Employment and Wage Formation in a Growth Model with Public Capital*

Xavier Raurich
Universitat de Girona

Valeri Sorolla†
Universitat Autònoma de Barcelona

Abstract

We develop an endogenous growth model with a non-competitive labor market characterized by a monopoly union in order to study the relation between growth and employment. We show that if there is wage inertia, economic growth positively affects employment in the long run. We also use the model to analyze the effects on employment and growth of increasing public capital.

Keywords: Employment, endogenous growth, wage formation, public capital.

JEL number: E24, O41.

*We thank Jordi Caballé for helpful discussions. Raurich is grateful to Universitat de Girona for financial support through grant UdG 9101100. Sorolla is grateful for financial support to Spanish Ministry of Education through DGICYT grant SEC2000-0684 and to Generalitat de Catalunya through grant SGR2001-164.

†Correspondence Address: Valeri Sorolla, Universitat Autònoma de Barcelona, Departament d'Economia i d'Història Ecnòmica, Edifici B, 08193 Bellaterra (Barcelona), Spain. Phone: (34)-935812728. e-mail: valeri.sorolla@uab.es

1. Introduction

In this paper we study the relation between growth and employment. While existing literature postulates a negative relationship between these two variables in the short-run, only some papers in the economic growth literature have analyzed this relationship in the long-run. Among others, Pissarides (1990), using a matching model of the labor market, finds a positive effect of growth on employment via the capitalization effect[1]. Aghion and Howitt (1994) adds to this positive effect a negative one due to the creative destruction effect of growth. As the main result of the paper, we present an alternative explanation for a long run positive effect of growth on employment based on real wage inertia, that is, when the real wage set in one period depends on previous wages. This positive effect occurs because, due to the wage inertia, the increases in productivity, which are associated to economic growth, do not fully translate into wage increases that prevent employment growth.[2]

Blanchard and Wolfers (2000) argue that wage inertia explains that a decline in economic growth results in a temporary reduction in the employment rate, as delays in wage adjustment makes wages grow in excess of productivity growth for some time. In contrast, in this paper, we show that in a growth model with wage inertia a decline in the growth rate reduces the employment rate permanently. This main result of the paper does not seem to be inconsistent with the data, because empirical evidence shows that there is wage inertia in the wage setting process (see Blanchard and Katz (1997) and (1999)) and also shows that there is a positive relation between economic growth and employment in the long run (see Daveri and Tabellini (2000)).

In this paper, wage inertia is obtained in a labor market characterized by a monopoly union that sets the wage as a mark-up over a reservation wage, that depends on past wages and the unemployment benefit. To close the economy, we consider a simple overlapping generations model (OLG, henceforth) that explains capital accumulation and growth.

We also use the model to analyze how public capital affects growth and employment. To this end, we assume that the technology depends on public capital,

[1] "an increase in growth raises the rate at which the returns for creating a plant (or a firm) will grow and hence increases the capitalized value of those returns, thereby encouraging more entry by new plants and therefore more job creation"(Aghion and Howitt (1998) pp. 127).

[2] Bean and Pissarides (1993), Eriksson (1997) and Daveri and Tabellini (2000) present models that analyze the influence of different exogenous variables on growth and unemployment. Nevertheless, none of these models includes wage inertia.

so that economic growth increases with public capital as shown by the data (see Aschauer (1989), among many others). Recent empirical evidence has also shown that employment increases with public capital (see Pereira and Roca-Sagales (1999) and Demetriades and Mamuneas (2000)). In the model developed in this paper, increases in public capital enhance growth, which positively affects employment when there is wage inertia.[3] More precisely, when the wage depends on both past wages and the unemployment benefit, the employment rate converges to a long-run steady state, which increases with public capital. In contrast, when the wage only depends on past wages, the employment rate grows at a constant rate until full-employment is achieved. In this case, increasing public capital enhances employment growth during the transition to full-employment. Finally, when the wage only depends on the unemployment benefit and, thus, there is no wage inertia, the employment rate is constant and does not depend on public capital. Summarizing, in this model public capital increases growth and the effects on employment depend on the assumptions made on the wage formation process.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 defines the equilibrium and shows how the properties of the equilibrium depend on the wage formation process. Also in this section, we compare the effects on growth and employment of increasing public capital when different modes of government financing are considered. Section 4 concludes.

