients of the linearized matrix and are described in the appendix.

The optimal evolution of the economy can then be described by

\[
z(t) = \bar{z} + (z_0 - \bar{z})e^{\mu t}
\]

(17a)

\[
l(t) = \bar{l} + \left(\frac{\mu - a_{11}}{a_{12}}\right)[z(t) - \bar{z}]
\]

(17b)

where \(\mu\) is the stable (negative) eigenvalue corresponding to the linearized system in (16). Equation (17b) represents the saddle path for the economy in the \((l, z)\) space. For a plausible range of parameter values, it can be numerically demonstrated that the slope of the saddle path is negative, implying that along the transition path, the evolution of leisure is inversely related to that of the infrastructure-private capital ratio. This also implicitly means that there is a positive relationship between leisure and private capital, which is consistent with a large body of empirical work that finds a negative relationship between wealth and labor supply; see Holtz-Eakin et al. (1993), Cheng and French (2000), Coronado and Perozek (2003), and Algan et al. (2003). Finally, the consumption-private capital ratio evolves according to

\[
c(t) = \bar{c} + \Delta[z(t) - \bar{z}]
\]

(17c)

where,

\[
\Delta = \frac{(1 - \tau_w)}{\theta(1 + \tau_c)}[\bar{l}w_z(\bar{z}, \bar{l}) + \left(\frac{\mu - a_{11}}{a_{12}}\right)\{w(\bar{z}, \bar{l}) + w_{l}(\bar{z}, \bar{l})\}]
\]

The dynamic time paths described in (17a)-(17c) represent the average behavior of this heterogeneous agent economy. The evolution of the aggregate economy is tracked by the (gradual) accumulation of the stock of infrastructure relative to private capital \((z)\). Since both infrastructure and private capital represent stocks that are being accumulated, we rule out instantaneous jumps in \(z\). However, leisure, the consumption-capital ratio, and the growth rates of the key variables of the system represent flows and hence can respond instantaneously to new information.

### 3 Distributional Dynamics

Given the characterization of the average behavior of the economy in Section 2, we now proceed to an analysis of a cross-section of its agents, so as to determine the evolution of that cross-section relative to the average evolution of the economy. Specifically, we will focus on the distributional dynamics of private capital (wealth), leisure, post- and pre-tax income, and welfare. Having
characterized these distributions and their evolution over time, we will then analyze their dynamic response to a range of fiscal policy shocks.

3.1 Distribution of Private Capital (Wealth)

The first step in our analysis is to derive the distribution of the stock of relative private capital or wealth. To do this, let \( k_i = K_i/K \) denote \( i \)-th consumer’s private capital stock relative to the average stock of private capital in the economy. Combining (7) and (10), the evolution of the \( i \)-th agent’s relative capital stock can be expressed as

\[
\dot{k}_i = [gy(z, l) - \tau_k r(z, l)] k_i + w(z, l) \left( 1 - (1 - \frac{1 + \theta}{\theta}) l_i \right) - \left( 1 - l - \frac{(1 - \tau_w) l}{\theta(1 + \tau_c)} \right) k_i - \phi y(z, l)
\]

Further, from (8’), we know that each agent chooses the same rate of growth for labor supply (or leisure). Then, it must be the case that

\[
l_i = \alpha_i l
\]

where \( \alpha_i \) reflects the \( i \)-th agent’s relative leisure, i.e., the agent’s leisure relative to the economy-wide average. This measure will be determined from the macroeconomic equilibrium. Using (19), the evolution of the relative capital stock can be re-written as

\[
\dot{k}_i = [gy(z, l) - \tau_k r(z, l)] k_i + w(z, l) \left( 1 - \frac{1 + \theta}{\theta} \alpha_i l \right) - \left( 1 - l - \frac{(1 - \tau_w) l}{\theta(1 + \tau_c)} \right) k_i - \phi y(z, l)
\]

It is evident from (20) that the evolution of relative private capital or wealth will depend on the evolution of the economy’s aggregate infrastructure-private capital ratio, average leisure (or labor supply), and relative leisure. As we will demonstrate subsequently, in the long-run as \( z \to \tilde{z} \) and \( l \to \tilde{l} \), relative capital, \( k_i \), converges to a stationary level, say \( \tilde{k}_i \), where \( \dot{k}_i = 0 \). Using this condition in (20) enables us to express relative leisure, \( \alpha_i \), as:

\[
\alpha_i = \frac{\theta}{1 + \theta} \left[ \frac{\{\eta(1 - \tau_w) - \phi(1 - \tilde{l})\} + \{g - (1 - \eta)\tau_k\}(1 - \tilde{l})\tilde{k}_i - \eta \left( 1 - \tilde{l} - \frac{(1 - \tau_w) \tilde{l}}{\theta(1 + \tau_c)} \right) \tilde{k}_i}{\eta(1 - \tau_w) \tilde{l}} \right]
\]

Since each agent chooses the same growth rate of labor supply, relative leisure, as given in (21), remains constant throughout transition. Using (21) in (20) and linearizing around the steady-state levels of \( \tilde{z}, \tilde{l} \), and \( \tilde{k}_i \), while noting (17a)-(17b), we can derive the following differential equation for the relative private capital stock:

\[
\dot{k}_i = \delta_1 (z - \tilde{z}) + \delta_2 (k_i - \tilde{k}_i)
\]
where \( \delta_1 = \delta_1(\tilde{z}, \tilde{l}, \tilde{k}_i) \) and \( \delta_2 = \delta_2(\tilde{z}, \tilde{l}) \) are constants evaluated at the steady-state and are given by

\[
\delta_1 = \left( \frac{\tilde{y}}{\tilde{l}} \right) \left[ \left( \frac{\mu - a_{11}}{a_{12}} \right) \left\{ \frac{(\eta - g) + (1 - \eta)\tau_k}{1 - \tilde{l}} \right\} - \frac{(1 - \eta)(g - \tau_k)}{\tilde{z}/\tilde{l}} \right] \tilde{k}_i + \left( \frac{\delta_1}{\mu - \delta_2} \right) \left( z_0 - \tilde{z} \right) e^{\mu t}
\]

A stable solution to (22) takes the form

\[
k_i(t) = \tilde{k}_i + \left( \frac{\delta_1}{\mu - \delta_2} \right) \left( z_0 - \tilde{z} \right) e^{\mu t}
\]

Setting \( t = 0 \) in (23), we get

\[
k_{i,0} = \tilde{k}_i + \left( \frac{\delta_1}{\mu - \delta_2} \right) \left( z_0 - \tilde{z} \right)
\]

Given the initial relative capital endowment, \( \tilde{k}_i, \) (21) and (24) can now be solved for the steady-state distribution of capital, \( \tilde{k}_i \) and relative leisure, \( \alpha_i. \)

Further, using the definition of \( \delta_1 \) and collecting terms, the evolution of the relative capital stock along the equilibrium path can be expressed as

\[
k_i(t) - \tilde{k}_i = \left[ \Omega_1 \tilde{k}_i + \Omega_2 \right] [z(t) - \tilde{z}]
\]

where \( \Omega_1 \) and \( \Omega_2 \) are constants, given by

\[
\Omega_1 = \left( \frac{\tilde{y}/\tilde{l}}{\mu - \delta_2} \right) \left[ \left( \frac{\mu - a_{11}}{a_{12}} \right) \left\{ \frac{(\eta - g) + (1 - \eta)\tau_k}{1 - \tilde{l}} \right\} - \frac{(1 - \eta)(g - \tau_k)}{\tilde{z}/\tilde{l}} \right]
\]

\[
\Omega_2 = \left( \frac{\tilde{y}/\tilde{l}}{\mu - \delta_2} \right) \left[ \left( \frac{\mu - a_{11}}{a_{12}} \right) \left\{ \frac{\phi - \eta(1 - \tau_w)}{1 - \tilde{l}} \right\} + \frac{\phi(1 - \eta)}{\tilde{z}/\tilde{l}} \right]
\]

From (25), we see that the evolution of the relative private capital stock tracks the evolution of the infrastructure-private capital ratio. As \( t \to \infty, \) and \( z(t) \to \tilde{z}, \) and \( k_i(t) \) approaches its steady-state level, \( \tilde{k}_i, \) i.e., the distribution of relative capital converges to its steady-state distribution.

