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Fiscal Transfers and Distributive Conflict in a Simple Endogenous Growth Model with Unemployment

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FISCAL TRANSFERS AND DISTRIBUTIVE CONFLICT IN A SIMPLE ENDOGENOUS GROWTH MODEL WITH UNEMPLOYMENT

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ABSTRACT

In the simplified formal treatment proposed in this paper, a decrease in a policy parameter—the ratio of total tax revenues to GDP—can monotonically increase long-term growth rate and may lead to a higher employment level. This notwithstanding, the paper shows that the redistributive implications of such a decrease may induce the wage earners to oppose it. As a consequence, policy makers reflecting social preferences may undertake redistributive transfers generating persistent unemployment and lowering growth even if commitment technologies allowing them to follow pre-announced tax policies were feasible.

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KEY WORDS: endogenous growth, tax burden, welfare reforms, capital-labor conflict, politico-economic models.

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1 INTRODUCTION

In recent years, it is increasingly common to hear economists, commentators and public officials claiming that the low employment rate and the disappointing growth performance of continental Europe vis-à-vis the United States (see table 1 and 2) have to be attributed – among other factors – to the more generous welfare system and heavier tax burden of the former (see table 3). The obvious policy implication of this claim for countries like France, Germany or Italy is that they should implement structural reforms aimed at reducing both the amount of redistribution operated through the welfare system and the associated tax burden if they want to raise employment and stimulate investment (see table 4), thus enhancing long-term growth. Hence, those advocating the urgency of these reforms argue that the wage earners' organizations and political representatives opposing them are myopic, since they do not fully appreciate the long-term benefits that also their constituency can enjoy if the economy grows persistently at higher rates. In contrast, this paper presents a simple general-equilibrium endogenous growth model, which follows the classical dichotomy in dividing the population between capitalists (firms' owners) and workers, and where it can be perfectly rational from the viewpoint of a wage earner to oppose these reforms even if they lead to higher employment and boost long-term growth. Indeed, it is shown that workers can have good reasons to resist a cut in the share of GDP devoted to redistributive transfers in their favor even in a set-up where i) they take into account the future benefits accruing to them (or to their descendants) in case of higher growth, and ii) this cut has an unambiguously positive effect on employment and long-run growth. In other words, even conceding that these reforms will permanently raise the employment level and improve the growth performance of the economy, and even assessing their effects on workers' well-being should be evaluated in a very long-term perspective, their redistributive implications might be such that workers could be better off if they are not implemented.

TABLE 1

EMPLOYMENT RATE (NUMBER EMPLOYED RELATIVE TO WORKING-AGE POPULATION) IN THE 1990S (ANNUAL AVERAGE)

France	Germany	Italy	United States
58.5	64.9	52.5	72.4

Source: Based on OECD data.

TABLE 2

REAL GDP: PERCENTAGE CHANGE IN THE 1990S (ANNUAL AVERAGE)

France	Germany	Italy	United States
1.8	1.6	1.6	3.2

Source: OECD

Furthermore, it is worth to emphasize that these reforms can be against the interests of the current workers even if they provide that cuts in redistributive transfers shall be implemented only in the future. This is at odds with those concluding that the welfare state would survive only if social and political actors cannot commit themselves to implement in the future what they decide in the present. Indeed, the model presented here shows also that policy makers reflecting the interests of both the capitalists and the workers may implement permanent redistributive transfers in favor of the workers no matters whether a commitment technology is feasible.

Finally, in this set-up, an increase of the workers' influence on the political process may raise the unemployment rate and depress economic growth. If, in a democratic society, the political influence of a social group depends on its relative size, this implies in the model that unemployment may increase as firms' ownership is concentrated in the hands of a smaller fraction of total population.

The paper is organized as follows: section 2 discusses the relevant literature; section 3 presents the model; section 4 derives the optimal tax rates, and section 5 concludes.

TABLE 3

TOTAL GOVERNMENT OUTLAYS AS A PERCENT OF GDP IN 2000

France	Germany	Italy	United States
51.0	43.3	44.4	32.6

Source: OECD

TABLE 4

TOTAL GROSS INVESTMENT: AVERAGE ANNUAL PERCENTAGE CHANGE, 1991-1998

France	Germany	Italy	United States
-0.3	1.1	-0.4	4.9

Source: Caselli et al., 2001.

2 RELEVANT LITERATURE

The link between economic growth and fiscal policy modeled in the paper depends on the depressing impact on the rate of return to private investment that more massive redistributive transfers can cause by increasing the tax rate and the wage pressure. The former mechanism has been emphasized by the literature studying the effects of tax policy in growth models (see Rebelo, 1991; Stokey and Rebelo, 1995; McGrattan and Schmitz, 1999), the latter by those focusing on the so-called "labor-market channel" (see Alesina *et al*., 2002), namely on the proposition that high public spending and taxation reduces profits and investment by putting upward pressure on private sector wages. Indeed, fiscal redistribution can distort labor-supply incentives,[1] by affecting the ratio between the income conditional on working and the income conditional on not working (see Phelps, 1997; Pissarides, 1998). Hence, the model presented in this paper is consistent with the literature emphasizing that higher public transfers and taxation tend to raise both the real wages and the capital-labor ratio, and to lower both the employment rate and the expected return on capital, thus depressing investment and growth (see Daveri and Tabellini, 2000). In this sense, the model addresses the negative incentive effects that redistribution has at both the giving end (by raising taxes) and at the receiving end (by discouraging labor-market participation). Within this framework, the paper vindicates the intuition according to which the wage earners can be right in resisting a cut in welfare programs and taxation, since they appropriate only a portion of the fruits of the higher growth made possible by the cut, while bearing its entire impact in terms of less favorable income distribution.

