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Le Van, Cuong and Pham, Ngoc-sang and Pham, Thi Kim
Cuong and Tran-Nam, Binh

IPAG, CNRS, PSE, and TIMAS, EM Normandie Business School,
Métis Lab, EconomiX, Paris Nanterre University, UNSW Business
School, UNSW Sydney

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Governance, productivity and economic development

Cuong LE VAN* Ngoc-Sang PHAM[†] Thi Kim Cuong PHAM[‡]
Binh TRAN-NAM[§]

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Abstract

This paper explores the interplay between transfer policies, R&D, corruption, and economic development using a general equilibrium model with heterogeneous agents and a government. The government collects taxes, redistributes fiscal revenues, and undertakes public investment (in R&D, infrastructure, etc.). Corruption is modeled as a fraction of tax revenues that is siphoned off and removed from the economy. We first establish the existence of a political-economic equilibrium. Then, using an analytically tractable framework with two private agents, we examine the effects of corruption and evaluate the impact of various policies, including redistribution and innovation-led strategies.

JEL Classifications: D5, H54, O3.

Keywords: Corruption, governance, R&D investment, economic development, productivity, general equilibrium.

1 Introduction

Corruption is one of the most classical topics, not only in economics but also in many other fields.¹ The Transparency International defines “corruption as the abuse of entrusted power for private gain” (Transparency International (2025)). Of course, corruption is a multidimensional concept. A large number of studies, both theoretical and empirical, show that corruption has a harmful effect on economic performance. For instance, [Mauro \(1995\)](#) provides a cross-country empirical analysis during the period 1980-1983, which shows a significant negative association between corruption and

*IPAG, CNRS, PSE, and TIMAS. Email: Cuong.Le-Van@univ-paris1.fr.

[†]EM Normandie Business School, Métis Lab (France). Email: npham@em-normandie.fr. Phone: +33 2 50 32 04 08. Address: EM Normandie (campus Caen), 9 Rue Claude Bloch, 14000 Caen, France.

[‡]*Corresponding author.* EconomiX, Paris Nanterre University. Email: pham_tkc@parisnanterre.fr. Phone: +33 1 40 97 77 21. Address: Bâtiment G - Maurice Allais, 200, Avenue de la République, 92001 Nanterre cedex

[§]UNSW Business School, UNSW Sydney. Email: b.tran-nam@unsw.edu.au

¹See, for example, [Olken and Pande \(2012\)](#) for a detailed survey in the context of developing countries.

investment, as well as growth. Corruption variable used in this empirical study corresponds to “the degree to which business transactions involve corruption or questionable payments” from the Business International Cooperation definition.

Grundler and Potrafke (2019) present empirical evidence based on data for 175 over the period 2012–2018 – a period during which the Corruption Perceptions Index (CPI) is comparable across countries and over time. They show that corruption (i.e., CPI) is negatively associated with economic growth, especially in autocracies and countries with low government effectiveness and rule of law. Similarly, using a panel of 142 countries from 1994 to 2014, Cieřlik and Goczek (2018) show that higher corruption is strongly associated with lower GDP growth and foreign investment ratio.

Other empirical studies further indicate the adverse consequences of corruption on other dimensions of an economy such as human capital accumulation and environmental quality. As underlined in Abdulla (2021), corruption has a negative effect on the stock of human capital and its elimination would increase aggregate output by 18-21% on average. In parallel, Wang, Danish, Zhang, and Wang (2018) analyze the relationship between economic growth, CO2 emissions, and corruption in a panel of BRICS countries from 1996 to 2015, concluding that control of corruption is crucial for mediating the relationship between economic growth and environmental quality and can contribute to reduction in CO2 emissions. In an analysis using a panel covering 21 Central and Eastern European countries, Petrova (2020) finds that higher levels of corruption and bureaucratic inefficiency are associated with lower levels of redistributive spending.

Some theoretical studies model the impact of corruption on economic outcomes. Aghion, Akcigit, Cag, and Care (2016) develop a growth model with innovation to analyze the effect of taxation and corruption on growth, and innovation. They demonstrate that corruption lowers the optimal tax rate and reduces growth. Moreover, their empirical analysis across US states confirms that higher local corruption attenuates the positive effect of taxation on both growth and innovation, suggesting that if governments are aiming for economic growth, investing resources in fighting corruption makes a lot of sense. Marakbi and Villieu (2020) analyze the link between corruption, economic growth, and inflation into a monetary growth model where a corruption sector allows households evading from taxation. Their finding predicts a U-shaped relationship between corruption and inflation, whereby beyond a threshold value of corruption, corruption and inflation move in the same direction and lowers the efficiency of seigniorage.

Conversely, a strand of literature suggests that, under some conditions, corruption and rent-seeking may potentially be associated with positive outcomes, in particular when corruption contributes to “grease to the wheels”. The seminar paper of Leff (1964) discusses a particular type of corruption: the practice of buying favors from the bureaucrats responsible for formulating and administering the government’s economic policies. It is unsurprising that this kind of market activities may be beneficial, which leads to the “grease the wheels” hypothesis. More recently, Meon and Weill (2010), using a panel of 69 both developed and developing when exploring the impact of corruption on aggregate efficiency, suggest that corruption (measured by CPI from Transparency International or World Bank’s corruption indicator) is less detrimental in countries where the rest of the institutional framework is weaker. In particular, in

some countries where institutions are particularly ineffective, corruption may serve as a “grease to the wheels”. At the local level, [Demir, Hu, Liu, and Shen \(2022\)](#) highlight the importance of firm and city heterogeneity in shaping firms productivity reaction to corruption, in particular, for firms that are export-oriented, more profitable, publicly owned, grow-faster, the corruption may positively impact their productivity. A recent study of [Hartwig and Sturm \(2025\)](#) focuses on the relationship between corruption and income inequality. This analysis, using a dataset covering up to 160 countries, concludes that corruption does not necessarily increase income inequality. If the objective of public policy is to reduce income inequality, anti-corruption efforts is not sufficient, but targeting unemployment, a robust driver of inequality, should be prioritized in government interventions. There are also empirical studies suggesting that tax corruption may, at least in the short run, promote innovation. For example, a study by [Doan, Vu, Tran-Nam, and Nguyen \(2021\)](#), using firm-level panel data from Vietnam covering the period 2005–2015, finds that petty tax corruption has a positive effect on all types of firm-level innovative activities. One possible explanation is that firms may use the “tax savings” from corruption to finance business improvements, including various types of innovative inputs.

Despite these insights, few studies have simultaneously examined the interplay between corruption, transfer policies, innovation and economic development, specially within a general-equilibrium framework. This paper develops then a two-period general equilibrium model to address the following key questions:

1. What are the macroeconomic effects of the interaction between taxation, redistribution and public investment in R&D? Could they improve economic outcomes even in the presence of corruption?
2. Are the economic outcomes in the case without interventions better than those under intervention when corruption is present? May corruption and innovation co-existence be Pareto-improving?

Our framework considers a finite number of heterogeneous agents who can borrow/lend through a financial market and produce the single output of the economy. Each agent has her own production function. Each agent has to pay a tax which equals a fraction of their income and receives a transfer from the government. Both tax rates and transfers are individualized and time dependent. In the first period, the government also makes an public investment (including R&D, infrastructure, education, ...), which will improve agents’ productivity in the second period. However, there may exist a fraction of collected tax revenue, which is disappeared and fail to contribute to economic activity. We refer to this lost fraction as *corruption*.