2. The Economy

In this section we develop a simple endogenous growth model with a non-competitive labor market, that allows us to illustrate how the effects of growth on employment depend on the assumptions made on the wage formation process. We first describe the technology and the labor market. Next, we characterize the consumers' behavior and we close the section with a description of the government budget constraint.

Firms produce the only good of the economy using the following production function introduced by Barro (1990):

$$Y_t = AK_t^{\alpha} L_t^{1-\alpha} g_t^{1-\alpha}, \ \alpha \in (0,1) \,,$$

[3] Raurich and Sorolla (2003) present a model where public capital may increase employment in the long run when the elasticity of the labor demand with respect to wages increases with public capital. In contrast, in this paper, this elasticity is constant and public capital positively affects employment when there is wage inertia.

where Y_t is aggregate output, K_t is the aggregate stock of capital, L_t is the labor force, and g_t measures the services derived from the stock of public capital in the economy. Profit maximization implies that factor prices are equated to marginal productivities so that the interest rate is:

$$r_t = \frac{\partial Y_t}{\partial K_t},$$

and the wage is

$$w_t = \frac{\partial Y_t}{\partial L_t}. \tag{2.1}$$

Equation (2.1) characterizes the labor demand.

Following many others, we assume that the unions' preferences are characterized by the following Stone-Geary utility function:

$$V(w_t) = ((1-\tau_w)(1-\tau)w_t - w_t^r)^\gamma L_t, \ \gamma \in (0,1).$$

Thus, unions' utility depends on both employment and the difference between the wage net of taxes and a reservation wage, w_t^r (see de la Croix et al. (1996)). The parameter γ is a measure of the concavity of the utility function with respect to the difference between the wage and the reservation wage, τ_w is a tax on the wage that employed workers pay to finance the unemployment benefit and τ is an income tax. Unions choose a wage that maximizes the utility function taking into account that the labor demand depends on the wage (union's monopoly model). The solution of the program is

$$w_t = \frac{w_t^r}{(1-\tau_w)(1-\tau)(1-\gamma\alpha)},$$

where $-\frac{1}{\alpha}$ is the elasticity of the labor demand with respect to the wage, which is constant.

Following de la Croix et al. (1996), we assume that the reservation wage is a weighted average of the unemployment benefit and of the wage in the previous period[4]

$$w_t^r = \phi d_t + (1-\phi)(1-\tau_w)(1-\tau)w_{t-1},$$

[4] We could also interpret w_t^r as an aspiration wage. In this case the weights associated to the previous wage and the unemployment benefit would be positive constants that could be larger than one. As noted by Blanchard and Katz (1997), the reservation wage is not observable and as they say "models based on fairness suggest that the reservation wage may depend on factors such as the level and the rate of growth of wages in the past, if workers have come to consider that wage increase as fair. Perhaps a better word than reservation wage in that context is aspiration wage" (see pp. 54).

where d_t is the unemployment benefit net of taxes and $\phi \in [0,1]$ provides a measure of the intensity of past wages in the wage formation process. It follows that the wage equation is

$$w_t = \frac{\phi d_t + (1-\phi)(1-\tau_w)(1-\tau) w_{t-1}}{(1-\tau_w)(1-\tau)(1-\gamma\alpha)}. \tag{2.2}$$

The previous wage equation shows the existence of wage inertia provided $\phi < 1$. Wage inertia could also be derived in an efficient wage model where workers' disutility depends on the comparison between current and past wages (see Collard et al. (2000) and de la Croix et al. (2000)). Therefore, the assumption that drives equation (2.2) is not the wage setting under unionism but that agents' utility depends on the comparison between present and past wages. Finally, note that the labor demand, (2.1), and the wage equation, (2.2), describe the labor market.