The dispersion of the stock of relative capital and its dynamic evolution can be described by its standard deviation, since a linear relationship exists between relative capital at any time \( t \) and its steady-state level, as shown in (25). Therefore, we can derive:

\[
\sigma_k(t) = \left[ 1 + \Omega_1 \{z(t) - \tilde{z}\} \right] \sigma_k
\]
where $\sigma_k$ denotes the standard deviation of relative capital. The initial distribution of relative capital is therefore given by

$$\sigma_{k,0} \equiv \sigma_k(0) = [1 + \Omega_1 \{z_0 - \tilde{z}\}]\tilde{\sigma}_k$$  \hspace{1cm} (27b)

Combining (27a) and (27b), we can express distribution of relative capital in terms of its initial distribution:

$$\sigma_k(t) = \frac{[1 + \Omega_1 \{z(t) - \tilde{z}\}]}{[1 + \Omega_1 \{z_0 - \tilde{z}\}]} \sigma_{k,0}$$  \hspace{1cm} (28)

Since the initial distribution of capital is given, $\sigma_{k,0}$ is pre-determined. Therefore (28) completely characterizes the evolution of the standard deviation of the relative capital stock, given its initial distribution and the initial stock of the economy-wide infrastructure to private capital ratio. Starting with an initial deviation of the infrastructure-private capital ratio from its long-run steady-state, (28) suggests that

$$\text{sgn}\left[1 + \Omega_1 \{z_0 - \tilde{z}\}\right] = \text{sgn}\left[1 + \Omega_1 \{z(t) - \tilde{z}\}\right]$$

Therefore, if $z_0 < \tilde{z}$, so that $z(t)$ is increasing in transition, the dispersion of private capital will increase as it approaches its long-run dispersion. Exactly the reverse happens when $z_0 > \tilde{z}$. This happens because an increase in the stock of infrastructure relative to private capital increases the marginal return to private capital. Since private capital is more unequally distributed than labor supply, this raises the return for the capital-rich relative to that for the capital-poor, and consequently increases wealth inequality.

As $t \to \infty$, the standard deviation of relative capital converges to its steady-state level, given by

$$\lim_{t \to \infty} \sigma_k(t) \equiv \tilde{\sigma}_k = \frac{1}{[1 + \Omega_1 \{z_0 - \tilde{z}\}]}\sigma_{k,0}$$  \hspace{1cm} (28a)

The steady-state distribution of private capital is therefore determined by (i) its initial distribution, $\sigma_{k,0}$, and (ii) the initial deviation of the economy-wide infrastructure to private capital ratio from its steady-state level, $(z_0 - \tilde{z})$.

### 3.2 Distribution of Leisure

The standard deviation of relative leisure can be obtained by exploiting the linear relationship between relative leisure and the steady-state distribution of private capital, derived in (21):

$$\sigma_\alpha \equiv \sigma_l = \frac{1}{1 + \theta} \left[ \frac{1}{(1 + \tau_c)} - \theta \left\{ \frac{(\eta - g) + (1 - \eta)\tau_k}{\eta(1 - \tau_w)} \right\} \left( \frac{1 - \tilde{l}}{l} \right) \right] \tilde{\sigma}_k$$  \hspace{1cm} (29)

The distribution of leisure depends on the steady-state distribution of private capital, and the average steady-state allocation of time to leisure. Note that since the steady-state distribution of private capital, derived in (28a), is determined in part by its (given) initial distribution, (29)
indicates that the distribution of leisure will be constant throughout transition, in contrast to the
time-varying distribution of private capital given in (28). This is a consequence of the constancy
of relative leisure, $\alpha_i$, as each agent in the economy chooses the same growth rate for labor supply;
see (8’).

### 3.3 Distribution of Income

Another critical component of inequality is the distribution of private income over the $i$ agents in
the economy. However, a key classification in the distributional dynamics for income concerns the
pre-tax and post-tax distributions. We begin by characterizing the post-tax distribution of income.
The after-tax disposable income (net of lump-sum taxes) for the $i$-th private agent is defined as the
sum of after-tax capital and labor income:

$$Y_i = (1 - \tau_k)r(z,l)K_i + (1 - \tau_w)w(z,l)(1 - l_i)K$$

(29a)

Aggregating over $i$ agents, the aggregate after-tax disposable income is given by

$$Y = [(1 - \tau_k)r(z,l) + (1 - \tau_w)w(z,l)(1 - l)]K$$

(29b)

Defining after-tax relative income for the $i$-th agent as $y_i = Y_i / Y$, its distribution can be expressed
as

$$y_i(t) = s_kk_i(t) + (1 - s_k) \left[ 1 + (1 - \alpha_i) \frac{l(t)}{1 - l(t)} \right]$$

(30)

where $s_k$ represents the share of after-tax capital in total income, while $1 - s_k$ represents the
corresponding share of labor income:

$$s_k = s_k(z,l) = \frac{(1 - \tau_k)r(z,l)K}{Y}$$

Similarly, the pre-tax distribution of income can be derived as

$$y^*_i(t) = s^*_k k^*_i(t) + (1 - s^*_k) \left[ 1 + (1 - \alpha_i) \frac{l(t)}{1 - l(t)} \right]$$

(31)

where and $s^*_k$ denotes the share of pre-tax capital income in total pre-tax income:

$$s^*_k = s^*_k(z,l) = \frac{r(z,l)}{r(z,l) + w(z,l)(1 - l)}$$

The distributional properties of after-tax and pre-tax relative income can be derived from (30) and
(31), respectively:

$$\sigma_y(t) = s_k\sigma_k(t) - (1 - s_k) \left[ \frac{l(t)}{1 - l(t)} \right] \sigma_l$$

(32a)

$$\sigma^*_y(t) = s^*_k\sigma_k(t) - (1 - s^*_k) \left[ \frac{l(t)}{1 - l(t)} \right] \sigma_l$$

(32b)
The results in (32a) and (32b) indicate that the evolution of the standard deviation of after-tax and pre-tax income is a weighted average of the standard deviations of relative capital and relative leisure, with the weights being determined by the respective pre-and post-tax shares of capital and labor income in total income. Since the distribution of pre- and post-tax income depends on average labor supply and its dispersion, the standard deviation of the distribution of income will be subject to instantaneous jumps in the short run, as both the average supply of labor and its dispersion can change instantaneously in response to shocks. Over time, the gradual adjustment of the labor-leisure choice and the distribution of relative capital causes the distribution of income to converge to its long-run steady-state. To understand the dynamics of the dispersion of relative income, we begin by linearizing post-tax relative income, given in (30) around the steady-state, while recalling (25):

\[
y_i(t) - \bar{y}_i = s_k[k_i(t) - \bar{k}_i] + \frac{(1 - s_k)(1 - \alpha_i)}{(1 - \bar{l})^2} [\bar{u}(t) - \bar{l}]
\]