The possibility of generating unemployment is an original feature of the model presented here. To the best of my knowledge, indeed, no other model belonging to the growing literature on how redistribution affects growth deals with the presence of unemployment. This allows the present paper to predict that where the workers have a relevant influence on the political process it is more likely that the amount of redistribution operated through the fiscal policy can create persistent unemployment.

This paper follows Lansing (1999) in studying the significant case of capitalists' log-utility and in obtaining the result that—differently than in Judd (1985)—the open-loop solution to the social planner's problem does not entail zero redistributive transfers in the long run. This result is important, since Judd

[1] See Bourguignon (2001). Prescott (2003) presents some evidence on the role of taxes in explaining the differences between the USA and continental Europe in labor supply across time.

(1985) is at the origin of the conclusion that the perpetuation of government transfers would constitute a "political failure" (see Hassler et al., 2003; see also Besley and Coate, 1998, for the definition of "political failure"), which is due to the lack of mechanisms committing the policy makers to follow the optimal—but time-inconsistent—fiscal policy dictating zero redistributive transfers in the future. In contrast--and as in Lansing (1999)--the open-loop solution to the social planner's problem obtained in the present paper is also time consistent.[2] This makes the analysis more realistic, in the light of the mentioned lack of effective mechanisms committing the fiscal authorities to implement pre-announced policies.

The simple politico-economic process modeled here predicts that more inequality may lead to more redistribution. This is common to Alesina and Rodrik (1994), Persson and Tabellini (1994) and Benabou (1996). However, differently than in these papers, where more inequality has to be intended as a lower ratio of the median voter's wealth to the average wealth, in the present paper more inequality means that firms' ownership is concentrated in the hands of fewer households.

3 THE MODEL

In the economy under consideration, there are capitalists, workers and the government. The capitalists are the firms' owners and do not work, while the workers do not save. This classical dichotomy can be micro founded by assuming "that capitalists are on a corner of their labor supply decision due to their wealth, leisure being a normal good, and workers find neither saving nor borrowing valuable because of the transactions costs associated with small transactions" (Judd, 1985, p. 84). Time is discrete and the time horizon is infinite. Although individuals have finite lives, the model considers immortal extended families ("dynasties"). All markets are perfectly competitive. Expectations are rational, in the sense that they are consistent with the true processes followed by the relevant variables. In this framework in which there is no source of random disturbances, this implies perfect foresight.

The firms

There is a large number (normalized to be one) of identical firms. The only good produced in this economy is Y_t, which is the numéraire of the system. Each firm produces this single good according to the

[2] This differentiates the formal set-up presented here from the politico-economic model developed by Park and Philippopulos (2003), which focuses on time-inconsistent open-loop solutions.

technology

$$Y_t = A_t L_t^{\alpha} K_t^{1-\alpha},\ 0<\alpha<1, \tag{1}$$

where A_t is a variable measuring the state of technology, K_t is capital (capital can be interpreted in a broad sense, inclusive of all reproducible assets) and L_t is labor. It is assumed that A_t is a positive function of the stock of capital existing in the economy: $A_t = K_t^{\alpha}$.[3] Moreover, consistently with Frankel (1962), it is supposed that although A_t is endogenous to the economy, each firm takes it as given, since a single firm would only internalize a negligible amount of the effect that its own investment decisions have on the aggregate stock of capital. Finally, note also that the price of Y_t is set to be one.

Assuming that firms' revenues are taxed, the period net (after taxes) profits π_t of a firm are given by:

$$\pi_t = (1-\tau_t)Y_t - W_t L_t,\ \ 0 \le \tau_t \le 1, \tag{2}$$

where τ_t is the tax rate, W_t is the real wage. and I_t is gross investment.

The capital stock evolves according to

$$K_{t+1}=I_t+(1-\delta)K_t,\ K_0 \text{ given}, \tag{3}$$

where for simplicity and without loss of generality it is assumed full capital depreciation (δ=1).

The capitalists

Each capitalist owns one firm, in the sense that s/he is the proprietor of the firm's productive assets and is entitled to receive its net profits. Thus, s/he has also full control on her/his own firm's decisions. Moreover, the capitalists take account of the welfare and resources of their actual and perspective descendants. Indeed, following Barro and Sala-i-Martin (1995), this intergenerational interaction is modeled by imaging that the current generation maximizes utility and incorporates a budget constraint over an infinite future.[4] The number of these dynasties of capitalists is supposed to remain constant over time (and normalized to unity). Finally, again for simplicity and without loss of generality, bequests are assumed to be

[3] Consistently with this formal set-up, one can interpret technological progress as labor augmenting.