On the consumers' side, we consider a standard overlapping generations model (OLG, henceforth). We assume that each consumer lives for two periods. In the first period, consumers inelastically supply one unit of labor, consume, and save. In the second period, they consume the income generated by the savings accumulated during the first period. Moreover, we assume that in each period t, there are N_t consumers in their first period of life, and that population grows at a constant growth rate, $n \geq -1$. For simplicity, we assume that consumers' utility function is homothetic so that the savings function is a constant fraction of income, i.e., $s_t = sI_t$ where $s \in (0,1)$, and $I_t = (1-\tau_w)(1-\tau) w_t$ when the consumer is employed and $I_t = d_t$ when the consumer is unemployed.[5] Because each agent inelastically supplies one unit of labor in the first period, the aggregate labor supply is equal to N_t, and aggregate savings are equal to

$$S_t = s\left(L_t(1-\tau_w)(1-\tau) w_t + (N_t - L_t) d_t\right),$$

where $N_t - L_t$ are the unemployed workers that receive the unemployment benefit.

The government collects taxes in order to finance both the unemployment benefit and a public input. More precisely, the unemployment benefit, as we said, is financed by means of taxes on the wage payed by workers[6], i.e.

$$(N_t - L_t) d_t = \tau_w w_t L_t, \tag{2.3}$$

[5] Assume that the utility function is $\ln c_t^1 + \beta \ln c_t^2$, where c_t^1 and c_{t+1}^2 are consumption in the first and in the second period, respectively. Then, the fraction of income devoted to saving is $s = \frac{\beta}{1+\beta} \in (0,1)$.

[6] De la Croix et al. (1996) assumes that the unemployment benefit is financed by means of taxes on the labor income payed by both workers and firms. For simplicity, we assume that only workers pay taxes to finance the unemployment benefit.

and government revenues, R_t, are equal to

$$R_t = \tau_k r_t K_t + (1 - \tau_w)\,\tau w_t L_t,$$

where τ_k is the tax on the capital income. We also assume that the government devotes a fraction v of the production to the public input and that the services derived from the public input are congested by the number of workers in the economy.[7] This implies that the services derived from the public input are

$$g_t = \frac{vY_t}{L_t}. \tag{2.4}$$

Furthermore, we assume that the government budget constraint is balanced in each period, i.e.

$$vY_t = R_t. \tag{2.5}$$

3. The Equilibrium

In this section, we derive the equations that characterize the equilibrium of this economy. To this end, we first derive the equilibrium production function and the equilibrium government budget constraint.

Substituting (2.4) into the production function and solving for g_t, we obtain

$$g_t = (vA)^{\frac{1}{\alpha}} \left(\frac{K_t}{L_t}\right).$$

Plugging the previous expression into the production function, we derive the production function in equilibrium

$$Y_t = BK_t, \tag{3.1}$$

where $B = A\,(vA)^{\frac{1-\alpha}{\alpha}}$ measures total factor productivity. Next, combining (2.1) and (2.5), we derive the equilibrium government budget constraint

$$v = \alpha\tau_k + (1-\alpha)\,\tau\,(1-\tau_w)\,. \tag{3.2}$$

In equilibrium, the savings accumulated by the consumers are the next period stock of capital, i.e., $K_{t+1} = S_t$. Using the aggregate savings function and (2.3), we get

[7] The introduction of a congestion effect avoids scale effects which are not empirically supported.

$$K_{t+1} = s\left(\left(1-\tau_w\right)\left(1-\tau\right)+\tau_w\right) w_t L_t.$$

Combining (2.1) with (3.1), we obtain the growth rate of capital

$$\frac{K_{t+1}}{K_t} = s\left(1-\alpha\right) B\left(1-\tau\left(1-\tau_w\right)\right), \tag{3.3}$$

which coincides with the rate of growth of output as follows from (3.1). Let us denote the economic growth rate by G. Note that the economic growth rate increases with the fraction of production devoted to public capital, v. Thus, public capital increases economic growth.

We proceed to obtain the equilibrium rate of employment. First, we use (2.1) and (3.1) to derive the labor demand

$$w_t = \left(1-\alpha\right) B\left(\frac{K_t}{L_t}\right).$$

Using the previous equation and (3.3), we obtain

$$\frac{w_t L_t}{w_{t-1} L_{t-1}} = G. \tag{3.4}$$

Equation (3.4), derived from the labor demand, implies that the aggregate labor income grows at a constant growth rate which coincides with the economic growth rate. The reason is that in equilibrium the aggregate labor income is a constant fraction of production and, thus, it grows with production. The increase in the aggregate labor income may imply either larger wages or larger employment. We will show that if there is no wage inertia then an increase in economic growth fully translates into wage growth and there is no increase in the employment rate. Therefore, only when there is wage inertia, economic growth causes employment growth.