Then, the evolution of the dispersion of relative income, measured by its standard deviation, is given by

\[
\sigma_y(t) - \bar{\sigma}_y = s_k[\sigma_k(t) - \bar{\sigma}_k] - \frac{(1 - s_k)}{(1 - \bar{l})^2} [\bar{l}(t) - \bar{l}]\sigma_l
\]  

(33a)

where \(\bar{\sigma}_y\) denotes the steady-state standard deviation of post-tax relative income. As is evident from (33b), the dynamic evolution of post-tax income inequality depends critically on (i) the evolution of wealth inequality, which in turn depends on the adjustment of the economy-wide infrastructure-private capital ratio; see (28), (ii) the dynamic adjustment of the average labor-leisure choice, and (iii) the dispersion of relative leisure. Therefore, an underlying policy shock will affect the distribution of income through two critical channels: first, through its effects on the economy’s aggregate or average variables, and secondly, through the long-run responses of the dispersions of relative wealth and leisure. Over time, as \(z(t)\) and \(l(t)\) converge to their respective steady-state levels, the dispersion of income approaches its stationary steady-state.

Another critical component of the dynamics of income inequality is its short-run or instantaneous dynamics. To see this, evaluate (33a) at \(t = 0\), while noting that the dispersion of wealth is unchanging in the short run (since private capital is instantaneously fixed):

\[
\sigma_y(0) - \bar{\sigma}_y = \frac{(1 - s_k)}{(1 - \bar{l})^2} [\bar{l}(0) - \bar{l}]\sigma_l
\]

(33b)

The short-run dynamics of income inequality can be very different from its transitional and long-run behavior. From (33b), we see that the short-run adjustment of the dispersion of relative income depends on (i) the initial response of average leisure relative to its long-run response, given by \(l(0) - \bar{l}\) and (ii) the dispersion of relative leisure, \(\sigma_l\). Therefore, the short-run dynamics of income distribution are governed by the instantaneous effect of an underlying shock on the labor-leisure...
3.4 Distribution of Welfare

Economic welfare is a key indicator of the impact of government policies on national well-being, and it is important to study its distributional properties given the unequal distribution of private wealth and income in the economy. Using the utility function (1), we can state the instantaneous level of welfare for individual $i$ as

$$X_i = \frac{1}{\gamma} (C_i l_i^\theta)^\gamma$$

(33a)

Noting that the consumption-capital ratio is given by $c_i = C_i / K_i$, we can re-write (30a) as

$$X_i = \frac{1}{\gamma} (c_i l_i^\theta K_i)^\gamma$$

(33b)

The aggregate level of instantaneous welfare is then given by

$$X = \frac{1}{\gamma} (c l^\theta K)^\gamma$$

(33c)

Noting (6), (9), and (25), we can express the evolution of relative welfare as

$$x_i(t) = \frac{X_i}{X} = \left( \frac{l_i}{l} \right)^{(1+\theta)\gamma} = \alpha_i^{(1+\theta)\gamma}$$

(34)

The relative welfare level derived in (34) can be used to derive a measure of welfare inequality:

$$x_i^{1/(1+\theta)\gamma} \equiv u_i = \alpha_i$$

(35)

The standard deviation of relative welfare is then given by that of relative leisure, from (29):

$$\sigma_u = \sigma_l = \frac{1}{1+\theta} \left[ \frac{1}{1+\tau_c} - \theta \left\{ \frac{(\eta - g) + (1-\eta)\tau_k}{\eta(1-\tau_w)} \right\} \left( \frac{1-l}{l} \right) \right] \tilde{\sigma}_k$$

(36)

4 Numerical Analysis

Given the analytical complexity of the model, its predictions will be derived through a numerical exposition. The main objective of our numerical analysis is to determine the effect of fiscal policy shocks on the (i) aggregate economy, and (ii) the distributions of wealth (capital), income (pre- and post-tax), and welfare, both in the long-run as well as in transition. Specifically, we will consider two categories of fiscal shocks: (i) an increase in government spending on infrastructure, which may be financed through a wide range of taxation policies, and (ii) changes in the tax rates on capital income, labor income, and consumption, for any given level of government spending.

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7Similar results can be derived for the distribution of pre-tax income as well.
We begin with the specification of a benchmark economy. To calibrate the benchmark, we use values for the structural parameters that are consistent with their corresponding estimates from the empirical literature. The following table illustrates the choice of the structural and policy parameters in calibrating the benchmark equilibrium:

<table>
<thead>
<tr>
<th>Benchmark Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preferences</td>
</tr>
<tr>
<td>Production</td>
</tr>
<tr>
<td>Infrastructure Investment</td>
</tr>
</tbody>
</table>

Since we have set the infrastructure spending ratio, $g$, to 5% of GDP, and the government has a range of tax instruments at its disposal with which to finance this spending, the underlying financing policies must be characterized. Therefore, this leads to different benchmark equilibria depending on the particular taxation policy used to finance the benchmark government spending on infrastructure. To this end, the government budget constraint in (4a) and (4b) provide some useful financing rules. We will consider four alternative financing scenarios, where $g$ is financed by (I) lump-sum taxes, (II) a tax on capital income, (III) a tax on labor income, and (IV) a tax on consumption. This leads to the following financing rules for the government:

<table>
<thead>
<tr>
<th>Government Spending Financing Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) Lump-sum tax financing</td>
</tr>
<tr>
<td>(II) Capital income tax financing</td>
</tr>
<tr>
<td>(III) Labor income tax financing</td>
</tr>
<tr>
<td>(IV) Consumption tax financing</td>
</tr>
</tbody>
</table>

The benchmark equilibrium for the aggregate economy under the above four financing rules is reported in Table 1. For the purpose of brevity, we report the steady-state aggregate values of the two key endogenous variables: the ratio of infrastructure to private capital, $\bar{z}$, and the average economy-wide allocation of time to leisure, $\bar{l}$. In addition, we also report the equilibrium growth rate. For example, when government spending is financed by lump-sum taxes, the ratio of infrastructure to private capital is about 0.25, the average allocation of time to leisure is approximately 78 percent, while the economy-wide growth rate is 2.83 percent. In general, lump-sum tax-financing generates the highest growth rate among all the financing rules, while capital income tax-financing generates the lowest. On the other hand, while lumpsum tax-financing yields the smallest allocation of time to leisure, labor income tax-financing leads to the largest allocation.

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8The choice of the preference parameters $\beta$ and $\gamma$ yield an intertemporal elasticity of substitution in consumption of 0.4, which is in line with corresponding empirical estimates; see Guvenen (1998). The output elasticity of infrastructure lies within the consensus range of 0.1 – 0.3; see Gramlich (1994). The ratio of public investment to GDP, $g$, is chosen to equal the average economic infrastructure spending as a fraction of GDP in the OECD countries. Finally, while $A$ is a scale parameter, the relative weight of leisure in utility, $\theta$, is chosen to yield an equilibrium labor-leisure allocation that is consistent with empirical evidence.
The different values of growth rates and equilibrium variables in Table 1 underscore the different degrees of economy-wide distortions generated by the different financing instruments used for financing the provision of infrastructure.