[4] As Barro and Sala-i-Martin (1995, p. 60) point out, "this setting is appropriate if altruistic parents provide transfers to their children, who give in turn to their children, and so on. The immortal family corresponds to finite-lived individuals who are connected via a pattern of operative intergenerational transfers that are based on altruism".

accidental.[5]

The representative capitalist's problem amounts to deciding a contingency plan for consumption C_t, L_t and I_t in order to maximize:

$$\sum_{s=t}^{\infty} \theta^{s-t} \ln(C_s), \quad 0<\theta<1, \tag{4}$$

subject to (3) and to

$$C_t + I_t \leq \pi_t, \tag{5}$$

where θ is a time-preference parameter.

The workers

For simplicity and without loss of generality, it is assumed that the working population is constant and that its size is N. Moreover, it is assumed that workers are identical and that they do not save. A worker's period utility is given by

$$u(.) = \begin{cases} \ln(W_t + G_t) \text{ if employed} \\ \ln(\eta G_t) \text{ if not employed, } \eta > 1, \end{cases} \tag{6}$$

where G_t is the workers' non-labor income (namely the monetized value of the welfare entitlements and government transfers made to all workers in period t) and η>1 captures the fact that a worker can enjoy more leisure (and/or undertake some non-market activity) when s/he is not employed.

[5] In other words, it is ruled out the existence of actuarially fair annuities paid to the living investors by a financial institution collecting their wealth as they die: the wealth of someone who dies is inherited by some newly born individual.

It is implicitly assumed that each worker is endowed with one unit of time and that time is indivisible: either the entire unit is supplied as labor or none of it is supplied (see Rogerson, 1988). Since workers are identical, this implies that at $W_t<(\eta-1)G_t$ aggregate labor supply is zero (no worker is willing to work). Hence, it is apparent that market forces simultaneously determine W_t and L_t in such a way that one has or $W_t>(\eta-1)G_t$ entailing $L_t=N$ (full employment), or $L_t<N$ entailing $W_t=(\eta-1)G_t$. In the presence of unemployment ($L_t<N$), one may think that the workers to be employed are selected at random.

The government

The government provides the same transfers and/or welfare entitlements to all workers and must balance its budget in each period. Hence,

$$NG_t=\tau_t Y_t. \tag{7}$$

4 DETERMINATION OF THE TAX RATES

Labor-market equilibrium

Capitalists' optimality condition with respect to the choice of the labor input is

$$(1-\tau_t)\alpha A_t L_t^{\alpha-1} K_t^{1-\alpha} = W_t, \tag{8}$$

thus implying that labor demand is:

$$L_t = K_t\left[\frac{(1-\tau_t)\alpha A_t}{W_t}\right]^{1/(1-\alpha)}. \tag{9}$$

As the tax rate exceeds the threshold $\bar{\tau}=\dfrac{\alpha}{\alpha+\eta-1}$ there is unemployment,[6] and the equilibrium level of employment decreases with τ_t. Indeed, equilibrium in the labor market implies

$$L_t = L(\tau_t) = \begin{cases} \dfrac{(1-\tau_t)\alpha N}{\tau_t(\eta-1)} & \text{if } \tau_t > \bar{\tau} \\ N & \text{otherwise,} \end{cases} \tag{10}$$

where the employment level decreases monotonically with τ_t whenever $\tau_t > \bar{\tau}$.

[6] It is not surprising that the threshold $\bar{\tau}$ decreases with η, namely with the utility that workers can enjoy by undertaking some non-market activity.

Considering (8) and (10), the equilibrium real wage is

$$W_t = (1 - \tau_t)\alpha A_t \left[L(\tau_t)\right]^{\alpha-1} K_t^{1-\alpha}. \tag{11}$$

Capital accumulation along an equilibrium path

By solving the intertemporal problem of the representative capitalist (see the Appendix), one obtains the difference equation governing the equilibrium motion of the capital stock for given trajectory of τ_t:

$$K_{t+1} = \theta(1-\alpha)K_t(1-\tau_t)[L(\tau_t)]^{\alpha}, \tag{12}$$

from which one can verify that the growth rate of K_t is monotonically decreasing in the tax rate:

$$\mu_t = \mu(\tau_t) = \theta(1-\alpha)(1-\tau_t)[L(\tau_t)]^{\alpha} - 1,\ \mu_t \equiv \frac{K_{t+1} - K_t}{K_t}. \tag{13}$$

Note also that along a balanced growth path (where by definition $\tau_t=\tau$) the economy's rate of growth is monotonically decreasing in τ:

$$\rho = \rho(\tau) = \theta(1-\alpha)(1-\tau)[L(\tau)]^{\alpha} - 1,\ \rho_t \equiv \frac{Y_{t+1} - Y_t}{Y_t}. \tag{14}$$