Next, we combine the wage equation, (2.2), with (2.3) to derive the growth rate of wages

$$\frac{w_t}{w_{t-1}} = \frac{\frac{\lambda_2}{1+n}}{1-\lambda_1\left(\frac{L_t}{N_t-L_t}\right)}, \tag{3.5}$$

where

$$\lambda_1 = \frac{\phi\tau_w}{\left(1-\tau_w\right)\left(1-\tau\right)\left(1-\gamma\alpha\right)} \text{ and } \lambda_2 = \frac{\left(1+n\right)\left(1-\phi\right)}{1-\gamma\alpha}.$$

Equation (3.5) shows that the growth rate of wages negatively depends on the unemployment rate. According to Blanchard and Katz (1999) this wage equation is empirically supported by US data.

Let us define the employment rate by $l_t = \frac{L_t}{N_t}$. Combining (3.4) and (3.5), we obtain the dynamic equation that characterizes the equilibrium rate of employment

$$G = \frac{\lambda_2 \left(\frac{l_t}{l_{t-1}}\right)}{1 - \lambda_1 \left(\frac{l_t}{1-l_t}\right)}. \tag{3.6}$$

We define an equilibrium of this economy as a set of sequences $\{l_t, K_t\}_{t=0}^{\infty}$ such that jointly satisfy (3.3), (3.6), an initial condition on the stock of capital, K_0, and an initial condition on the employment rate, l_0.[8] And, we define a balanced growth path equilibrium (BGP, henceforth) as an equilibrium path where capital grows at a constant rate and the employment rate remains constant. The following proposition characterizes the BGP:

Proposition 3.1. *There exists a unique BGP equilibrium. Along this path,* $\frac{K_t}{K_{t-1}} = G$, *where*

$$G = s(1-\alpha) B (1 - \tau(1-\tau_w)),$$

and

$$l = 1 - \frac{\lambda_1}{1 + \lambda_1 - \frac{\lambda_2}{G}}.$$

Proof. The proof follows from (3.3) and imposing $l_t = l$ for all t in (3.6).

In order to guarantee for a well defined BGP, that is $l \in [0,1]$, we must assume that the parameters satisfy the following relation: $G > \lambda_2$. Next, in the proposition below, stability of the BGP is discussed.

Proposition 3.2. *Assume that* $\phi \in (0,1)$. *Then, the BGP equilibrium is globally stable. Thus, the dynamic equilibrium converges to the BGP from any initial condition.*

[8]Actually, the initial condition on the employment rate follows from an initial condition on the wage, w_{-1}. This is the actual initial condition because unions set the wage using the value of the wage in the previous period, as follows from (2.2). Combining this equation with (2.1), (3.1) and the initial condition on capital, the initial employment rate is obtained as a function of w_{-1}.

Proof. Using (3.6), it can be shown that if $l_t = l$ then $\frac{\partial l_t}{\partial l_{t-1}} \in (0,1)$. This means that the BGP is locally stable and because there is a unique BGP it is also globally stable.

While the growth rate of both capital and output is constant along the equilibrium path as follows from (3.3), the employment rate changes along the transition to the BGP if $\phi \in (0,1)$. Moreover, because $\lambda_2 > 0$ when $\phi \in (0,1)$ and thus there is inertia in the wage formation process, the employment rate positively depends on the economic growth rate and on public capital, as follows from (3.3). This result points out the importance of the wage formation process in driving the dynamics of employment. Actually, when $\phi = 1$ and thus the reservation wage does not depend on past wages, $l_t = l = \frac{1}{1+\lambda_1}$ for all t. In this case, the employment rate does not exhibit transition and the growth rate does not affect the rate of employment, which implies that an increase in public capital causes more growth but does not affect the rate of employment. In contrast, when $\phi = 0$ and thus the reservation wage coincides with the wage in the previous period, (3.6) simplifies into the following equation:

$$\frac{l_t}{l_{t-1}} = \frac{G}{\lambda_2}.$$

This equation defines the gross growth rate of the employment rate. Because of the assumptions made, this gross growth rate is larger than one implying that the employment rate monotonically grows until full employment is achieved. Moreover, economic growth increases the growth rate of employment during the transition.