Our paper makes three main contributions. Our first one is to establish the existence of a political-economic equilibrium with externality related to transfers and innovation. Our proof consists of two steps: i) given a vector of government tax revenues $\mathcal{T}$, we prove, under mild assumptions, the existence and uniqueness of competitive equilibrium. This equilibrium is continuous in $\mathcal{T}$. Moreover, it generates tax revenue T for the government; ii) using the Brouwer fixed point theorem, we prove the existence of a vector $\mathcal{T}^*$ so that the equilibrium associated with this vector generates government’s revenue which coincides to $\mathcal{T}^*$, i.e., $T = \mathcal{T}^*$. So, there exists a

political-economic equilibrium with transfers and innovation.²

Our second contribution is to explore the effects of various redistribution policies and public investment, as well as the impact of corruption, within a tractable framework that features individualized taxes and transfers. After computing the equilibrium outcomes, we show that public investment and R&D efficiency have a positive impact on aggregate output, while corruption exerts a negative effect.

Our third contribution is to provide policy insights on redistribution and R&D policy by comparing the GDPs in the scenario S0. inaction (i.e., no government intervention) with one of the three following cases: S1. imperfect intervention with public investment in R&D and redistribution policy in the presence of corruption; S2. imperfect intervention with only redistribution policy in the presence of corruption; and S3. distorted taxation, a very high tax on the most productive agent.

Scenario	Government Action	Corruption	Outcomes
S0. Inaction	No intervention	None	Baseline outcome
S1. Public investment in R&D and redistribution policy	High public investment	Present or not	If investment is efficient, productivity increases; output rises, even with corruption
S2. Tagerted redistribution policy	Redistribution from low to high productivity agents	Present or not	Transfers boost investment where returns are highest, leading to higher aggregate output, even with corruption.
S3. Distorted taxation	High taxes on productive or high-investment agents	Present or not	Discourages investment; reduces aggregate investment and output.

Table 1: Comparison of economic outcomes under different government intervention scenarios

While we prove that the corruption is always harmful, we argue that inaction may be worse than imperfect interventions for several reasons. Indeed, as shown in Table 1, we highlight two scenarios (S1, S2) in which imperfect interventions lead to better outcomes than the inaction scenario (S0). In the scenario S1, when the government engages in significant public investment and the efficiency of that investment is high (in the sens that it meaningfully enhances firm productivity), firms become more productive and, thanks to this, the output will be higher than that in the inaction scenario (S0), even if a small fraction of the output is lost to corruption. In the scenario S2, the government taxes agents having low productivity and low discount factors, and

²Our proof of the equilibrium existence is inspired by [Mitra \(1998\)](#), [Le Van, Morhaim, and Dimaria \(2002\)](#), [Gourdel, Hoang-Ngoc, Le Van, and Mazamba \(2004\)](#), [d’Albis and Le Van \(2006\)](#), [Bosi, Le Van, and Phung \(2025\)](#). The main difference is that they work under optimal growth models (with a representative consumer) while we work with a two-period model with a finite number of consumers.

transfers resources to the most productive agents. In this case, aggregate investment and output would increase, even in the presence of pretty corruption.

These insights allow us to understand why corruption and quite good outcomes may happen at the same time, as shown in some empirical studies. By the way, our theoretical results contribute to clarify the "grease to the wheels" hypothesis. However, we also show that poorly designed redistribution policies, such as imposing high taxes on agents having high productivity or high investment rates (scenario S3. distorted taxation), can be detrimental, as they may reduce aggregate investment and overall production.³

From a theoretical point of view, our paper is related to [Dimaria and Le Van \(2002\)](#). There are, however, several key differences. First, [Dimaria and Le Van \(2002\)](#) study an optimal growth model (with one representative agent) while our model has heterogeneous agents. Secondly, [Dimaria and Le Van \(2002\)](#) consider a corruption regarding international aid (in form of loan) while we study corruption via redistribution process.⁴

The remainder of the paper is organized as follows. Section 2 presents a general equilibrium with public investment and corruption. Section 3 investigates the existence of equilibrium while Section 4 addresses the effects of different policies and corruption. Section 5 concludes. Technical proofs are presented in Appendix A.

2 A model with transfers, public investment, and corruption

2.1 Individual choice

We consider a two-period economy with m of agents ($i = 1, \dots, m$) and a government. There is one good. At date 0, the agent i is endowed $w_{i,0}$ units of good. She has to pay a tax $\tau_{i,0}w_{i,0}$ and also receives $\gamma_{i,0}T_0$ from the government. The net transfer received by agent i is $\gamma_{i,0}T_0 - \tau_{i,0}w_{i,0}$ which can be positive or negative. We only require that $\tau_{i,0}, \gamma_{i,0}$ are in the interval $[0, 1]$.

Each agent can borrow or lend an amount $b_{i,0}$ at date 0 with the real return R_1 which is endogenous. Assume that there is no borrowing constraint. She can invest in capital with an amount of $k_{i,1}$ to produce at date 1 following the technology which is characterized by the function $A_i F_i(k_{i,1})$ where A_i represents the productivity or the technological level.

At date 0, each agent chooses current and future consumption $(c_{i,0}, c_{i,1})$, capital investment $(k_{i,1})$, saving or borrowing $(b_{i,0})$ to maximize intertemporal utility. The

³In reality, it is not easy to determine whether a distorted tax results from corruption or not.

⁴In [Dimaria and Le Van \(2002\)](#), corruption means that a fraction of aid is diverted by some bureaucrats. This fraction can be disappeared from the country or come back to the economy as an extra-consumption or extra-investment. In our paper, corruption means that a fraction of tax revenue is disappeared from the country. [Dimaria and Le Van \(2002\)](#) show that international aid may be beneficial for economic growth even the corruption takes place if international aid (or corrupted amount from aid) is used to increase the aggregate investment or the incentive of private firms).

problem facing agent i can be written as:

$$\max_{(c_{i,0}, c_{i,1}, k_{i,1}, b_{i,0})} u_i(c_{i,0}) + \beta_i u(c_{i,1}) \quad (1a)$$

$$\text{subject to constraints: } c_{i,0} + k_{i,1} \leq (1 - \tau_{i,0})w_{i,0} + b_{i,0} + \gamma_{i,0}T_0 \quad (1b)$$

$$c_{i,1} \leq (1 - \tau_{i,1})A_i F_i(k_{i,1}) - R_1 b_{i,0} + \gamma_{i,1}T_1 \quad (1c)$$

$$c_{i,0} \geq 0, c_{i,1} \geq 0, k_{i,1} \geq 0 \quad (1d)$$

where $\beta_i \in (0, 1)$ is the rate of time preference of agent i .

The redistribution policy at date 1 is represented by the rates $\tau_{i,1}$ and $\gamma_{i,1}$ which are also in the interval $[0, 1)$.

We assume that the productivity A_i depends on the public investment in the sense that $A_i = \mathcal{A}_i(D_0)$ where D_0 represents the government's investment which includes R&D investment, education, public infrastructure, etc. (Pham and Pham (2020)). We can relate individual productivity to innovation brought about by public investment. The amount D_0 is taken as given by any individual agent.

We require basic assumptions on the function $\mathcal{A}(\cdot)$.

Assumption 1. *The function $\mathcal{A}(\cdot) : \mathbb{R}_+ \rightarrow \mathbb{R}_+$ is continuous and increasing. $\mathcal{A}_i(0) > 0$.*

This assumption implies that without public investment, the production function of agent i becomes $\mathcal{A}_i(0)F_i(k_{i,1})$.