Capitalists' optimal tax rate

Suppose that the tax rates were set caring only about the capitalists' interests ("plutocracy", see Hassler et al., 2003), namely suppose that the government decides in t on the fiscal transfers by solving

$$\underset{\{\tau_s\}_{s=t}^{\infty}}{\mathrm{Max}} \sum_{s=t}^{\infty} \theta^{s-t} \ln\left\{(1-\theta)(1-\alpha)K_s(1-\tau_s)[L(\tau_s)]^{\alpha}\right\} \qquad \text{subject to } 0\le\tau_s\le 1 \text{ and to (12), } K_t \text{ given.} \tag{15}$$

It is trivial that the capitalists' optimal sequence of tax rates $\left\{\tau_s^C{}_s\right\}_{s=t}^{\infty}$ is such that

$$\tau_s^C = \tau^C = 0 \ \ \forall s. \tag{16}$$

The capitalists would prefer that the welfare entitlements and the government transfers in favor of the workers will be suppressed, so as to avoid the tax burden financing the public outlays and the upward pressure on the wage due to the non-labor income enjoyed by the workers.

Workers' optimal tax rate

In contrast, it is not generally the case that rational workers prefer to suppress any redistributive public intervention. Indeed, they may face a trade-off between taking possession of a larger share of national product thanks to increases in the redistributive tax and benefiting from a more rapid capital accumulation thanks to a lower tax. The possible existence of this trade-off can be verified by solving the problem of a social planner caring only about the workers' well-being ("dictatorship of the proletariat", see Hassler et al., 2003):

$$\underset{\{\tau_s\}_{s=t}^{\infty}}{\mathrm{Max}} \sum_{s=t}^{\infty} \xi^{s-t} u(.) \text{ subject to } 0 \leq \tau_s \leq 1 \text{ and to (12), } K_t \text{ given, } 0<\xi<1, \tag{17}$$

where ξ is the workers' time-preference parameter and

$$u(.) = \begin{cases} \ln\left\{K_s N^{\alpha-1}[\alpha(1-\tau_s)+\tau_s]\right\} \text{ if } \tau_s \leq \bar{\tau} \\ \ln\left\{\eta \tau_s K_s N^{\alpha-1}\left[\dfrac{(1-\tau_s)\alpha}{\tau_s(\eta-1)}\right]^{\alpha}\right\} \text{ otherwise.} \end{cases} \tag{18}$$

The workers' optimal sequence of tax rates $\left\{\tau_s^W{}_s\right\}_{s=t}^{\infty}$ is such that (see the Appendix for the derivation)

$$\tau_s^W = \tau^W = \begin{cases} 1-\alpha-\xi \text{ if } \bar{\tau} < 1-\alpha-\xi \\ \bar{\tau} \text{ if } 1-\alpha-\xi \leq \bar{\tau} \leq \dfrac{1-\alpha-\xi}{(1-\alpha)} \\ \dfrac{1-\alpha-\xi}{(1-\alpha)} \text{ if } 0 < \dfrac{1-\alpha-\xi}{(1-\alpha)} < \bar{\tau} \\ 0 \text{ if } 0 \geq 1-\alpha-\xi, \end{cases} \tag{19}$$

where one has persistent unemployment if $1-\alpha-\xi > \bar{\tau}$.[7] Note that (19) is both the time consistent and the open-loop solution to (17): it solves the workers' problem no matters whether they have or have not the possibility to credibly commit themselves to following a pre-announced tax policy.[8]

Therefore, the following proposition holds:

Proposition 1 (i) It can be perfectly rational (whenever 1-α-ξ>0) for the workers' to oppose any reform of the welfare state imposing in the present and/or in the future a reduction of the share of national product that is redistributed to them below a certain critical threshold (1-α-ξ), although this reduction (if permanent)

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[7] Notice that having assumed full capital depreciation (δ=1), a plausible calibration of the other parameter values should require the assignment of a relatively low value to the time-preference parameters θ and ξ.

[8] This is due to the absence in this set-up of the influence that future tax policy may have on current investors' behavior via anticipation effects (see Lansing, 1999).

boosts long-run growth, and (ii) there exists a conflict (whenever $1-\alpha-\xi>0$) between capitalists and workers over the determination of the size of the welfare state (and the tax rate necessary to finance it).

Proof. Given that (19) solves (17), it is trivial that any reduction of τ_s below τ^W brings about a fall in the lifetime utility of the representative dynasty of workers. Moreover, by considering (14) it is apparent that any $\tau<\tau^W$ entails $\rho(\tau)>\rho(\tau^W)$. Hence, (i) is demonstrated. Finally, by comparing (16) and (19) it is straightforward that whenever $1-\alpha-\xi>0$ one has $\tau^C<\tau^W$, thus demonstrating (ii).