4.1 Government Spending and the Dynamics of Growth and Inequality

Table 2 reports the effect of an increase in government spending on infrastructure on the aggregate steady-state equilibrium and the short-run and long-run responses of the distributions of wealth, income, and welfare. We consider an increase in government expenditure on infrastructure by 5 percentage points, from its benchmark level of 5% of GDP to 10% of GDP. Four possible financing schemes are considered for this spending increase: (I) lump-sum tax financing, (II) capital income tax-financing, (III) labor income tax-financing, and (IV) consumption tax-financing. The exact magnitude of the required tax increases in each case are calculated using the benchmark financing rules implied by the government budget constraint (4a), as described in the previous section.

The aggregate steady-state effects of each policy shock are reported in Table 2A, while the distributional impact of these policies are reported in Tables 2B and 2C. Specifically, Table 2B reports the short-run or instantaneous response of the standard deviations of wealth, post-tax and pre-tax income, and relative welfare. Table 2C reports the corresponding effects on the steady-state standard deviations. In each case, while reporting standard deviations, we express them relative to their initial, or pre-shock standard deviations. Therefore, for any variable \( x \), the short-run impact of a shock on its dispersion is given by \( \sigma_x(0)/\hat{\sigma}_x,0 \), where \( \sigma_x(0) \) is the instantaneous value of the standard deviation of the distribution of \( x \) on the impact of the shock, while \( \hat{\sigma}_x,0 \) is the corresponding pre-shock (initial) standard deviation. The long-run response is given by \( \hat{\sigma}_x/\hat{\sigma}_x,0 \), where \( \hat{\sigma}_x \) is the long-run standard deviation of the distribution of \( x \). The transitional response of the distributions are obtained by plotting the ratio \( \sigma_x(t)/\hat{\sigma}_x,0 \) and are depicted in Figure 1. Therefore, if \( \sigma_x(t)/\hat{\sigma}_x,0 > 1 \), it implies that the dispersion in the distribution of \( x \) has worsened (inequality has increased), while if \( \hat{\sigma}_x/\hat{\sigma}_x,0 < 1 \), then the corresponding dispersion has narrowed (inequality has declined), relative to its initial, pre-shock distribution. Finally, in the case where \( \sigma_x(t)/\hat{\sigma}_x,0 = 1 \), the underlying policy shock has no effect on the distribution of \( x \).

4.1.1 Lumpsum Tax-financed Increase in Government Spending

**Aggregate Effects:** The steady-state effects of an infrastructure spending increase financed by lumpsum taxes are reported in Table 2A, row 1. The results are quite standard and therefore our discussion can be brief. In general, an increase in government spending on infrastructure increases the economy’s aggregate stock of infrastructure relative to private capital and reduces the average allocation of time to leisure, thereby increasing average labor supply. The long-run increase in the stock of infrastructure increases the productivity of both aggregate private capital and labor and, in equilibrium, raises the long-run growth rate and average welfare.
Since the lumpsum tax is non-distortionary at both the aggregate and the cross-sectional level, this policy experiment enables us to isolate the pure effect of a government spending increase. At first glance, the results reported in Table 2B and 2C look surprising. In the short run, both pre-tax and post-tax income inequality decline by 7 percent, relative to their pre-shock levels, indicating that infrastructure spending has a redistributive effect. However, in the long-run, despite being growth-enhancing, the short run distributional effects are reversed: income inequality increases by more than 4 percent, while wealth inequality and welfare inequality increase by 3 percent and 10 percent, respectively. Therefore, higher infrastructure spending generates intertemporal trade-offs not only for the distribution of income, but also between efficiency (growth) and equity (relative welfare). This is a significant result, since the government spending was financed through a non-distortionary lumpsum tax.

The intuition behind the above result can be better understood by referring to Figure 1A, which illustrates the dynamic response of the economy’s aggregate variables and distributions. The increase in government spending, insofar as it represents the augmentation of a productive input, creates an instantaneous positive wealth effect, which reduces the marginal utility of wealth. This causes leisure to jump up on impact of the shock, as shown in fig. 1A(i). Thereafter, as the stock of infrastructure rises in the economy, it raises the productivity of both labor and private capital, and this causes leisure to fall in transition to its new, but lower steady-state equilibrium.

Fig. 1A(ii) depicts the dynamic response of the distributions of wealth, pre-tax and post-tax income. Since the stock of private capital and its initial distribution is fixed in the short run, wealth inequality does not change on impact of the shock. In transition, the increasing stock of public infrastructure raises the marginal product of private capital and encourages private capital accumulation. Since capital is unequally distributed in the economy, capital-rich agents experience a larger increase in their return on private capital investment than do capital-poor agents. As a consequence, wealth in equality increases in transition to a higher level in the long-run. Since the government spending is financed by a non-distortionary lumpsum tax, the pre-tax and post-tax distribution of income are identical. The initial upward jump in average leisure causes income inequality to decrease instantaneously on impact of the shock. Since capital-rich agents also enjoy more leisure, the initial increase in leisure increases its dispersion and thereby narrows the dispersion of labor supply, thereby causing income inequality to fall in the short run. In transition, however, this trend is reversed. The wealth effect of the higher stock of infrastructure eventually causes the increasing dispersion of relative capital income to dominate the labor productivity effect, so that income inequality gradually increases in transition. In the long-run, the higher government spending leads to an overall increase in income inequality relative to its initial benchmark. As Table 2C indicates, the higher wealth and income inequality in the long-run also increases the dispersion of welfare. Even though average leisure declines, its dispersion is more unequal in the long-run relative to its initial dispersion.

Fig. 1A(iii) throws some light on the growth-inequality relationship. In the short run, both the
growth rate of output and income inequality decline relative to their initial pre-shock levels. In transition, both growth and income inequality increase and approach their respective higher long-run levels. This indicates that for this particular policy shock, there exists a positive correlation between growth and inequality that is sustained through time. However, as fig. 1A(ii) shows, there may be a sharp intertemporal trade-off in the dynamic response of income inequality. Finally, this policy experiment also highlights the trade-off between efficiency and equity: a non-distortionary government spending policy which enhances long-run growth and average welfare can also worsen inequality, irrespective of whether it is measured in terms of wealth, income, or welfare.

4.1.2 Capital Income Tax-financed Increase in Government Spending

*Aggregate Effects:* The aggregate impact of a government spending increase financed by a tax on private capital income is reported in Table 2A, row 2. As is evident, the effects are qualitatively similar to the previous case: the ratio of infrastructure to private capital increases, leisure declines, and both growth and average welfare increase in the long-run. However, since the public spending on infrastructure is now financed using a distortionary tax that lowers the after-tax return on private capital, it partially offsets the positive impact of the higher government spending thereby leading to a smaller expansionary effect on the economy compared to the lumpsum tax case.

*Distributional Effects:* The dynamic response of the economy and the distributions depend on the interaction between two offsetting effects along the transition path. On the one hand, the higher government spending on infrastructure tends to increase the productivity of both capital and labor, thereby affecting the labor-leisure choice and raising average factor incomes. On the other hand, the higher tax on capital income permanently reduces the after-tax return on private capital, which has a dampening effect on productivity. Since factor incomes are distributed unequally across the economy, both the spending increase and the distortionary financing instrument will have a redistributive effect on the economy. The short-run and long-run distributional effects are reported in Tables 2B and 2C (row 2). Since the financing instrument is distortionary, the response of pre-tax and post-tax income inequality will be distinct. In the short run, while wealth inequality is instantaneously fixed, both post-tax and pre-tax income inequality decline, with the decline in post-tax income inequality being larger than that for pre-tax income inequality. In the long-run, wealth inequality increases very slightly by 1 percent, and post-income inequality and welfare inequality fall by 1.5 and 2 percent, respectively. However, the initial decline in pre-tax income inequality is reversed in the long-run, and it increases by about 5 percent.

