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Endogenous Growth through Government Policy*

Chetan Ghate

and

Paul J. Zak

Claremont Graduate University

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*We thank Arthur Denzau and Thomas Borcherding for useful comments which have improved this paper. The usual disclaimer applies. Correspondence to: Paul J. Zak, Department of Economics, Claremont Graduate University, Claremont, CA 91711-6165, paul.zak@cgu.edu

Abstract

This paper illustrates two reasonable political decision mechanisms by which fiscal policy generates endogenous growth under a constant returns to scale production technology, absent externalities. Based on the dynamics induced by various policy choices, we demonstrate that policies that maximize capital deepening generate balanced growth and are Pareto optimal. In contrast, policies chosen by the median voter produce balanced growth, but are suboptimal.

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1 Introduction

There is clear evidence that developed countries grow at roughly constant rates, consistent with models that generate balanced growth paths (Pritchett, 1996; Quah, 1997; Tanzi & Zee, 1997; Easterly & Rebelo, 1997; Temple, 1999). Growth theorists have posited a variety of mechanisms that endogenously generate balanced growth, including technological externalities (Romer 1986, 1990), the accumulation of human capital (Lucas, 1988; Galor & Tsiddon, 1996; Zak, 1999), or accumulation of another production input such as public capital (Aschauer, 1989; Devarajan, Xie & Zou, 1998; Barro, 1990; Turnovsky, 1998). In this paper we propose a simple instrument that generates endogenous growth with a single accumulable factor and constant returns to scale production, absent externalities. This mechanism is non-accumulating public investment. We demonstrate that fiscal policy that maximizes capital deepening is Pareto optimal, while fiscal policy chosen by the median voter is suboptimal, yet both produce balanced growth paths.

2 Aggregate Policy Setting and Endogenous Growth

Since growth increases tax revenues and promotes political stability (Zak, 2000), in this section we model policy-makers as maximizing *capital deepening* by choosing an income tax rate at time t, $\tau_t \in (0,1)$, and public investment, $\lambda_t \geq 0$.[1] Public investment raises private productivity which, in turn, raises output and consumption. This construct obviates the need for policy-setters to know consumers' utility functions; rather they need only observe the economy's state variable, K_t, when making policy choices at time t.

Because we seek to generate balanced growth paths, we derive optimal fiscal policy using a Cobb-Douglas production function, $Y_t = K_t^{\alpha}\lambda_t^{1-\alpha}$, where K is the private capital stock, population is constant and normalized to unity, and $\alpha \in (0,1)$. Leisure

[1] Ghate & Zak (1999) use a similar construct and cite a broad literature in political science that identifies economic growth as a primary factor that determines constituents' support for politicians.

is not valued in this economy. The form of the production function shows that public investment (e.g. education expenditures), is necessary to produce output. The optimal fiscal policy problem at time t is the solution to

$$Max_{\lambda,\tau} \frac{K_{t+1}}{K_t} \tag{1}$$

s.t.

$$\begin{aligned} Y_t(1-\tau_t) &= C_t + I_t && (2) \\ K_{t+1} &= I_t + (1-\delta)K_t && (3) \\ Y_t\tau_t &= \lambda_t. && (4) \end{aligned}$$

where C is aggregate consumption and I is private investment. Equation (2) is the national income accounting identity equating after tax output to aggregate private consumption plus private investment. Equation (3) is the stock accounting identity for private capital which depreciates at rate $\delta \in [0,1]$ in each period. Equation (4) is the government budget constraint which equates tax revenues to public investment expenditures. For simplicity, government borrowing is disallowed. It is important to reiterate that we model public investment as a non-accumulable factor since if two types of capital accumulate, it is well-established that endogenous growth obtains (Aghion & Howitt, 1998).[2]

The solution to the optimal fiscal policy problem (1) to (4) is given by

$$\begin{aligned} \lambda_t^\star &= (1-\alpha)^{\frac{1}{\alpha}} K_t && (5) \\ \tau_t^\star &= (1-\alpha) \ \ \forall t && (6) \end{aligned}$$

Optimal public investment, (5), is linearly related to private capital, while the optimal tax is the proportion of output spent on public investment. The following proposition shows that the policy set $\{\lambda_t^\star, \tau_t^\star\}_{t=0}^{\infty}$ is Pareto optimal in a representative agent economy.