Authority's optimal tax rate

Let us assume next that the government decides on the fiscal policy by maximizing a welfare function that takes into account the well-being of both the capitalists and the workers. In other words, let the government decide in t on the fiscal transfers by solving

$$\underset{\{\tau_s\}_{s=t}^{\infty}}{\text{Max}} \sum_{s=t}^{\infty} \xi^{s-t} \left\{ \ln\left\{ (1-\xi)(1-\alpha)K_s(1-\tau_s)[L(\tau_s)]^{\alpha} \right\} + \phi u(.) \right\} \text{ subject to } 0\le\tau_s\le 1 \text{ and to (12), } \phi>0,\ K_t \text{ given,} \quad (20)$$

where for simplicity we assume $\xi=\theta$ and where $u(.)$ is given by (18). The parameter ϕ measures the weight that the workers have on the political decision process vis-à-vis the capitalists. In the special case in which ϕ=N, the government maximizes an utilitarian welfare function which is the sum of individual utilities. This special case captures the idea that in a democratic society the influence exerted by each social group on public choices tends to reflect its relative size, so that the weight that the fiscal authority assigns in its welfare criterion to the utility of the representative member of each group is equal to the number of individuals belonging to that group.

The authority's optimal sequence of tax rates $\left\{\tau_s^A\right\}_{s=t}^{\infty}$ is such that (see the Appendix for the derivation)

$$\tau_s^A = \tau^A = \begin{cases} \dfrac{(1-\alpha-\xi)\phi-\alpha}{\phi+1} \text{ if } \bar{\tau} < \dfrac{(1-\alpha-\xi)\phi-\alpha}{\phi+1} \\ \bar{\tau} \text{ if } \dfrac{(1-\alpha-\xi)\phi-\alpha}{\phi+1} \le \bar{\tau} \le \dfrac{(1-\alpha-\xi)\phi-\alpha}{(\phi+1)(1-\alpha)} \\ \dfrac{(1-\alpha-\xi)\phi-\alpha}{(\phi+1)(1-\alpha)} \text{ if } 0 < \dfrac{(1-\alpha-\xi)\phi-\alpha}{(\phi+1)(1-\alpha)} < \bar{\tau} \\ 0 \text{ if } 0 \ge (1-\alpha-\xi)\phi-\alpha, \end{cases} \quad (21)$$

[9]

[9] Notice that having assumed full capital depreciation ($\delta=1$), a plausible calibration of the other parameter values should

where one has persistent unemployment if $\bar{\tau} < \dfrac{(1-\alpha-\xi)\phi-\alpha}{\phi+1}$. Again, (21) is both the time-consistent and the open-loop solution to (20).[10]

Therefore, the following propositions hold:

Proposition 2 When the workers gain more influence on the political process (ϕ becomes larger), (i) persistent unemployment may be created (if $\dfrac{(1-\alpha-\xi)\phi-\alpha}{\phi+1}$ goes beyond the threshold $\bar{\tau}$ as a consequence of the increase in ϕ) or exacerbated (if $\dfrac{(1-\alpha-\xi)\phi-\alpha}{\phi+1}$ was already beyond $\bar{\tau}$), and (ii) the equilibrium rate of growth may be depressed (if $(1-\alpha-\xi)\phi-\alpha>0$).

Proof. Considering (10), (21) and the fact that $\dfrac{(1-\alpha-\xi)\phi-\alpha}{\phi+1}$ increases with ϕ, it is apparent that (i) and (ii) are true.

Proposition 3 The "survival of the welfare state", namely the persistence of fiscal policies lowering long-run growth and creating unemployment, does not reflect any "institutional failure", i.e. it is not due to the policy makers' impossibility to credibly commit themselves to following pre-announced policies.

Proof. The fact that (21) is both the time-consistent and the open-loop solution to (20) rules out the possibility that the emergence and the persistence of tax rates and government transfers lowering long-run growth and the employment level can be due to the lack of an appropriate commitment technology.

If in a democratic society the political influence of a social group depends on its relative size, proposition 2 implies that unemployment may tend to increase as firms' ownership is concentrated in the hands of a smaller fraction of total population. In its turn, proposition 3 can be interpreted by arguing that in a capitalistic economy the negative effects of the distributive conflict on long-run growth can be hardly eliminated by designing more efficient institutions.

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require the assignment of a relatively low value to the time-preference parameters θ and ξ.

[10] See footnote 8.

5 CONCLUSION

In the simplified formal treatment proposed in this paper, a decrease in a policy parameter—the ratio of total tax revenues to GDP—can monotonically increase long-term growth rate and may lead to a higher employment level. This notwithstanding, the paper shows that the redistributive implications of such a decrease may induce the wage earners to oppose it. As a consequence, policy makers reflecting social preferences may undertake these redistributive transfers even if commitment technologies allowing them to follow pre-announced tax policies were feasible. Persistent unemployment and low growth may be the outcome of this politico-economic process.