2.2 Government

At date 0, the government collects an amount $T_0 \equiv \tau_{i,0}w_{i,0}$ of good from each agent i and redistributes it in the form of transfers $\gamma_{i,0}T_0$. Moreover, the government spends $D_0 = \gamma_{d,0}T_0$ in public investment.

We note that individuals can borrow or lend in the first period 0, while the government cannot. As a result, government budgets are balanced in both periods. Its budget constraint at date 0 is written as:

$$\sum_{i=1}^m \tau_{i,0}w_{i,0} = T_0 = G_0 = \sum_{i=1}^m \gamma_{i,0}T_0 + \gamma_{d,0}T_0 + (1 - \sum_{i=1}^m \gamma_{i,0} - \gamma_{d,0})T_0 \quad (2)$$

At date 1, the government collects an amount $\tau_{i,1}A_i F_i(k_{i,1})$ from each agent and does the redistribution. Since we consider a two-period model, we abstract from R&D in the second period.

$$\sum_{i=1}^m \tau_{i,1}A_i F_i(k_{i,1}) = T_1 = G_1 = \sum_{i=1}^m \gamma_{i,1}T_1 + (1 - \sum_{i=1}^m \gamma_{i,1})T_1. \quad (3)$$

The amounts $(1 - \sum_{i=1}^m \gamma_{i,0} - \gamma_{d,0})T_0$ and $(1 - \sum_{i=1}^m \gamma_{i,1})T_1$ are retained by the government. These amounts does not return to the economy, reflecting the presence of corruption.⁵

Let us clarify some notions.

⁵Alternatively, we can view the disappeared public resources as governance inefficiency or public transaction costs of government spending.

Definition 1. The list $(\tau_{i,t}, \gamma_{i,t})_{i=1}^m$ is the redistribution policy of the government at date t . The amount $\gamma_{d,0}T_0$ represents the government effort in public investment at date 0.

We say that there is a corruption at date 0 if the fraction $\gamma_{c,0} \equiv (1 - \sum_{i=1}^m \gamma_{i,0} - \gamma_{d,0})$ is strictly positive. We say that there is a corruption at date 1 if the fraction $\gamma_{c,1} \equiv 1 - \sum_{i=1}^m \gamma_{i,1}$ is strictly positive.

We say that there is no intervention if taxes, transfers and R&D are zero, i.e. $\tau_{i,t} = \gamma_{i,t} = \gamma_{d,t} = 0$ for any i and for any $t = 0, 1$.

Precisely, we consider that corruption exists if a part of the resources disappears from the economy. This part of resources corresponds to the positive fraction $1 - \sum_{i=1}^m \gamma_{i,0} - \gamma_{d,0}$ at date 0 and $1 - \sum_{i=1}^m \gamma_{i,1}$ at date 1. We note that other papers add diverted resources to household budget as a corruption consumption (Dimaria and Le Van (2002)) or corruption income (Aghion, Akcigit, Cag, and Care (2016)).

It should be noticed that when there is no intervention, there is no corruption, and the government is not analyzed in this economy. Our modeling is similar to a recent empirical study showing that corruption may distort public spending structure (Mondjeli and Ambassa (2025)). When analyzing the impact of corruption on the allocation of public expenditures across 45 sub-Saharan African countries, these authors show that corruption leads to a significant decrease in capital expenditures, diverting resources away from long-term investment projects.

We impose the following assumptions on utility, production functions, and other constraints.

Assumption 2. $w_{i,0} > 0, \tau_{i,t} \in [0, 1), \gamma_{i,t}, \gamma_{d,t} \in [0, 1]$ and $\sum_{i=1}^m \gamma_{i,t} + \gamma_{d,t} \leq 1$ for any i , for any t .

For any i , the utility function u_i is twice continuously differentiable, strictly increasing, strictly concave and $u'_i(0) = \infty$ while the production function F_i is continuously differentiable, strictly increasing, concave and $F_i(0) = 0$.

2.3 General equilibrium

We now present our notion of equilibrium.

Definition 2 (competitive equilibrium with a government budget). A competitive equilibrium with transfers and innovation is a non-negative list

$$\left((c_{i,0}, c_{i,1}, k_{i,1}, b_{i,0})_{i=1}^m, R_1, T_0, T_1, D_0 \right)$$

satisfying the following conditions:

1. $R_1 > 0$.
2. $T_0 = \sum_{i=1}^m \tau_{i,0} w_{i,0}$, $T_1 = \sum_{i=1}^m \tau_{i,1} F_i(k_{i,1})$, $D_0 = \gamma_{d,0} T_0$.
3. Given R_1, T_0, T_1, D_0 , the allocation $(c_{i,0}, c_{i,1}, k_{i,1}, b_{i,0})$ is a solution to the problem of agent i .

4. *Market clearing conditions:*

$$\sum_{i=1}^m (c_{i,0} + k_{i,1}) = \sum_{i=1}^m (1 - \tau_{i,0}) w_{i,0} + \left(\sum_{i=1}^m \gamma_{i,0} \right) T_0 \quad (4)$$

$$\sum_{i=1}^m c_{i,1} = \sum_{i=1}^m (1 - \tau_{i,1}) \mathcal{A}_i(D_0) F_i(k_{i,1}) + \left(\sum_{i=1}^m \gamma_{i,1} \right) T_1 \quad (5)$$

$$\sum_{i=1}^m b_{i,0} = 0. \quad (6)$$

3 Existence of equilibrium

The equilibrium defined in Definition 2, involves externalities and endogenous transfers (T_1 is endogenous), which makes the task of establishing its existence non-trivial. This section aims at proving its existence by two steps. First, given government tax revenues T_0, T_1 , we prove the existence and uniqueness of a competitive equilibrium. This equilibrium is continuous in (T_0, T_1) . Moreover, it generates tax revenues for the government. Secondly, using the Brouwer fixed point theorem, we prove the existence of a couple (T_0^*, T_1^*) so that the equilibrium associated with this couple generates government's revenues which are exactly (T_0^*, T_1^*) . So, there exists a political-economic equilibrium with transfers and innovation in Definition 2.

Let us start by introducing the notion of the competitive equilibrium given government intervention T_0, T_1, D_0 .

Definition 3 (competitive equilibrium). *Let $T_0, T_1, D_0 \geq 0$ be given and $D_0 \leq T_0$. A competitive equilibrium is a non-negative list $\left((c_{i,0}, c_{i,1}, k_{i,1}, b_{i,0})_{i=1}^m, R_1 \right)$ satisfying the following conditions:*

1. $R_1 > 0$.
2. *Given R_1 , the allocation $(c_{i,0}, c_{i,1}, k_{i,1}, b_{i,0})$ is a solution to the agent i 's problem.*
3. *Market clearing conditions:*

$$\sum_{i=1}^m (c_{i,0} + k_{i,1}) = \sum_{i=1}^m (1 - \tau_{i,0}) w_{i,0} + \left(\sum_{i=1}^m \gamma_{i,0} \right) T_0 \quad (7)$$

$$\sum_{i=1}^m c_{i,1} = \sum_{i=1}^m (1 - \tau_{i,1}) \mathcal{A}_i(D_0) F_i(k_{i,1}) + \left(\sum_{i=1}^m \gamma_{i,1} \right) T_1 \quad (8)$$

$$\sum_{i=1}^m b_{i,0} = 0. \quad (9)$$

Remark 1. *Denote*

$$W_0 \equiv \sum_{i=1}^m w_{i,0}, \quad \bar{W}_1 \equiv \sum_{i=1}^m \mathcal{A}_i(W_0) F_i(W_0), \text{ and } \bar{W} \equiv \max(W_0, \bar{W}_1). \quad (10)$$