The dynamic adjustment of the economy is shown in Figure 1B. Since the initial stocks of private capital and infrastructure are instantaneously fixed, the higher tax on capital income reduces the after-tax return on private capital, which in turn reduces the marginal productivity of labor on impact of the government spending shock. As a result, leisure jumps up in the short run. However, as the benefits of the higher productive government spending that the capital income tax
finances are realized over time, both the productivity of labor and private capital increases, causing a decline in leisure and an increase in labor supply in transition and the long-run equilibrium; see fig. 1B(i). From fig. 1B(ii), we see that starting from its initial distribution, wealth inequality increases slightly in transition, though the increase is much smaller than the previous case of lumpsum tax-financed government spending. This reflects the redistributive effect of the capital income tax used to finance government spending: the lower after-tax return on private capital narrows its dispersion, as capital-rich agents experience a larger decline in their after-tax income than the capital-poor. This partially offsets the wealth-creating effect of infrastructure spending. The short run upward in leisure causes both pre-tax and post-tax income inequality to decline instantaneously in response to the shock; see (33b). However, since the fall in after-tax capital income is larger than the pre-tax income, the initial decline in post-tax income inequality is larger than that for pre-tax inequality.

In transition, as the stock of infrastructure rises due to the higher government spending, the productivity benefits of such spending more than offset the contractionary effect of the capital income tax, so that agents begin accumulating private capital. This wealth effect tends to increase both post-tax and pre-tax income inequality in transition. However, in the long-run equilibrium, the dispersion of post-tax income is lower than its benchmark dispersion as the redistributive effect of the higher tax rate dominates the wealth effect of the higher government expenditure. This is due to the fact that the permanently higher capital income tax narrows the dispersion of capital income, as capital-rich agents experience a larger decline in their after-tax income than the capital-poor do. This effect is augmented by the higher equilibrium labor supply, which indicates that the capital-poor will increase labor supply by a larger amount relative to the capital-rich (who enjoy more leisure). Together, this contributes to a less dispersed after-tax income. Since pre-tax income is not affected by the underlying tax effects, it increases in transition due to the wealth effect of the higher government spending. The lower dispersion of after-tax income also implies that the dispersion of consumption is lower, and this reduces welfare inequality.

The growth-inequality relationship is depicted in fig. 1B(iii). In the short run, both the growth rate and post-tax inequality decline, driven by the higher tax on capital income. This yields a positive correlation between the two variables. However, in the long run, the correlation is negative, as growth is higher but post-tax income inequality lower than their respective benchmarks. Since, average welfare is higher and welfare inequality is lower in equilibrium, a capital income tax-financed increase in productive government spending does not generate any long-run trade-off between efficiency and equity, as opposed to the case of lumpsum tax-financing.

4.1.3 Labor Income Tax-financed Increase in Government Spending

Aggregate Effects: The long-run effects on the aggregate economy for this policy shock are reported in Table 2A, row 3. As before, the higher government expenditure has a net expansionary effect on the economy: it raises the infrastructure-private capital ratio and long-run growth.
However, since the government spending is now financed by raising the tax on labor income, it reduces the after-tax marginal product of labor, thereby discouraging employment and increasing the average allocation of time to leisure in equilibrium. The lower after-tax labor income also reduces average welfare in the long run.

**Distributional Effects:** The dynamic response of the economy and the underlying distributions depend on the interaction of two opposing influences: the permanent decline in the after-tax wage rate and labor productivity due to the higher tax on labor income, and the increase in the productivity of labor and capital due to the higher stock of public infrastructure. As in the previous case, both pre-tax and post-tax income inequality fall in the short run, but contrary to the capital income tax-financing case, it is pre-tax income inequality that falls more than post-tax inequality. In the long-run, however, post-tax income inequality increases by more than 8 percent, while wealth and welfare inequality rise by about 3 percent and 10 percent, respectively. Pre-tax income inequality is still lower in the long-run equilibrium, by almost 30 percent relative to its benchmark; see Tables 2B and 2C, row 3.

The transitional dynamics for this policy shock are illustrated in Figure 1C. On impact, the higher labor income tax instantaneously reduces average post-tax wage income and causes the agents to reduce labor supply. This is depicted by an upward jump in leisure in fig. 1C(i). In transition, as the tax revenues finance infrastructure accumulation, the productivity of capital and labor increase, which partially offsets the initial drop in after-tax wages. As a result, leisure gradually declines in transition as the agent increases work effort. In the long-run however, leisure is above its pre-shock level, indicating that the tax distortion on the labor-leisure choice outweighs the productivity benefit of higher infrastructure. Wealth inequality remains unchanged on impact of the shock, but both pre- and post-tax income inequality fall in the short run, as is shown in Figure 1C(ii). The fall in post-tax income inequality is smaller than its pre-tax counterpart, specifically because of the dampening effect of the higher tax on post-tax labor income. In transition, the rise in the marginal product of private capital generated by the rising stock of public infrastructure raises wealth inequality. Since the higher tax on labor income permanently lowers average labor supply, it widens the dispersion of after-tax income in transition. This happens because the capital-poor agents supply more labor than the capital-rich agents, and therefore the tax on labor income impinges more on the capital-poor than on the capital-rich. This increases the dispersion of labor income and, in equilibrium, is reinforced by the larger dispersion of capital income (wealth). The increase in post-tax income inequality also increases the dispersion of consumption, thereby increasing welfare inequality in equilibrium. Since pre-tax income is insulated from the distortions of the labor income tax, its dispersion remains lower relative to its initial benchmark.

Figure 1C(iii) indicates that the relationship between economic growth and post-tax income inequality is positive over time: both measures decline in the short run and increase in the long run. However, the efficiency-equity trade-off is still present: this policy raises long-run growth, but
worsens average welfare and inequality measured in terms of wealth, post-tax income, and welfare. Finally, the policy generates an intertemporal trade-off in the distribution of post-tax income.

4.1.4 Consumption Tax-financed Increase in Government Spending

Aggregate Effects: The steady-state aggregate effects of this policy experiment are reported in Table 2A, row 4. Qualitatively, the long-run effects are similar to that of a lumpsum tax-financed increase in productive government spending: the policy has a net expansionary effect on the economy, with a rise in the infrastructure-private capital ratio, labor supply, growth, and welfare. In fact, when compared with the capital income tax and labor income tax-financing cases, the consumption tax seems to be the least distortionary as a financing instrument, after the lumpsum tax.

Distributional Effects: Following the increase in government spending and the consumption tax, leisure jumps up in the short run as the lower after-tax return on consumption increases the marginal utility of leisure. Thereafter, as the productivity benefits of government spending are realized along the transition path, labor supply increases and leisure falls. In Figure 1D (i), this is depicted by a long-run decline in the average time allocation to leisure. Further, since the consumption tax does not impinge directly on factor incomes, the evolution of pre- and post-tax income inequality coincide with each other. As seen from fig. 1D (ii) wealth inequality, though fixed in the short run, gradually rises in transition as the rising stock of government-provided infrastructure raises the return to private capital and widens its dispersion. As explained previously, the initial increase in leisure widens its disoersion and narrows that of labor supply. This causes an instantaneous decline in income inequality. However, in transition, the wealth-creating effect of infrastructure spending dominates the positive impact on labor productivity and, since private capital is more unequally distributed than labor supply to begin with, this raises long-run income inequality relative to its initial benchmark.