APPENDIX

Optimal capital accumulation

One can derive the optimal accumulation rule of the representative capitalist by backward induction. Supposing that there is a final period T. It is straightforward that in T the representative capitalist would set $K_{T+1}=0$. Hence, the problem to be solved in T-1 by each capitalist is the following:

$$\max_{K_T} \ln\left[(1-\alpha)K_{T-1}\left[(1-\tau_{T-1})A_{T-1}\left(\frac{\alpha}{W_{T-1}}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}} - K_T\right] + \theta\ln\left[(1-\alpha)K_T\left[(1-\tau_T)A_T\left(\frac{\alpha}{W_T}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}}\right],$$

for exogenously given paths of τ_t, A_t and W_t, K_{T-1} given. The necessary (and sufficient) condition for a maximum is:

$$-\left[(1-\alpha)K_{T-1}\left[(1-\tau_{T-1})A_{T-1}\left(\frac{\alpha}{W_{T-1}}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}} - K_T\right]^{-1} + \theta K_T^{-1} = 0,$$

from which one can obtain the optimal decision rule:

$$K_T = \frac{\theta(1-\alpha)K_{T-1}\left[(1-\tau_{T-1})A_{T-1}\left(\frac{\alpha}{W_{T-1}}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}}}{(1+\theta)}. \qquad \text{(A1)}$$

Given (A1), the problem to be solved in T-2 by the representative capitalist is:

$$\underset{K_{T-1}}{\mathrm{Max}} \ln\left[(1-\alpha)K_{T-2}\left[(1-\tau_{T-2})A_{T-2}\left(\frac{\alpha}{W_{T-2}}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}} - K_{T-1}\right] + \theta\ln\left[\frac{(1-\alpha)K_{T-1}}{1+\theta}\left[(1-\tau_{T-1})A_{T-1}\left(\frac{\alpha}{W_{T-1}}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}}\right] +$$

$$+\theta^2\ln\left[\frac{\theta(1-\alpha)K_{T-1}}{1+\theta}\left[(1-\tau_{T-1})A_{T-1}\left(\frac{\alpha}{W_{T-1}}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}}\right] + \theta^2\ln\left[(1-\alpha)\left[(1-\tau_T)A_T\left(\frac{\alpha}{W_T}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}}\right]$$

for exogenously given paths of τ_t, A_t and W_t, K_{T-2} given. The necessary (and sufficient) condition for a maximum is:

$$-\left[(1-\alpha)K_{T-2}\left[(1-\tau_{T-2})A_{T-2}\left(\frac{\alpha}{W_{T-2}}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}} - K_{T-1}\right]^{-1} + (\theta+\theta^2)K_{T-1}^{-1} = 0,$$

from which one can obtain the optimal decision rule:

$$K_{T-1} = \frac{(\theta+\theta^2)(1-\alpha)K_{T-2}\left[(1-\tau_{T-2})A_{T-2}\left(\frac{\alpha}{W_{T-2}}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}}}{(1+\theta+\theta^2)}. \tag{A2}$$

Iterating this procedure j-times and letting $T \to \infty$ and $j \to \infty$, one obtains the optimal (time-invariant) rule:

$$K_{t+1} = \theta(1-\alpha)K_t\left[(1-\tau_t)A_t\left(\frac{\alpha}{W_t}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}}. \tag{A3}$$

By considering (11) and the fact that $A_t = K_t^{\alpha}$, (A3) gives the equilibrium law of motion (12). Furthermore, it is apparent by inspecting (A3) that current capitalists' decisions do not depend on future tax rates.

Optimal tax policies

Given (12), one can solve the problem of the fiscal authority by maximizing

$$\sum_{s=t}^{\infty}\xi^{s-t}\left\{\psi\ln\left[(1-\xi)(1-\alpha)K_s(1-\tau_s)[L(\tau_s)]^{\alpha}\right] + \phi u(.) + \lambda_s\left[\xi(1-\alpha)K_s(1-\tau_s)[L(\tau_s)]^{\alpha} - K_{s+1}\right]\right\} \tag{A4}$$

with respect to τ_t, K_{t+1} and the Lagrange multiplier λ_t, where $0 \le \tau_s \le 1$, and ψ is a dummy variable such that $\psi=0$ under the "dictatorship of the proletariat" and $\psi=1$ when the fiscal authority cares about both the capitalists and the workers.

For an interior solution to (A4) consistent with full employment, the following conditions must be satisfied:

$$\frac{(1-\alpha)\phi}{\alpha+(1-\alpha)\tau_t} - \frac{\psi}{(1-\tau_t)} - Z_t\xi(1-\alpha)[L(\tau_t)]^{\alpha} = 0,\ Z_t \equiv \lambda_t K_t, \tag{A5a}$$

$$\frac{\xi(\phi+\psi)}{\alpha+(1-\alpha)\tau_t}+Z_{t+1}(1-\tau_{t+1})\xi^2(1-\alpha)[L(\tau_{t+1})]^{\alpha}-Z_t(1+\mu_t)=0,\ \mu_t\equiv\frac{K_{t+1}-K_t}{K_t}, \tag{A5b}$$

$$(1-\tau_t)\xi(1-\alpha)[L(\tau_t)]^{\alpha}-(1+\mu_t)=0, \tag{A5c}$$

where $L(\tau_t)=L(\tau_{t+1})=N$. An optimal path must also satisfy the transversality condition

$$\lim_{s\to\infty}\xi^s Z_s=0. \tag{A6}$$

From the system (A5) one can derive the difference equation in τ_t that an interior solution to (A4) consistent with full employment must satisfy:

$$f(\tau_t,\tau_{t+1})=\xi\phi+\psi+\frac{(1-\alpha)\xi\phi(1-\tau_{t+1})}{\alpha+(1-\alpha)\tau_{t+1}}-\frac{(1-\alpha)\phi(1-\tau_t)}{\alpha+(1-\alpha)\tau_t}=0,\ 0\le\tau_t\le\bar{\tau}\ \ \forall t. \tag{A7}$$