W_0 is the aggregate endowment at date 0. We will see that $\bar{W}_1$ is an upper bound of the aggregate production at date 1. Indeed, since R&D does not exceed the total public budget at date 0, i.e. $D_0 \leq T_0$, for any equilibrium, we have

$$\sum_{i=1}^m \tau_{i,0} w_{i,0} \equiv T_0 \leq W_0 \leq \bar{W}$$

$$\sum_{i=1}^m \tau_{i,1} \mathcal{A}_i(D_0) F_i(k_{i,1}) \equiv T_1 \leq \sum_{i=1}^m A_i(W_0) F_i(W_0) \leq \bar{W}_1 \leq \bar{W}.$$

While it is standard to prove the existence of equilibrium in Definition 3, we require additional assumptions to obtain its uniqueness.

Assumption 3. Assume that, for any i , F_i is strictly concave, $F'_i(0) = \infty$ and $u'_i(c) + cu''_i(c) \geq 0$ for any $c > 0$.

Proposition 1. Let Assumptions 1, 2, and 3 be satisfied. Then, there exists a unique competitive equilibrium. The competitive equilibrium is continuous in (T_0, T_1, D_0) .

Proof. See Appendix A. $\square$

To get that the competitive equilibrium is unique and continuous in (T_0, T_1, D_0) , we require Assumption 3 because we work with a finite number of consumers. In Mitra (1998), Le Van, Morhaim, and Dimaria (2002), there is only one representative consumer. So, they do not need such an assumption.

Our second step is to prove the existence of political-economic equilibrium with transfers and innovation in Definition 2. To do this, we make use of the Brouwer fixed point theorem. First, we define the following function.

Definition 4. Define the function $\Gamma : [0, \bar{W}]^2 \rightarrow [0, \bar{W}]^2$ by the following.

For $(T_0, T_1) \in [0, \bar{W}]^2$ and $D_0 = \gamma_{d,0} T_0$, where $\gamma_d \in [0, 1]$, since there exists a unique equilibrium (as in Definition 3), we can define

$$\Gamma_1(T_0, T_1) = \sum_{i=1}^m \tau_{i,0} w_{i,0} \tag{11}$$

$$\Gamma_2(T_0, T_1) = \sum_{i=1}^m \tau_{i,1} \mathcal{A}_i(D_0) F_i(k_{i,1}). \tag{12}$$

Proposition 2. Let Assumptions 1, 2, and 3 be satisfied. Then, there exists a political-economic equilibrium with transfers and innovation.

Proof. For each $(T_0, T_1) \in [0, \bar{W}]^2$ and $D_0 = \gamma_{d,0} T_0$ where γ_d is parameter in $[0, 1]$, there exists a unique competitive equilibrium (as in Definition 3) whose outcomes are continuous in (T_0, T_1) . Denote the capital allocation by $k_{i,1}(T_0, T_1)$ for $i = 1, \dots, m$. Define the mapping Γ as in Definition 4. By Proposition 1, this mapping is continuous. Moreover, by Remark 1, we have $\Gamma_2(T_0, T_1) \in [0, \bar{W}]$. Applying the Brouwer fixed point theorem, there exists $(T_0^*, T_1^*) \in [0, \bar{W}]^2$ satisfying

$$T_0^* = \sum_{i=1}^m \tau_{i,0} w_{i,0}, \quad T_1^* = \sum_{i=1}^m \tau_{i,1} \mathcal{A}_i(D_0) F_i(k_{i,1}(T_0^*, T_1^*)). \tag{13}$$

This couple (T_0^*, T_1^*) together with its associated competitive equilibrium (as in Definition 3) constitutes a competitive equilibrium with a government budget following Definition 2. We have finished our proof. $\square$

4 Analytical results

For the sake of tractability, we consider a simple model with two groups of agents ($m = 2$) to obtain explicit analytical results.

Assumption 4. Assume that there are two groups $i = 1, 2$ with logarithmic utility $u_i(c) = \ln(c)$, agents in each group are identical so that we have two representative agents, and

$$F_i(k) = k, \quad A_i(D) = A_i(1 + a_i D) \text{ for any } k, D. \quad (14)$$

where A_i is the autonomous productivity and a_i represents the effect of the R&D investment on the agent i 's productivity.

4.1 Equilibrium outcomes with and without intervention

First, we compute the equilibrium in the absence of intervention.

Lemma 1. Let Assumption 4 be satisfied. Assume that two productivities are different, i.e. $A_2 \neq A_1$. Focus on the case without interventions: $\tau_{i,t} = \gamma_{i,t} = 0$ for any i, t . There exists a unique equilibrium. In equilibrium, we have

$$K_1^* = k_{1,1} + k_{2,1} = \frac{\beta_2}{1 + \beta_2} w_{2,0} + \frac{\beta_1}{1 + \beta_1} w_{1,0} \quad (15a)$$

$$Y_1^* = \left(\frac{\beta_2}{1 + \beta_2} w_{2,0} + \frac{\beta_1}{1 + \beta_1} w_{1,0} \right) \max(A_1, A_2). \quad (15b)$$

Proof. See Appendix A. $\square$

In the absence of government intervention, the economy outputs (aggregate capital K_1 and aggregate GDP Y_1) at date 1 are defined by the initial endowment $\omega_{i,0}$, saving/investment preferences β_i , and autonomous productivities A_i , $i = 1, 2$

In the presence of intervention, we have the following result.

Proposition 3. Let Assumption 4 be satisfied. Assume that

$$(1 - \tau_{2,1})(1 + a_2 \gamma_{d,0} T_0) A_2 > (1 - \tau_{1,1})(1 + a_1 \gamma_{d,0} T_0) A_1,$$

where $T_0 = (\tau_{1,0} w_{1,0} + \tau_{2,0} w_{2,0})$.

There exists a unique equilibrium. In equilibrium, we have $k_{1,1} = 0$ and $k_{2,1} > 0$.

1. The aggregate capital is equal to

$$K_1 = k_{2,1} = \frac{\frac{\beta_2 [(1 - \tau_{2,0}) w_{2,0} + \gamma_{2,0} (\tau_{1,0} w_{1,0} + \tau_{2,0} w_{2,0})]}{(1 + \beta_2)} + \frac{\beta_1 [(1 - \tau_{1,0}) w_{1,0} + \gamma_{1,0} (\tau_{1,0} w_{1,0} + \tau_{2,0} w_{2,0})]}{(1 + \beta_1)}}{1 + \left(\frac{\gamma_{2,1}}{1 + \beta_2} + \frac{\gamma_{1,1}}{1 + \beta_1} \right) \frac{\tau_{2,1}}{(1 - \tau_{2,1})}} \quad (16)$$

K_1 is increasing in $\gamma_{1,0}$ and $\gamma_{2,0}$ but decreasing in $\gamma_{1,1}$ and $\gamma_{2,1}$.

2. The GDP of the economy at date 1 equals

$$Y_1 = \left(1 - \tau_2 \gamma_{c,1}\right) \left(1 + a_2(\gamma_{c,1} - \gamma_{c,0})T_0\right) A_2 k_{2,1}. \quad (17)$$

Proof. See Appendix A. $\square$

According to Proposition 3, when the after-redistribution productivity of agent 2 is higher than that of agent 1, the total capital K_1 is used by the agent 2. Some remarks deserve to mention.