The relationship between growth and post-tax income inequality, shown in fig. 1D (iii), is qualitatively similar to the lumpsum tax-financing case, so our comments can be brief. growth and inequality are positively correlated, both in transition and in the steady-state. Income inequality is subject to an intertemporal trade-off, as it declines in the short run, but this trend is reversed in transition and the long-run. Finally, the efficiency-equity trade-off is evident for this policy as well, as growth and average welfare increase, but the dispersion of wealth, income, and welfare worsen.

4.2 Tax Policies and Redistribution

In this section, we examine the redistributive effects of various taxation policies on wealth, income, and welfare inequality. Specifically, we consider four permanent tax shocks: (A) an increase
in the tax on capital income, (B) an increase in the labor income tax rate, (C) an increase in the consumption tax rate, and (D) a switch from the labor income tax to a consumption tax, as a means of financing a given level of infrastructure investment. In experiments (A)-(C), we consider a 10 percentage point increase in the respective tax rate from their benchmark equilibrium described in Table 1, while keeping the level of government spending fixed at its benchmark level of 5 percent of GDP. We calibrate these increases by an appropriate adjustment of lumpsum taxes, in accordance with the government budget constraint (4a). For experiment (D), we replace the labor income tax with a consumption tax, while keeping government spending unchanged. These policy changes and their aggregate and distributional effects are described in Table 3, while Figure 2 illustrates the transitional dynamics. Since the basic intuition underlying the various distortions introduced by these tax rates have already been described in the previous section, our discussion here can be brief.

4.2.1 An Increase in the Capital Income Tax

The increase in the capital income tax rate instantaneously reduces the after-tax return on private capital, thereby reducing the rate of private capital accumulation and raising the stock of infrastructure relative to private capital. The lower after-tax return on capital and the reduction in private capital accumulation dampens labor productivity as well, and this increases the allocation of time to leisure in the long run. The lower labor supply and return to capital depress the economy’s long run growth rate and welfare; see Table 3A, row 1. Tables 3B and 3C reports the effects of this policy on the distributions of wealth, income, and welfare, in the short run and the long run, respectively. The dispersion of wealth, post-tax income, and welfare decline in equilibrium, while that of pre-tax income increases.

The intuition behind this result can be understood from fig. 2A. On impact, the lower after-tax return on capital causes leisure to jump up and overshoot its higher long run equilibrium (fig. 2A(i)). Starting from its initial distribution, wealth inequality falls over time as agents reduce capital accumulation in response to the higher tax. Since private capital is unequally distributed, the decline in the after-tax return for capital-rich agents is much larger than for the capital-poor. Consequently, this causes the dispersion of wealth to narrow over time. The fall in the after-tax return on private capital and the initial upward jump in average leisure instantaneously reduces the dispersion of post-tax income, as the capital-rich reduce their work effort more than the capital-poor. Over time, as wealth inequality declines, post-tax income inequality remains below its initial benchmark level; see fig. 2A(ii). The decline in income inequality also narrows the dispersion of consumption, which causes welfare inequality to fall. On the other hand, since the pre-tax share of capital in total output is larger than its post-tax share, pre-tax income inequality is higher than its initial impact. Therefore, by reducing the return to the factor that is more unequally distributed in the economy (i.e., private capital), the higher tax on capital income has a long-term redistributive effect on the economy. However, the redistributive effect of the tax on
capital income generates a trade-off between growth and income inequality as the economy ends up with a lower growth rate in the long run. The growth-inequality relationship is therefore positive over time.

4.2.2 An Increase in the Labor Income Tax

An increase in the tax rate on labor income reduces the after-tax wage rate, causing the agent to substitute leisure for work, thereby increasing the equilibrium allocation of time to leisure. The fall in labor supply reduces the marginal product of capital, which eventually translates into a decline in long-run growth and welfare; see Table 3A, row 2. The short-run and long-run distributional effects are reported in Tables 3B and 3C. While wealth and welfare inequality increase slightly in equilibrium, the increase in post-tax income inequality is much larger. On the other hand, pre-tax income inequality falls.

The increase in the labor income tax reduces the after-tax return to the factor (labor) that is less unequally distributed relative to private capital. Since poorer agents supply more labor relative to richer agents, the decline in their after-tax wage income is larger than for the richer agents. Consequently, the dispersion of labor income increases. Moreover, since government spending on infrastructure is unchanged, the dampening effect of the decrease in labor supply on the marginal product of capital is largely offset, which prevents wealth inequality from falling. As a result, post-tax income inequality increases, both in the short run and long run. As is evident from fig. 2B(i)-(ii), the long-run adjustment of average leisure and the respective distributions is almost instantaneous. Figure 2B(iii) indicates that growth and inequality are negatively correlated over time: both the short run and the long run are characterized by an increase in inequality and a decline in the growth rate. Therefore, this tax policy lowers both efficiency and equity.

4.2.3 An Increase in the Consumption Tax

An increase in the tax on consumption reduces the after-tax return on consumption, causing the agent to substitute towards leisure and away from consumption. The fall in labor supply has a dampening effect on the productivity of private capital, leading to a decline in long-run growth and welfare; see Table 3A, row 3. On the other hand, Tables 3B and 3C indicate that the consumption tax increase has a redistributive effect on the economy: it reduces income (both pre- and post-tax) inequality slightly, by about 1 percent, and welfare inequality by about 9 percent, relative to their initial benchmarks. Wealth inequality, however, remains unaffected.

From Figure 2C, we see that both pre-and post tax income inequality decline instantaneously in the short run. These two measures of income inequality evolve together since the consumption tax does not directly impact on pre- and post-tax factor returns. Facing a lower after-tax return on consumption, agents re-allocate time towards leisure. Since capital-rich agents enjoy more
leisure than their capital-poor counterparts, this reduces the dispersion of labor supply, thereby reducing income inequality. Wealth inequality remains virtually unchanged throughout transition due to two mutually reinforcing reasons: first, the higher consumption tax rate does not affect the return of private capital. Second, since the government keeps its infrastructure spending unchanged, this partially offsets the effects of a lower equilibrium labor supply. During transition, income inequality rises slightly as the reduction in average labor supply increases the dispersion of labor income. However, the long-run level of income inequality is lower relative to its initial pre-shock level. The lower equilibrium income inequality also reduces the dispersion of welfare. The relationship between growth and inequality is positive over time: both decline in the short run as well as in the long run. This policy reduces efficiency by lowering growth, but raises equity by reducing the dispersion of welfare. This yields a trade-off between efficiency and equity in equilibrium.