Along a balanced growth path, one must have $\tau_{t+1}=\tau_t=\tau$ in equation (A7). By linearizing (A7) around τ, one can check that $-\left.\frac{\partial f(.)/\partial\tau_t}{\partial f(.)/\partial\tau_{t+1}}\right|_{\tau_{t+1}=\tau_t=\tau}=\frac{1}{\xi}>1$: the only path in a neighborhood of τ consistent with $\lim_{t\to\infty}\tau_t=\tau$ must be characterized by

$$\tau_t=\tau=\frac{\phi(1-\alpha-\xi)-\alpha\psi}{(1-\alpha)(\phi+\psi)}\ge 0\ \ \forall t. \tag{A8}$$

It is easy to verify that only this path can be an equilibrium trajectory in a neighborhood of $\tau=\frac{\phi(1-\alpha-\xi)-\alpha\psi}{(1-\alpha)(\phi+\psi)}$.

For an interior solution to (A4) with unemployment, one must satisfy conditions (A5b), (A5c) and

$$\frac{\phi-\alpha(\phi+\psi)}{\tau_t}-\frac{[\psi+\alpha(\phi+\psi)]}{(1-\tau_t)}-Z_t\xi(1-\alpha)[L(\tau_t)]^{\alpha}\left[\frac{\alpha+\tau_t}{\tau_t}\right]=0, \tag{A9}$$

where now $L(\tau_t)=\frac{(1-\tau_t)\alpha N}{\tau_t(\eta-1)}<N$. Again, an optimal path must also satisfy (A6).

From the system consisting of (A5b), (A5c) and (A9) one can derive the difference equation in τ_t that an interior solution to (A4) consistent with the presence of unemployment must satisfy:

$$g(\tau_t,\tau_{t+1})=(\phi+\psi)+\frac{\xi\phi}{\alpha+\tau_{t+1}}-\frac{\phi}{\alpha+\tau_t}=0,\ \bar{\tau}<\tau_t\le 1\ \ \forall t. \tag{A10}$$

Along a balanced growth path with unemployment one must have $\tau_{t+1}=\tau_t=\tau$ in equation (A10). By linearizing (A10) around τ, one can check that $- \left. \frac{\partial g(.)/\partial \tau_t}{\partial g(.)/\partial \tau_{t+1}} \right|_{\tau_{t+1} = \tau_t = \tau} = \frac{1}{\xi} > 1$: again, the only path in a neighborhood of τ consistent with $\lim_{t\to\infty} \tau_t = \tau$ must be characterized by

$$\tau_t = \tau = \frac{\phi(1-\alpha-\xi)-\alpha\psi}{(\phi+\psi)} > \bar{\tau} \quad \forall t. \tag{A11}$$

It is easy to verify that only this path can be an equilibrium trajectory in a neighborhood of $\tau = \frac{\phi(1-\alpha-\xi)-\alpha\psi}{(\phi+\psi)}$.

Given (A8) and (A11), the time-invariant policy rule is the following:

$$\tau_t = \tau = \begin{cases} \frac{\phi(1-\alpha-\xi)-\alpha\psi}{\phi+\psi} \text{ if } \bar{\tau} < \frac{\phi(1-\alpha-\xi)-\alpha\psi}{\phi+\psi} \\ \bar{\tau} \text{ if } \frac{\phi(1-\alpha-\xi)-\alpha\psi}{\phi+\psi} \le \bar{\tau} \le \frac{\phi(1-\alpha-\xi)-\alpha\psi}{(\phi+\psi)(1-\alpha)} \\ \frac{\phi(1-\alpha-\xi)-\alpha\psi}{(\phi+\psi)(1-\alpha)} \text{ if } 0 < \frac{\phi(1-\alpha-\xi)-\alpha\psi}{(\phi+\psi)(1-\alpha)} < \bar{\tau} \\ 0 \text{ if } 0 \ge (1-\alpha-\xi)\phi - \alpha\psi. \end{cases} \tag{A12}$$

An alternative derivation of the optimal tax policies

One can also derive the optimal tax rates as the (subgame-perfect) equilibrium policies of the fiscal authority in the game that it plays with the capitalists. Suppose again that there is a final period T. We already mentioned that in T the capitalists would set $K_{T+1}=0$. Therefore, the problem to be solved in T by the authority is the following:

$$\max_{\tau_T} \psi \ln\left\{(1-\alpha)K_T(1-\tau_T)[L(\tau_T)]^{\alpha}\right\} + \phi u(.) \qquad \text{subject to } 0\le\tau_T\le 1,\ K_T \text{ given.} \tag{A13}$$