1. **R&D efficiency.** GDP at date 1, Y_1 , is increasing in the efficiency a_2 of R&D. The higher the R&D process's efficiency, the higher GDP.
2. **Effect of corruption.** GDP at date 1 is naturally decreasing with the fraction of resource lost $\gamma_{c,1}$ (i.e. $1 - \gamma_{1,1} - \gamma_{2,1}$) and $\gamma_{c,0}$ (i.e., $1 - \gamma_{1,0} - \gamma_{2,0} - \gamma_{d,0}$). It means that the corruption is always harmful for the economic development.

4.2 Effects of government interventions

To investigate the effects of government interventions, we compare these outcomes with those in the case without interventions and provide the comparative statics regarding the role of distribution policy $(\tau_{i,t}, \gamma_{i,t})_{i=1}^2$ and government effort $\gamma_{d,0}$ in R&D.

Proposition 4. *Let Assumptions in Proposition 3 hold. In equilibrium, the gap between the GDP of the economy with interventions and without intervention is*

$$Y_1 - Y_1^* = (1 - \tau_{2,1} \gamma_{c,1}) (1 + a_2 \gamma_{d,0} T_0) A_2 \frac{\frac{\beta_2 [(1 - \tau_{2,0}) w_{2,0} + \gamma_{2,0} T_0]}{(1 + \beta_2)} + \frac{\beta_1 [(1 - \tau_{1,0}) w_{1,0} + \gamma_{1,0} T_0]}{(1 + \beta_1)}}{1 + \left(\frac{\gamma_{2,1}}{1 + \beta_2} + \frac{\gamma_{1,1}}{1 + \beta_1}\right) \frac{\tau_{2,1}}{(1 - \tau_{2,1})}} \quad (18)$$

$$- \left(\frac{\beta_2}{1 + \beta_2} w_{2,0} + \frac{\beta_1}{1 + \beta_1} w_{1,0} \right) \max(A_1, A_2), \quad (19)$$

where $T_0 = \tau_{1,0} w_{1,0} + \tau_{2,0} w_{2,0}$, $\gamma_{c,1} \equiv 1 - \gamma_{1,1} - \gamma_{2,1}$.

The capital gap is

$$K_1 - K_1^* = \frac{\frac{\beta_2 [(1 - \tau_{2,0}) w_{2,0} + \gamma_{2,0} (\tau_{1,0} w_{1,0} + \tau_{2,0} w_{2,0})]}{(1 + \beta_2)} + \frac{\beta_1 [(1 - \tau_{1,0}) w_{1,0} + \gamma_{1,0} (\tau_{1,0} w_{1,0} + \tau_{2,0} w_{2,0})]}{(1 + \beta_1)}}{1 + \left(\frac{\gamma_{2,1}}{1 + \beta_2} + \frac{\gamma_{1,1}}{1 + \beta_1}\right) \frac{\tau_{2,1}}{(1 - \tau_{2,1})}} - \left(\frac{\beta_2}{1 + \beta_2} w_{2,0} + \frac{\beta_1}{1 + \beta_1} w_{1,0} \right).$$

Observe that $Y_1 - Y_1^*$ is continuously increasing in the R&D efficiency a_2 . Moreover, if $\gamma_{d,0} T_0 > 0$, we have $\lim_{a_2 \rightarrow \infty} (Y_1 - Y_1^*) = \infty$. By consequence, we obtain the following result.

Proposition 5 (inaction versus intervention and corruption: role of efficiency). *Let Assumptions in Proposition 3 hold. Assume that the government effort in public investment is significant, i.e., $\gamma_{d,0} T_0 > 0$.*

1. When the efficiency a_2 is high enough, we have $Y_1 - Y_1^* > 0$. This happens even there is a corruption, i.e., $1 > \gamma_{1,0} + \gamma_{2,0} + \gamma_{d,0}$ and $1 > \gamma_{1,1} + \gamma_{2,1}$.
2. When the efficiency a_2 is low and/or the corruption is high (i.e., $1 - \gamma_{1,1} - \gamma_{2,1}$ is high), then $Y_1 - Y_1^* < 0$.

As mentioned above the presence of the corruption is always harmful for the economic development. However, Proposition 5 argues that the inaction may be worse. Indeed, Proposition 5's point 1 shows that when the government provides a significant investment in public investment and it is quite efficient (i.e. high value of a_2), we obtain more economic output with respect to the inaction situation, even a part of tax revenue is wasted due to a corruption.

Proposition 5 is related to Dimaria and Le Van (2002)'s Proposition 3 where they show, in an optimal growth framework, that a scenario, where embezzling improves the productivity, corruption is not very high and the incentive effect is important, would be better than the inaction scenario (where the productivity remains the same and there is no corruption).

We now focus on the case without public investment, i.e., $\gamma_{d,0} = 0$. Could the output in the economy with intervention and corruption be higher than the output in the absence of intervention? We argue this may be the case. The following result focuses on the role of time preference rate.

Proposition 6 (inaction versus intervention and corruption: role of saving rate). *Let Assumption 4 be satisfied. Assume also that $\gamma_{d,0} = 0$, $A_2 > A_1$, and there is no intervention at date 1, i.e., $\tau_{1,1} = \tau_{2,1} = 0$. The output gap equals*

$$Y_1 - Y_1^* = A_2 \frac{\beta_2}{1 + \beta_2} \left(\gamma_{2,0} \tau_{1,0} w_{1,0} - (1 - \gamma_{2,0}) \tau_{2,0} w_{2,0} \right) + A_2 \frac{\beta_1}{1 + \beta_1} \left(\gamma_{1,0} \tau_{2,0} w_{2,0} - (1 - \gamma_{1,0}) \tau_{1,0} w_{1,0} \right). \quad (20)$$

1. If $\beta_1 = \beta_2 = \beta$, then we can compute that

$$Y_1 - Y_1^* = \frac{\beta_1}{1 + \beta} A_2 (1 - \gamma_{1,0} - \gamma_{2,0}) T_0 = -\frac{\beta_1}{1 + \beta} A_2 \gamma_{c,0} T_0 \leq 0 \quad (21)$$

This is strictly negative if and only if the wasted rate $\gamma_{c,0} > 0$.

2. Assume that $\gamma_{2,0} \tau_{1,0} w_{1,0} - (1 - \gamma_{2,0}) \tau_{2,0} w_{2,0} > 0$. We have $Y_1 - Y_1^* > 0$ if β_1 is low enough.
3. Assume that $\gamma_{1,0} \tau_{2,0} w_{2,0} - (1 - \gamma_{1,0}) \tau_{1,0} w_{1,0} < 0$. We have $Y_1 - Y_1^* < 0$ if β_2 is low enough.

Proof. See Appendix A. □

When both agents have the same rate of time preference, the presence of corruption lowers the aggregate output.

We now explain the intuition behind point 2 of Proposition 6. Condition $\gamma_{2,0} \tau_{1,0} w_{1,0} - (1 - \gamma_{2,0}) \tau_{2,0} w_{2,0} > 0$ means that the government's redistribution policy does increase

the after-transfer income of agent 2 (the most productive agent), corresponding to $(1 - \tau_{2,0})w_{2,0} + \gamma_{2,0}T_0 > w_{2,0}$ as shown in Appendix A. By combining with the fact that the most productive agent has a higher rate of time preference and a higher saving rate, the aggregate capital would be higher than that in the absence of intervention, even there is some corruption $\gamma_{c,0} > 0$. So, the economy's output would be higher.