[2]The optimal policy problem above is simply a modified planning problem, where the objective is capital deepening rather than utility maximization.

Proposition 1 *Suppose that all agents in the economy are identical and infinitely lived. Then the growth maximizing policy set given by (5), (6), for some initial condition $K_0 > 0$, is Pareto optimal.*

PROOF. The Pareto optimal fiscal policy problem is the solution to

$$Max_{\tau,\lambda} \sum_{t=0}^{\infty} \beta^t U(C_t) \tag{7}$$

s.t

$$K_{t+1} = F(K_t, \lambda_t)(1-\tau_t) + (1-\delta)K_t - C_t \tag{8}$$

$$\lambda_t = \tau_t F(K_t, \lambda_t) \tag{9}$$

where $U(C)$ is a smooth representation of preferences with the usual properties. Using the Cobb-Douglas production function given above, the solution to the Pareto problem can be shown to match growth maximization problem as claimed. ∎

Next, we characterize the aggregate dynamics induced by this fiscal policy. In order to simplify the dynamics, we consider an economy in which savings is a fixed proportion of income, as in Solow (1956).[3]

The capital market equilibrium condition is given by

$$K_{t+1} = s\overline{Y}_t + (1-\delta)K_t, \tag{10}$$

where $s \in (0,1)$ is the exogenous savings rate, and $\overline{Y} \equiv Y(1-\tau) = K^{\alpha}(\lambda^{\star})^{1-\alpha}(1-\tau^{\star})$ is aggregate income net of taxes when fiscal policy maximizes capital deepening. Substituting (5) and (6) into (10), the evolution of the economy is given by

$$K_{t+1} = s\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}} K_t + (1-\delta)K_t \tag{11}$$

The first term in (11) captures the complementarity of private capital and public investment in producing output, resulting in a term that is linear in K. The second term in (11) is the undepreciated capital remaining after production at time t which is also linear in K. Thus, optimal fiscal policy using a constant returns to scale

[3] Campbell & Mankiw (1991) present robust empirical support for constant savings rates.

production function results in a linear mapping from current period to next period's capital stock due to production complementarities between private capital and public investment.

The economy with optimal fiscal policy, (11), grows without bound if

$$s \geq \frac{\delta(1-\alpha)^{\frac{\alpha-1}{\alpha}}}{\alpha}. \tag{12}$$

If inequality (12) is satisfied, optimal fiscal policy produces an AK model–for any $K_0 > 0$, the economy exhibits balanced growth endogenously.[4] Thus, the model in this section illustrates that fiscal policy that maximizes capital deepening is Pareto optimal and generates balanced growth.

3 VOTING FOR POLICY

In this section we extend the analysis above by investigating the dynamics of an economy with a continuum of heterogeneous agents who vote over fiscal policy. Agents are identified by their wealth, where a type i agent has assets a^i and agents have unit mass.[5] The index $i \in (0, \infty)$ orders agents so that $i_2 > i_1$ implies $a^{i_2} > a^{i_1}$.

In order to compare this model to the one in the previous section, we assume that agents save a uniform and fixed proportion $s \in (0, 1)$ of their labor income each period, and limit all investments to last a single period. Consumers vote for fiscal policies to maximize discounted lifetime utility. Since voting occurs over a single issue (after substituting out τ using the government budget constraint) and preferences are single peaked, the median voter theorem is applicable. The fiscal policy choice faced by a type i agent at time t is

$$Max_{\tau,\lambda}\Sigma_{t=0}^{\infty}\beta^t U(c_t^i) \tag{13}$$

s.t.

$$c_t^i = w_t(1-\tau_t) + R_t a_t^i - a_{t+1}^i \tag{14}$$

[4]If condition (12) is not satisfied, the economy contracts to the origin.

[5]For simplicity, we abstract from heterogeneity in wages.

$$a_{t+1}^i = s[w_t(1-\tau_t) + R_t a_t^i] \tag{15}$$

$$\tau_t w_t = \lambda_t \tag{16}$$

Equation (14) is the agent's budget constraint equating time t consumption, c_t^i, to after-tax wage, $w_t(1-\tau_t)$, and the return on last period's investment, $R_t a_t^i$, minus assets held for the following period, a_{t+1}^i. The assumption of proportional savings given by equation (15). The term $R \equiv r + 1 - \delta$ is the yield on savings, with r the interest rate. The last equation, (16), is the government budget constraint equating tax revenue to public investment.