For an interior solution to (A13) consistent with full employment, the following condition must be satisfied:

$$\frac{(1-\alpha)\phi}{\alpha+(1-\alpha)\tau_T} - \frac{\psi}{(1-\tau_T)} = 0,\ 0 \le \tau_T \le \bar{\tau}. \tag{A14a}$$

Similarly, for an interior solution to (A13) consistent with the presence of unemployment, the following condition must be satisfied:

$$\frac{(1-\alpha)\phi}{\tau_T} - \frac{\alpha\phi}{(1-\tau_T)} - \frac{\psi(1+\alpha)}{(1-\tau_T)} - \frac{\psi\alpha}{\tau_T} = 0,\ \bar{\tau} < \tau_T \le 1, \tag{A14b}$$

Given (A14), one can compute the optimal tax rate in T:

$$\tau_T = \begin{cases} \dfrac{(1-\alpha)\phi - \alpha\psi}{\phi+\psi} \ \text{if } \bar{\tau} < \dfrac{(1-\alpha)\phi - \alpha\psi}{\phi+\psi} \\ \bar{\tau} \ \text{if } \dfrac{(1-\alpha)\phi - \alpha\psi}{\phi+\psi} \leq \bar{\tau} \leq \dfrac{(1-\alpha)\phi - \alpha\psi}{(\phi+\psi)(1-\alpha)} \\ \dfrac{(1-\alpha)\phi - \alpha\psi}{(\phi+\psi)(1-\alpha)} \ \text{if } \ 0 < \dfrac{(1-\alpha)\phi - \alpha\psi}{(\phi+\psi)(1-\alpha)} < \bar{\tau} \\ 0 \ \text{if } 0 \geq (1-\alpha)\phi - \alpha\psi. \end{cases} \tag{A15}$$

Given (A15) and the capitalists' decision rule (A1), the problem to be solved in T-1 by the authority is the following:

$$\underset{\tau_{T-1}}{\text{Max}}\, \psi \ln\left\{\frac{(1-\alpha)K_{T-1}(1-\tau_{T-1})[L(\tau_{T-1})]^{\alpha}}{1+\xi}\right\} + \phi u(.) + \xi(\psi+\phi)\ln\left\{\xi(1-\alpha)K_{T-1}(1-\tau_{T-1})[L(\tau_{T-1})]^{\alpha}\right\} + D \ \text{subject to}$$

$$0 \leq \tau_{T-1} \leq 1,\ K_{T-1} \text{ given,} \tag{A16}$$

where D is a constant whose value depends on the parameters.

For an interior solution to (A16) consistent with full employment, the following condition must be satisfied:

$$\frac{(1-\alpha)\phi}{\alpha + (1-\alpha)\tau_{T-1}} - \frac{[\psi + \xi(\psi+\phi)]}{(1-\tau_{T-1})} = 0,\ \ 0 \leq \tau_{T-1} \leq \bar{\tau}. \tag{A17a}$$

Similarly, for an interior solution to (A16) consistent with the presence of unemployment, the following condition must be satisfied:

$$\frac{(1-\alpha)\phi}{\tau_{T-1}} - \frac{\alpha\phi}{(1-\tau_{T-1})} - \frac{[\psi(1+\alpha) + \xi(\psi+\phi)]}{(1-\tau_{T-1})} - \frac{[\psi\alpha + \xi(\psi+\phi)]}{\tau_{T-1}} = 0,\ \ \bar{\tau} < \tau_{T-1} \leq 1. \tag{A17b}$$

Given (A17), one can compute the optimal tax rate in T-1:

$$\tau_{T-1} = \begin{cases} \dfrac{(1-\alpha)\phi - \alpha[\psi + \xi(\phi+\psi)]}{(\phi+\psi)(1+\xi)} \ \text{if } \bar{\tau} < \dfrac{(1-\alpha)\phi - \alpha[\psi + \xi(\phi+\psi)]}{(\phi+\psi)(1+\xi)} \\ \bar{\tau} \ \text{if } \dfrac{(1-\alpha)\phi - \alpha[\psi + \xi(\phi+\psi)]}{(\phi+\psi)(1+\xi)} \leq \bar{\tau} \leq \dfrac{(1-\alpha)\phi - \alpha[\psi + \xi(\phi+\psi)]}{(\phi+\psi)(1-\alpha)(1+\xi)} \\ \dfrac{(1-\alpha)\phi - \alpha[\psi + \xi(\phi+\psi)]}{(\phi+\psi)(1-\alpha)(1+\xi)} \ \text{if } \ 0 < \dfrac{(1-\alpha)\phi - \alpha[\psi + \xi(\phi+\psi)]}{(\phi+\psi)(1-\alpha)(1+\xi)} < \bar{\tau} \\ 0 \ \text{if } 0 \geq (1-\alpha)\phi - \alpha[\psi + \xi(\phi+\psi)]. \end{cases} \tag{A18}$$

Iterating this procedure j-times and letting $T \to \infty$ and $j \to \infty$, one still obtains the (time-invariant) policy rule (A12).

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