Point 3 of Proposition 6 shows another story: a distorted redistribution may be harmful for the economic growth, even there is no corruption (i.e., $\gamma_{1,0} + \gamma_{2,0} = 1$). This happens if the agent 1 (whose rate of time preference β_1 and saving rate are high) is too much taxed, because this reduces the saving of this agent which in turn decreases the aggregate investment.

We now emphasize an other bad intervention.

Proposition 7 (a harmful taxation). *Assume that $\beta_1 = \beta_2 = \beta > 0$ and we abstract from the public investment (i.e., $\gamma_{d,0} = 0$). Assume that $A_1 > A_2$ but there is a bad tax distortion in the sense that $(1 - \tau_{2,1})A_2 > (1 - \tau_{1,1})A_1$. In this case, we have $Y_1 < Y_1^*$.*

Proof. See Appendix A. □

The key of this result is the distorted taxation. Indeed, condition $(1 - \tau_{2,1})A_2 > (1 - \tau_{1,1})A_1$ means that the government sets a high tax rate $\tau_{1,1}$ on the most productive agent (agent 1 in this case) so that this agent cannot produce. By consequence, we have a lower output. It should be noticed that this can happen even there is no corruption (i.e., $\gamma_{1,t} + \gamma_{2,t} = 1$ for $t = 0, 1$).

5 Conclusion

We have developed a general equilibrium model that incorporates public investment and corruption. The existence of equilibrium is established using a two-step fixed-point argument. We have then analyzed the role of various redistribution and public investment policies, as well as the effect of corruption. Our findings show that corruption is consistently detrimental to economic development. However, policy inaction—defined as the absence of both redistribution and public investment—may lead to worse outcomes than scenarios in which corruption coexists with investment- or innovation-led policies.

The results demonstrate that under certain conditions, such as high efficiency of R&D investment or well-targeted redistribution strategies, the gains from public intervention can compensate for the losses due to corruption. This confirms that governance quality, particularly in the allocation and productivity of public resources, always plays an essential role in determining the effect of policy interventions. In particular, targeting transfers toward more productive agents or investing in high-impact R&D sector can mitigate the negative effects of corruption and even improve aggregate output. Furthermore, our analysis reveals that distorted taxation policies, such as over-taxing highly productive or high-saving agents, can be particularly damaging, even in the absence of corruption.

Overall, this study contributes to a better understanding of the conditions under which government intervention can be justified, even in environments where corruption is prevalent. These findings warn against adopting anti-corruption strategies that

neglect the broader context of fiscal policy design. Instead, they call for an integrated approach that considers the interaction between corruption, public investment efficiency, redistribution and taxation policies.

A Formal proofs

Proof of Proposition 1. By using the standard approach (see [Le Van and Pham \(2016\)](#) for instance), we can prove that there exists a competitive equilibrium.

Let us prove the uniqueness of equilibrium allocation and interest rate R_1 .

Consider the maximization problem of agent i . Since the utility function is strictly concave, there exists a unique consumption allocation $(c_{i,0}, c_{i,1})$ of the agent i , and so does $k_{i,1} - b_{i,0}$. We claim the uniqueness of $b_{i,0}$.

By Inada's condition $F'_i(0) = \infty$, we have $k_{i,1} > 0$. We can write standard first-order conditions (FOC):

$$u'_i(c_{i,0}) = \beta_i(1 - \tau_{i,1})A_iF'_i(k_{i,1})u'_i(c_{i,1}) \quad (22)$$

$$u'_i(c_{i,0}) = \beta_i R_1 u'_i(c_{i,1}). \quad (23)$$

So, $R_1 = (1 - \tau_{i,1})A_iF'_i(k_{i,1})$. When F_i is strictly concave, this implies that $k_{i,1}$ is continuously differentiable and decreasing in R_1 .

Denote $x_{i,0} \equiv (1 - \tau_{i,0})w_{i,0} + \gamma_{i,0}T_0$. Look at the FOC

$$u'_i(c_{i,0}) = \beta_i R_1 u'_i(c_{i,1}) \quad (24)$$

$$\Leftrightarrow u'_i(x_{i,0} + b_{i,0} - k_{i,1}) = \beta_i R_1 u'_i\left((1 - \tau_{i,1})A_iF'_i(k_{i,1}) - R_1 b_{i,0} + \gamma_{i,1}T_1\right). \quad (25)$$

So, $b_{i,0}$ is uniquely determined and it is continuously differentiable in R_1 . Taking the derivative of both sides with respect to R_1 we have

$$\begin{aligned} u''_i(c_{i,0})(b'_{i,0}(R_1) - k'_{i,1}(R_1)) &= \beta_i u'_i(c_{i,1}) \\ &\quad + \beta_i R_1 u''_i(c_{i,0})\left((1 - \tau_{i,1})A_iF'_i(k_{i,1})k'_{i,1}(R_1) - b_{i,0} - R_1 b'_{i,0}(R_1)\right). \end{aligned}$$

Combining with $(1 - \tau_{i,1})F'_i(k_{i,1}) = R_1$, we get that

$$\begin{aligned} u''_i(c_{i,0})(b'_{i,0}(R_1) - k'_{i,1}(R_1)) &= \beta_i u'_i(c_{i,1}) + \beta_i R_1 u''_i(c_{i,1})\left(R_1 k'_{i,1}(R_1) - b_{i,0} - R_1 b'_{i,0}(R_1)\right) \\ \Rightarrow \left(u''_i(c_{i,0}) + \beta_i R_1^2 u''_i(c_{i,1})\right)(b'_{i,0}(R_1) - k'_{i,1}(R_1)) &= \beta_i u'_i(c_{i,1}) - \beta_i R_1 b_{i,0} u''_i(c_{i,1}) \\ &= \beta_i \left(u'_i(c_{i,1}) + c_{i,1} u''_i(c_{i,1})\right) + \beta_i u''_i(c_{i,1})\left(-(1 - \tau_{i,1})A_iF'_i(k_{i,1}) - \gamma_{i,1}T_1\right) > 0. \end{aligned}$$

because $u'(c) + cu''(c) \geq 0$ for any $c > 0$. Therefore, we have $\beta_i u'_i(c_{i,1}) - \beta_i R_1 b_{i,0} u''_i(c_{i,1}) > 0$. This implies that $b'_{i,0}(R_1) - k'_{i,1}(R_1) < 0$. Since $k'_{i,1}(R_1) < 0$. We obtain $b'_{i,0}(R_1) < 0$.