4.2.4 A Switch from a Labor Income Tax to a Consumption Tax

This policy experiment allows the government to replace the labor income tax with a consumption tax as a means of financing a given level of government spending on infrastructure. The cut in the labor income tax raises the after-tax wage rate, thereby increasing the supply of labor. This more than offsets any leisure-enhancing effect of the consumption tax increase. Therefore, equilibrium labor supply increases. The higher labor supply raises the marginal product of private capital, thereby increasing private capital accumulation and, consequently, long-run growth and welfare; see Table 3A, row 4. Tables 3B and 3C indicate that this policy also has redistributive effects similar to the tax on capital income: wealth, post-tax income, and welfare inequality decline in the long-run equilibrium. While wealth inequality falls only very slightly, long-run post-tax income inequality declines by about 5 percent, while welfare inequality falls by about 7 percent, relative to their respective initial dispersions. This happens because both the redistributive effects of a cut in the labor income tax rate and the increase in the consumption tax rate tend to reinforce each other. The dynamic adjustment of the economy is illustrated in figure 2D and the basic intuition follows from the previous two policy experiments. Comparing the dynamics of growth and post-tax income inequality, we see that in the relationship is inverse throughout the transition: the economy experiences higher growth and lower inequality. In this sense, this policy does not generate any trade-off between efficiency and equity, as growth and average welfare increases, while income inequality declines.

In summary, one common characteristic of the distributional dynamics generated by the various distortionary tax shocks considered in this section is that the adjustment to the long run equilibrium is very rapid and is determined in a large part by the initial response of the labor-leisure choice. This is in sharp contrast to the case of a government spending increase, where the dynamic adjustment of the distributions is much more gradual. Moreover, the tax shocks considered do not generate any intertemporal trade-offs in the measures of income inequality. This is also contrary to the
effects of the government spending shock, where short-run and long-run responses were qualitatively
different. The basic difference arises from the fact that government spending causes the economy’s
stock of infrastructure to rise gradually in transition, thereby creating both a wealth effect and a
redistributive effect by its gradual impact on both aggregate variables and relative factor returns.
By contrast, a tax shock changes relative factor returns instantaneously and permanently, causing
most of the dynamic adjustment to occur on impact of the shock.

5 Conclusions

This paper examines the effect of government spending and taxation policies on the relationship
between growth and inequality. Specifically, three broad questions are analyzed:

(i) Do pro-growth policies such as government spending on infrastructure also reduce inequality
in the long-run?

(ii) Do the underlying taxation policies used for financing infrastructure investment affect the
growth-inequality relationship?

(iii) Do government spending and taxation policies generate intertemporal trade-offs in inequality
along the transition path?

To answer these questions, we extend an endogenous growth model, where private capital and
public infrastructure are the engines of growth, to an environment of heterogeneous agents, where
the source of heterogeneity comes from an initial distribution of private capital (wealth). In
addition, we assume that economic agents choose the allocation of time between labor and leisure
endogenously. Therefore, two factors play a critical role in determining the evolution of inequality:
first, the endogenous labor-leisure choice generates a distribution of labor supply in response to the
initial distribution of private capital (wealth). Second, the gradual accumulation of the stock of
infrastructure in the economy affects relative returns of the private factors of production (capital
and labor) by serving as a complementary input in production. To the extent that both private
factors are unequally distributed, this generates an endogenous distribution of wealth, income, and
welfare. Therefore, this framework yields growth and inequality as endogenous and interdependent
processes, both in equilibrium and in transition. We show that in the short run, the dynamics of
income inequality are determined primarily by the initial response of the labor-leisure choice, while
its transition and long-run adjustment is influenced by the evolution of the economy’s private and
public wealth (private capital and infrastructure).

Conducting several numerical policy experiments, we find that productive government spending
on infrastructure by itself is an ineffective tool of redistribution. It enhances economic growth,
but leads to sharply contrasting effects on income inequality over time: inequality falls in the short
run, but gradually increases over time and worsens in the long-run. This underscores the point
that pro-growth policies may not always be pro-poor and shows that an important source of the
efficiency-equity trade-off may lie in the design of government spending policies. For infrastructure
investment to have a redistributive effect on the economy, it must be financed by an appropriate taxation policy. In this respect, our results highlight the redistributive role of the capital income tax rate as a financing instrument for infrastructure investment. By reducing the after-tax income of the factor that is the principle source of inequality, and spending the proceeds on a productive public good such as infrastructure, the government opens up an effective mechanism through which its spending policies can have important redistributive effects. We also compare the redistributive effects of various taxation policies, and these again highlight the trade-off between growth and inequality. Interestingly, our experiments indicate that a policy where the consumption tax replaces the more conventional labor income tax can not only be growth-enhancing, but also can have significant redistributive effects on the economy by lowering inequality.

In summary, this paper makes several important contributions to the literature on government spending and taxation policies, economic growth, and inequality. First, it characterizes the mechanism through which growth-enhancing public policies such as infrastructure investment might affect the various sources of inequality in a dynamic economy. Second, it shows that government spending policies can generate intertemporal trade-offs in the evolution of income inequality. Finally, by highlighting the role of tax policies in influencing the distributional effects of government spending, we derive a rich array of results that can conceivably be taken to the data. These results also open up the door for future research. The analytical framework in this paper can be readily extended to examine the distributional consequences of several important public policy issues, such as the distributional effects of privatization and pricing of infrastructure goods, and the composition of government spending between public investment and consumption. Issues related to health and education spending can also be potentially studied in the context of this model. Another area of research can relate to the evolution of inequality in an open economy and access to international capital markets. Finally, while we consider initial private wealth as the source of inequality, a very useful extension would be to examine other possible sources such as preferences for public goods, skills, etc. These represent interesting and exciting areas of research, which we intend to pursue in the future.
<table>
<thead>
<tr>
<th>Mode of Financing Infrastructure</th>
<th>$g$</th>
<th>$\phi$</th>
<th>$\tau_k$</th>
<th>$\tau_w$</th>
<th>$\tau_c$</th>
<th>$\tilde{z}$</th>
<th>$l$</th>
<th>$\psi(%)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) Lump-sum tax financing</td>
<td>0.05</td>
<td>0.05</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.245</td>
<td>0.784</td>
<td>2.83</td>
</tr>
<tr>
<td>(II) Capital Income Tax financing</td>
<td>0.05</td>
<td>0</td>
<td>0.0625</td>
<td>0</td>
<td>0</td>
<td>0.269</td>
<td>0.793</td>
<td>2.61</td>
</tr>
<tr>
<td>(III) Labor Income-Tax financing</td>
<td>0.05</td>
<td>0</td>
<td>0</td>
<td>0.25</td>
<td>0</td>
<td>0.251</td>
<td>0.834</td>
<td>2.64</td>
</tr>
<tr>
<td>(IV) Consumption Tax financing</td>
<td>0.05</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0675</td>
<td>0.246</td>
<td>0.799</td>
<td>2.78</td>
</tr>
</tbody>
</table>

**Benchmark Financing rules:**

(I) Lump-sum tax financing: $\phi = g$

(II) Capital Income Tax financing: $\tau_k = \frac{g}{1-\eta}$

(III) Labor Income Tax financing: $\tau_w = \frac{g}{\eta}$

(IV) Consumption Tax financing: $\tau_c = \frac{\tilde{\Omega} g}{1-\tilde{\Omega} g}$; $\tilde{\Omega} = \frac{g}{\eta}(1-\tilde{\eta})$. 
TABLE 2
An Increase in Infrastructure Investment: Aggregate and Distributional effects
\((g = 0.05\) to \(0.1\))