Agents understand that factor prices depend on public investment when choosing fiscal policy. Profit maximization by firms leads to factor prices,

$$r_t = \alpha K_t^{\alpha-1}(\lambda_t)^{1-\alpha} \tag{17}$$

$$w_t = (1-\alpha)K_t^{\alpha}(\lambda_t)^{1-\alpha} \tag{18}$$

Using (17) and (18), the unique solution to the voting problem (13)–(16), determined by the median voter, is

$$\lambda_t^m = (1-\alpha)^{\frac{1}{\alpha}} K_t^{\frac{\alpha-1}{\alpha}} [(1-\alpha)K_t + \alpha a_t^m]^{\frac{1}{\alpha}}, \tag{19}$$

$$\tau_t^m = 1 - \alpha + \frac{\alpha a_t^m}{K_t}, \tag{20}$$

where a^m are the assets of the median voter. Equation (19) shows that the preferred level of public investment is increasing in the assets of the median voter. This obtains as λ increases wages and the return to savings, which, in turn, increase after-tax income. Likewise, public investment is also increasing in the capital stock.

Before the aggregate dynamics induced by this fiscal policy can be determined, the relationship between the median voter's wealth and aggregate wealth must be specified since public investment (19) and taxes (20) depend on the median voter's wealth. A straightforward relation is that the median voter owns a fixed proportion of aggregate capital, $a_t^m = \phi K_t$, for some $\phi \in (0,1)$. This follows since individual assets sum to aggregate capital $\int_0^\infty a_t^i d\mu = K_t$ where μ is an appropriately defined probability measure over agents, and by constraint (15) agents save a fixed proportion of income every period.[6]

[6]That is, the distribution of wealth is invariant over time.

Using the above relation for the median voter's wealth relative to the capital stock, optimal public investment and taxes are

$$\lambda_t^m = (1-\alpha)^{\frac{1}{\alpha}}[(1-\alpha(1-\phi)]^{\frac{1}{\alpha}}K_t \tag{21}$$

$$\tau_t^m = 1-\alpha(1-\phi) \quad \forall t, \tag{22}$$

The aggregate dynamics of this economy are captured in the capital market clearing condition

$$K_{t+1} = s\int_0^\infty [w_t(1-\tau) + R_t a_t^i]d\mu. \tag{23}$$

Using the adding up condition that relates individual assets to the capital stock, (23) can be written as

$$K_{t+1} = s[w_t(1-\tau) + (1-\delta+r_t)K_t]. \tag{24}$$

Embedding factor prices (17), (18), and the optimal policy choices (21), (22) into the capital market clearing condition (24), produces the dynamic equation

$$K_{t+1} = AK_t, \tag{25}$$

where $A = s[(1-\alpha)^{\frac{1}{\alpha}}(1-\alpha(1-\phi))^{\frac{1}{\alpha}} + \alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}(1-\alpha(1-\phi))^{\frac{1-\alpha}{\alpha}} + 1-\delta] > 0$. Thus, voting over fiscal policies again produces an AK model. It is straightforward to prove that the level of public investment chosen by voters is below the Pareto optimal level as the median consumer does not take into account aggregate growth when choosing policy. The extent of this distortion appears to be quite large, with the proportional difference between the two policies being $[1-\alpha(1-\phi)]^{\frac{1}{\alpha}}$.[7]

4 CONCLUSION

We have demonstrated two simple mechanisms through which fiscal policies transform otherwise standard growth models with constant returns to scale production into

[7]For instance, in a large economy such as the U.S, the proportion of aggregate wealth held by the median voter, ϕ, is near zero, while α is typically measured around $\frac{1}{3}$ (Cooley, 1995, Ch. 1). This puts the public investment chosen by the median voter 54% below the Pareto optimal level.

endogenous growth models, without appealing to externalities. Notably, the models herein produce balanced growth paths, qualitatively matching growth in developed countries, using reasonable optimal policy selection techniques. As a result, we have shown that balanced growth obtains without the knife-edge parameter restrictions required by many endogenous growth models.

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