So, $b_{i,0}$ is strictly decreasing in R_1 . Combining with the market clearing condition $\sum_{i=1}^m b_{i,0} = 0$, we get that R_1 is uniquely determined. $\square$

Proof of Lemma 1. Agent i 's problem becomes

$$\begin{aligned} & \max_{(c_{i,0}, c_{i,1}, k_{i,1}, b_{i,0})} u_i(c_{i,0}) + \beta_i u(c_{i,1}) \\ & \text{subject to constraints: } c_{i,0} + k_{i,1} \leq w_{i,0} + b_{i,0} \\ & \quad c_{i,1} \leq A_i k_{i,1} - R_1 b_{i,0} \\ & \quad c_{i,0} \geq 0, c_{i,1} \geq 0, k_{i,1} \geq 0 \end{aligned}$$

Without loss of generality, assume that $A_2 > A_1$. Since there is no borrowing constraint, the agent 1 does not produce and we find that

$$\begin{aligned} R_1 &= A_2 \\ -b_{1,0} &= \frac{\beta_1}{1 + \beta_1} w_{1,0} \\ k_{2,1} - b_{2,0} &= \frac{\beta_2}{1 + \beta_2} w_{2,0} \\ k_{2,1} &= \frac{\beta_2}{1 + \beta_2} w_{2,0} + b_{2,0} = \frac{\beta_2}{1 + \beta_2} w_{2,0} - b_{1,0} = \frac{\beta_2}{1 + \beta_2} w_{2,0} + \frac{\beta_1}{1 + \beta_1} w_{1,0}. \end{aligned}$$

The output at date 1 equals:

$$Y_1 = A_2 k_{2,1} = A_2 \left(\frac{\beta_2}{1 + \beta_2} w_{2,0} + \frac{\beta_1}{1 + \beta_1} w_{1,0} \right).$$

□

Proof of Proposition 3. Consider an equilibrium. We have $T_0 = \sum_{i=1}^m \tau_{i,0} w_{i,0}$. So, we have $D_0 = \gamma_{d,0} T_0 = \gamma_d \sum_{i=1}^2 \tau_{i,0} w_{i,0}$. The budget constraints of agent i are

$$\begin{aligned} c_{i,0} + k_{i,1} &\leq (1 - \tau_{i,0}) w_{i,0} + b_{i,0} + \gamma_{i,0} T_0 \\ c_{i,1} &\leq (1 - \tau_{i,1}) \mathcal{A}_i(D_0) k_{i,1} - R_1 b_{i,0} + \gamma_{i,1} T_1. \end{aligned}$$

We write the FOCs

$$\begin{aligned} u'_i(c_{i,0}) &= \beta_i R_1 u'_i(c_{i,1}) \\ u'_i(c_{i,0}) &= \beta_i (1 - \tau_{i,1}) \mathcal{A}_i(D_0) F'_i(k_{i,1}) u'_i(c_{i,1}) + \mu_{i,1} = \beta_i (1 - \tau_{i,1}) \mathcal{A}_i(D_0) u'_i(c_{i,1}) + \mu_{i,1} \\ \mu_{i,1} &\geq 0, \quad \mu_{i,1} k_{i,1} = 0. \end{aligned}$$

This implies that $R_1 \geq (1 - \tau_{i,1}) \mathcal{A}_i(D_0)$ for any i .

Since $(1 - \tau_{2,1})(1 + a_2 \gamma_{d,0} T_0) A_2 > (1 - \tau_{1,1})(1 + a_1 \gamma_{d,0} T_0) A_1$, we have

$$R_1 = (1 - \tau_{2,1}) \mathcal{A}_2(D_0).$$

Since $R_1 > (1 - \tau_{1,1}) \mathcal{A}_1(D_0)$, we have $\mu_{1,1} > 0$ which implies that $k_{1,1} = 0$.

In equilibrium, we have, for $i = 1, 2$,

$$\begin{aligned} c_{i,0} + k_{i,1} &= (1 - \tau_{i,0}) w_{i,0} + b_{i,0} + \gamma_{i,0} T_0 \\ c_{i,1} &= (1 - \tau_{i,1}) \mathcal{A}_i(D_0) F_i(k_{i,1}) - R_1 b_{i,0} + \gamma_{i,1} T_1. \end{aligned}$$

Then, we find that

$$\begin{aligned} c_{i,1} &= \beta_1 R_1 c_{i,0} \text{ for any } i = 1, 2 \\ -R_1 b_{1,0} + \gamma_{1,1} T_1 &= \beta_1 R_1 ((1 - \tau_{1,0})w_{1,0} + b_{1,0} + \gamma_{1,0} T_0) \end{aligned}$$

Then, we can find the saving of agent 1 by

$$\begin{aligned} -b_{1,0} R_1 (1 + \beta_1) &= \beta_1 R_1 ((1 - \tau_{1,0})w_{1,0} + \gamma_{1,0} T_0) - \gamma_{1,1} T_1 \\ -b_{1,0} &= \frac{\beta_1 R_1 ((1 - \tau_{1,0})w_{1,0} + \gamma_{1,0} T_0) - \gamma_{1,1} T_1}{(1 + \beta_1) R_1} \\ &= \frac{\beta_1 ((1 - \tau_{1,0})w_{1,0} + \gamma_{1,0} T_0)}{(1 + \beta_1)} - \frac{\gamma_{1,1} T_1}{(1 + \beta_1) R_1}. \end{aligned}$$

We now look at the agent 2's problem:

$$\begin{aligned} c_{2,1} &= \beta_2 R_2 c_{2,0} \\ \Leftrightarrow (1 - \tau_2) F_2(k_{2,1}) - R_1 b_{2,0} + \gamma_{2,1} T_1 &= \beta_2 R_2 ((1 - \tau_{2,0})w_{2,0} + b_{2,0} + \gamma_{2,0} T_0 - k_{2,1}) \\ \Leftrightarrow (1 + \beta_2) R_1 (k_{2,1} - b_{2,0}) &= \beta_2 R_1 ((1 - \tau_{2,0})w_{2,0} + \gamma_{2,0} T_0) - \gamma_{2,1} T_1. \end{aligned}$$

Then, combining with $b_{1,0} + b_{2,0} = 0$, we can compute the capital of agent 2

$$k_{2,1} = \frac{\beta_2 R_1 ((1 - \tau_{2,0})w_{2,0} + \gamma_{2,0} T_0) - \gamma_{2,1} T_1}{(1 + \beta_2) R_1} + b_{2,0} \quad (27)$$

$$= \frac{\beta_2 R_1 ((1 - \tau_{2,0})w_{2,0} + \gamma_{2,0} T_0) - \gamma_{2,1} T_1}{(1 + \beta_2) R_1} + \frac{\beta_1 R_1 ((1 - \tau_{1,0})w_{1,0} + \gamma_{1,0} T_0) - \gamma_{1,1} T_1}{(1 + \beta_1) R_1}. \quad (28)$$

Now, recall that

$$T_1 = \tau_{1,1} \mathcal{A}_1(D_0) F_1(k_{1,1}) + \tau_{2,1} \mathcal{A}_2(D_0) F_2(k_{2,1}) = \tau_{2,1} \mathcal{A}_2(D_0) k_{2,1}.$$

Hence,

$$\frac{T_1}{R_1} = \frac{\tau_{2,1} \mathcal{A}_2(D_0) k_{2,1}}{(1 - \tau_{2,1}) \mathcal{A}_2(D_0)} = \frac{\tau_{2,1}}{(1 - \tau_{2,1})} k_{2,1}. \quad (29)$$

Therefore, we find that

$$\begin{aligned} k_{2,1} \left(1 + \left(\frac{\gamma_{2,1}}{1 + \beta_2} + \frac{\gamma_{1,1}}{1 + \beta_1} \right) \frac{\tau_{2,1}}{(1 - \tau_{2,1})} \right) &= \frac{\beta_2 ((1 - \tau_{2,0})w_{2,0} + \gamma_{2,0} T_0)}{(1 + \beta_2)} + \frac{\beta_1 ((1 - \tau_{1,0})w_{1,0} + \gamma_{1,0} T_0)}{(1 + \beta_1)} \\ &= \frac{\beta_2 ((1 - \tau_{2,0})w_{2,0} + \gamma_{2,0} (\tau_{1,0} w_{1,0} + \tau_{2,0} w_{2,0}))}{(1 + \beta_2)} + \frac{\beta_1 ((1 - \tau_{1,0})w_{1,0} + \gamma_{1,0} (\tau_{1,0} w_{1,0} + \tau_{2,0} w_{2,0}))}{(1 + \beta_1)}. \end{aligned}$$

By consequence, we obtain (16).