A. Steady-State Aggregate Effects

<table>
<thead>
<tr>
<th>Policy Change</th>
<th>(d\tilde{z})</th>
<th>(dl)</th>
<th>(d\psi)</th>
<th>(dW(%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) Lump-sum tax financed increase in (g)</td>
<td>0.211</td>
<td>-0.016</td>
<td>0.658</td>
<td>2.21</td>
</tr>
<tr>
<td>(II) Capital Income Tax financed increase in (g)</td>
<td>0.280</td>
<td>-0.01</td>
<td>0.367</td>
<td>1.92</td>
</tr>
<tr>
<td>(III) Labor Income Tax financed increase in (g)</td>
<td>0.226</td>
<td>0.028</td>
<td>0.406</td>
<td>-0.674</td>
</tr>
<tr>
<td>(IV) Consumption Tax financed increase in (g)</td>
<td>0.214</td>
<td>-0.003</td>
<td>0.599</td>
<td>2.05</td>
</tr>
</tbody>
</table>

B. Short-run Distributional Effects

<table>
<thead>
<tr>
<th>Policy Change</th>
<th>(\sigma_{k}(0)/\tilde{\sigma}_{k,0})</th>
<th>(\sigma_{y}(0)/\tilde{\sigma}_{y,0})</th>
<th>(\sigma_{y}^{<em>}(0)/\tilde{\sigma}_{y}^{</em>})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) Lump-sum tax financed increase in (g)</td>
<td>1</td>
<td>0.930</td>
<td>0.930</td>
</tr>
<tr>
<td>(II) Capital Income Tax financed increase in (g)</td>
<td>1</td>
<td>0.925</td>
<td>0.985</td>
</tr>
<tr>
<td>(III) Labor Income Tax financed increase in (g)</td>
<td>1</td>
<td>0.919</td>
<td>0.381</td>
</tr>
<tr>
<td>(IV) Consumption Tax financed increase in (g)</td>
<td>1</td>
<td>0.921</td>
<td>0.921</td>
</tr>
</tbody>
</table>

C. Steady-State Distributional Effects

<table>
<thead>
<tr>
<th>Policy Change</th>
<th>(\tilde{\sigma}<em>{k}/\tilde{\sigma}</em>{k,0})</th>
<th>(\tilde{\sigma}<em>{y}/\tilde{\sigma}</em>{y,0})</th>
<th>(\tilde{\sigma}<em>{y}^{*}/\tilde{\sigma}</em>{y}^{*})</th>
<th>(\tilde{\sigma}<em>{u}/\tilde{\sigma}</em>{u,0})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) Lump-sum tax financed increase in (g)</td>
<td>1.029</td>
<td>1.044</td>
<td>1.044</td>
<td>1.10</td>
</tr>
<tr>
<td>(II) Capital Income Tax financed increase in (g)</td>
<td>1.01</td>
<td>0.985</td>
<td>1.049</td>
<td>0.982</td>
</tr>
<tr>
<td>(III) Labor Income Tax financed increase in (g)</td>
<td>1.028</td>
<td>1.084</td>
<td>0.691</td>
<td>1.098</td>
</tr>
<tr>
<td>(IV) Consumption Tax financed increase in (g)</td>
<td>1.029</td>
<td>1.043</td>
<td>1.043</td>
<td>1.023</td>
</tr>
</tbody>
</table>
**TABLE 3**
Effects of Tax Policies

A. Steady-State Aggregate Effects

<table>
<thead>
<tr>
<th>Policy Change</th>
<th>$d\tilde{z}$</th>
<th>$dl$</th>
<th>$d\psi$</th>
<th>$dW (%)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Increase in the Tax on Capital Income</td>
<td>0.049</td>
<td>0.006</td>
<td>-0.343</td>
<td>-0.447</td>
</tr>
<tr>
<td>(B) Increase in the Tax on Labor Income</td>
<td>0.003</td>
<td>0.019</td>
<td>-0.092</td>
<td>-0.959</td>
</tr>
<tr>
<td>(C) Increase in the Tax on Consumption</td>
<td>0.002</td>
<td>0.014</td>
<td>-0.058</td>
<td>-0.187</td>
</tr>
<tr>
<td>(D) Switch from Labor Income Tax to Consumption Tax</td>
<td>-0.01</td>
<td>-0.034</td>
<td>0.143</td>
<td>0.745</td>
</tr>
</tbody>
</table>

B. Short-run Distributional Effects

<table>
<thead>
<tr>
<th>Policy Change</th>
<th>$\sigma_k(0)/\bar{\sigma}_k,0$</th>
<th>$\sigma_y(0)/\bar{\sigma}_y,0$</th>
<th>$\sigma_y^*(0)/\bar{\sigma}_y,0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Increase in the Tax on Capital Income</td>
<td>1</td>
<td>0.949</td>
<td>1.036</td>
</tr>
<tr>
<td>(B) Increase in the Tax on Labor Income</td>
<td>1</td>
<td>1.016</td>
<td>0.836</td>
</tr>
<tr>
<td>(C) Increase in the Tax on Consumption</td>
<td>1</td>
<td>0.997</td>
<td>0.997</td>
</tr>
<tr>
<td>(D) Switch from Labor Income Tax to Consumption Tax</td>
<td>1</td>
<td>0.953</td>
<td>1.255</td>
</tr>
</tbody>
</table>

C. Steady-State Distributional Effects

<table>
<thead>
<tr>
<th>Policy Change</th>
<th>$\bar{\sigma}_k/\bar{\sigma}_k,0$</th>
<th>$\bar{\sigma}_y/\bar{\sigma}_y,0$</th>
<th>$\bar{\sigma}_y^*/\bar{\sigma}_y,0$</th>
<th>$\bar{\sigma}_u/\bar{\sigma}_u,0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Increase in the Tax on Capital Income</td>
<td>0.998</td>
<td>0.963</td>
<td>1.047</td>
<td>0.874</td>
</tr>
<tr>
<td>(B) Increase in the Tax on Labor Income</td>
<td>1.001</td>
<td>1.019</td>
<td>0.841</td>
<td>1.001</td>
</tr>
<tr>
<td>(C) Increase in the Tax on Consumption</td>
<td>1.000</td>
<td>0.998</td>
<td>0.998</td>
<td>0.915</td>
</tr>
<tr>
<td>(D) Switch from Labor Income Tax to Consumption Tax</td>
<td>0.999</td>
<td>0.953</td>
<td>1.255</td>
<td>0.935</td>
</tr>
</tbody>
</table>
Figure 1. An Increase in Government Spending on Infrastructure Investment: Aggregate and Distributional Dynamics

A. Lumpsum Tax-financed Increase in Government Spending

i. Leisure

ii. Distributions (Relative to Pre-shock Benchmark)

iii. GDP Growth and Post-tax Income Distribution (Relative to Pre-shock Benchmark)

B. Capital Income Tax-financed Increase in Government Spending

i. Leisure

ii. Distributions (Relative to Pre-shock Benchmark)

iii. GDP Growth and Post-tax Income Distribution (Relative to Pre-shock Benchmark)
Figure 1 (Continued). An Increase in Government Spending on Infrastructure Investment: Aggregate and Distributional Dynamics

C. Labor Income Tax-financed Increase in Government Spending

D. Consumption Tax-financed Increase in Government Spending
Figure 2. Tax Shocks: Aggregate and Distributional Dynamics

A. Increase in the Capital Income Tax Rate

B. Increase in the Labor Income Tax Rate
Figure 2 (Continued). Tax Shocks: Aggregate and Distributional Dynamics

C. Increase in the Consumption Tax Rate

D. Switch from Labor Income Tax to Consumption Tax
References