Then, the GDP of the economy at date 1 equals

$$\begin{aligned}
Y_1 &= \underbrace{\sum_{i=1}^2 c_{i,1}}_{\text{Consumption}} = \sum_{i=1}^2 (1 - \tau_{i,1}) \mathcal{A}_i(D_0) F_i(k_{i,1}) + \left(\sum_{i=1}^2 \gamma_{i,1} \right) T_1 \\
&= \sum_{i=1}^2 \mathcal{A}_i(D_0) F_i(k_{i,1}) - \left(1 - \sum_{i=1}^2 \gamma_{i,1} \right) T_1.
\end{aligned}$$

Denote $\gamma_{c,1} \equiv 1 - \sum_{i=1}^2 \gamma_{i,1}$. According to (29), we have $T_1 = \frac{\tau_{2,1}}{1 - \tau_{2,1}} R_1 k_{2,1} = \tau_{2,1} A_2 k_{2,1}$. Then, we have

$$Y_1 = \mathcal{A}_2(D_0) k_{2,1} - \gamma_{c,1} T_1 = (1 - \gamma_{c,1} \tau_{2,1}) \mathcal{A}_2(D_0) k_{2,1}.$$

The consumption of agent 1 is

$$\begin{aligned}
c_{1,0} &= (1 - \tau_{1,0}) w_{1,0} + \gamma_{1,0} T_0 + b_{1,0} \\
&= (1 - \tau_{1,0}) w_{1,0} + \gamma_{1,0} T_0 - \frac{\beta_1 R_1 \left((1 - \tau_{1,0}) w_{1,0} + \gamma_{1,0} T_0 \right) - \gamma_{1,1} T_1}{(1 + \beta_1) R_1} \\
&= \frac{1}{1 + \beta_1} \left((1 - \tau_{1,0}) w_{1,0} + \gamma_{1,0} T_0 \right) + \frac{\beta_1}{1 + \beta_1} \gamma_1 \tau_2 A_2 k_{2,1} \\
c_{1,1} &= \beta_1 R_1 c_{1,0} = \beta_1 (1 - \tau_{2,1}) A_2 c_{1,0}.
\end{aligned}$$

□

Proof of Proposition 6. First, it is easy to check all assumptions in Proposition 4. Then, by applying Proposition 4, we have

$$Y_1 - Y_1^* = \left(1 - \tau_{2,1} \gamma_{c,1} \right) A_2 \frac{\frac{\beta_2 \left[(1 - \tau_{2,0}) w_{2,0} + \gamma_{2,0} T_0 \right]}{(1 + \beta_2)} + \frac{\beta_1 \left[(1 - \tau_{1,0}) w_{1,0} + \gamma_{1,0} T_0 \right]}{(1 + \beta_1)}}{1 + \left(\frac{\gamma_{2,1}}{1 + \beta_2} + \frac{\gamma_{1,1}}{1 + \beta_1} \right) \frac{\tau_{2,1}}{(1 - \tau_{2,1})}} \quad (30)$$

$$- \left(\frac{\beta_2}{1 + \beta_2} w_{2,0} + \frac{\beta_1}{1 + \beta_1} w_{1,0} \right) A_2 \quad (31)$$

$$= A_2 \frac{\beta_2}{1 + \beta_2} \left((1 - \tau_{2,1} \gamma_{c,1}) \frac{(1 - \tau_{2,0}) w_{2,0} + \gamma_{2,0} T_0}{1 + \left(\frac{\gamma_{2,1}}{1 + \beta_2} + \frac{\gamma_{1,1}}{1 + \beta_1} \right) \frac{\tau_{2,1}}{(1 - \tau_{2,1})}} - w_{2,0} \right) \quad (32)$$

$$+ A_2 \frac{\beta_1}{1 + \beta_1} \left((1 - \tau_{2,1} \gamma_{c,1}) \frac{(1 - \tau_{1,0}) w_{1,0} + \gamma_{1,0} T_0}{1 + \left(\frac{\gamma_{2,1}}{1 + \beta_2} + \frac{\gamma_{1,1}}{1 + \beta_1} \right) \frac{\tau_{2,1}}{(1 - \tau_{2,1})}} - w_{1,0} \right) \quad (33)$$

In this case, the output gap equals

$$Y_1 - Y_1^* = A_2 \frac{\beta_2}{1 + \beta_2} \left(\gamma_{2,0} \tau_{1,0} w_{1,0} - (1 - \gamma_{2,0}) \tau_{2,0} w_{2,0} \right) \quad (34)$$

$$+ A_2 \frac{\beta_1}{1 + \beta_1} \left((1 - \tau_{1,0}) w_{1,0} + \gamma_{1,0} T_0 - w_{1,0} \right). \quad (35)$$

We see that

$$\begin{aligned}
(1 - \tau_{2,0})w_{2,0} + \gamma_{2,0}T_0 - w_{2,0} &= \gamma_{2,0}(\tau_{1,0}w_{1,0} + \tau_{2,0}w_{2,0}) - \tau_{2,0}w_{2,0} \\
&= \gamma_{2,0}\tau_{1,0}w_{1,0} - (1 - \gamma_{2,0})\tau_{2,0}w_{2,0} \\
(1 - \tau_{1,0})w_{1,0} + \gamma_{1,0}T_0 - w_{1,0} &= \gamma_{1,0}(\tau_{1,0}w_{1,0} + \tau_{2,0}w_{2,0}) - \tau_{1,0}w_{1,0} \\
&= \gamma_{1,0}\tau_{2,0}w_{2,0} - (1 - \gamma_{1,0})\tau_{1,0}w_{1,0}.
\end{aligned}$$

□

Proof of Proposition 7. We can easily check that assumptions in Proposition 4 holds and then we can apply it. We have

$$Y_1 = \left(1 - \tau_{2,1}\gamma_{c,1}\right) \left(1 + a_2\gamma_{d,0}T_0\right) A_2 \frac{\frac{\beta_2 \left[(1 - \tau_{2,0})w_{2,0} + \gamma_{2,0}T_0\right]}{(1 + \beta_2)} + \frac{\beta_1 \left[(1 - \tau_{1,0})w_{1,0} + \gamma_{1,0}T_0\right]}{(1 + \beta_1)}}{1 + \left(\frac{\gamma_{2,1}}{1 + \beta_2} + \frac{\gamma_{1,1}}{1 + \beta_1}\right) \frac{\tau_{2,1}}{(1 - \tau_{2,1})}} \quad (36)$$

$$< A_1 \frac{\beta}{1 + \beta} (w_{1,0} + w_{2,0} - (1 - \gamma_{1,0} - \gamma_{2,0})T_0) \quad (37)$$

$$< A_2 \frac{\beta}{1 + \beta} (w_{1,0} + w_{2,0}) = \left(\frac{\beta_2}{1 + \beta_2} w_{2,0} + \frac{\beta_1}{1 + \beta_1} w_{1,0}\right) \max(A_1, A_2) = Y^*. \quad (38)$$

□

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