From the previous analysis, we conclude that a permanent increase in the growth rate causes a permanent increase in the employment rate when there is wage inertia. We also conclude that the behavior of employment along the equilibrium path crucially depends on the value of the parameter ϕ. Interestingly, the empirical literature finds that the value of ϕ differs substantially between countries and depending on the use of micro and macro data (see, for example, Blanchard and Katz (1997), (1999)).

In what follows we derive the long run effects on employment and on the growth rate of increasing public capital when there is wage inertia, $\phi \in (0,1)$, and the equilibrium government budget constraint is taken into account. In other words, we compare the effects of increasing public capital under different modes of government financing and we also discuss the effects of increasing the unemployment benefit. The results are given in the following proposition:

Proposition 3.3. *Assume that* $\phi \in (0,1)$ *and let* $v^2 = (1-\alpha)(1-\alpha(1-\tau_k))$,

$v^1 \in (0, v^2)$, and $v^3 > v^2$. Then,

a) $\frac{\partial G}{\partial \tau_k} > 0$, *and if* $v > (<)\, v^2$ *then* $\frac{\partial G}{\partial \tau} < (>)\, 0$ *and* $\frac{\partial G}{\partial \tau_w} > (<)\, 0$.

b) $\frac{\partial l}{\partial \tau_k} > 0$, *if* $v < (>)\, v^1$ *then* $\frac{\partial l}{\partial \tau} > (<)\, 0$, *and if* $v < (>)\, v^3$ *then* $\frac{\partial l}{\partial \tau_w} < (>)\, 0$.

Proof. Part a follows from the definition of the long run growth rate in (3.3). Part b follows from the definition of the long run employment rate in Proposition 3.1.

Increasing public capital enhances the marginal product of labor and, hence, the wage increases. The increase in wages accelerates savings which explains the positive effect of public capital on economic growth. Furthermore, because of the assumptions made on the utility function, a tax on the capital income does not reduce savings. This explains the result in Part a of Proposition 3.3 that shows that increasing public capital always results in a larger growth rate when it is financed by means of taxes on the capital income. In contrast, an increase in the tax on the labor income drives two opposite forces that affect growth. On the one hand, it increases public capital which accelerates growth. On the other hand, an increase in the tax rate on the labor income reduces income, which deters growth as savings are reduced. This explains the ambiguity on the growth effects of increasing this tax. Finally, increasing the tax that is used to finance the unemployment benefit has exactly the opposite effects. It increases the income of the people who accumulate private capital and reduces public capital. Again, this explains that the growth effects of increasing this tax rate are ambiguous and depend on the value of the fraction of production devoted to public capital.

If there is wage inertia, then increasing public capital may enhance the employment rate provided it increases economic growth. When the increase in public capital is financed by means of taxes on the capital income, the employment rate always increases with this tax as growth unambiguously increases. This result is shown in Part b of Proposition 3.3. In contrast, when the increase in public capital is financed by means of taxes on the labor income, the employment rate decreases with this tax when the fraction of production devoted to public capital, v, is large. This negative effect may occur because taxes on the labor income enhance the wage payed by firms and, hence, reduce employment. Finally, an increase in the tax used to finance the unemployment benefit results in a reduction in the employment rate, unless the fraction of production devoted to public capital is very large. This negative effect occurs because increasing the unemployment benefit makes the wage larger and, hence, reduces the employment rate.

4. Conclusions

In the economy developed in this paper, aggregate labor income increases with economic growth. Thus, economic growth translates into either larger wages or larger employment. We have shown that only when there is wage inertia, economic growth does not fully translate into wage growth and, thus, causes employment growth. We have also shown that a permanent increase in the economic growth rate causes a permanent positive effect on the employment rate when there is wage inertia. In this case, a permanent increase in the growth rate increases the employment rate during the transition and in the BGP.

It follows that those government policies that increase growth may result in a larger employment rate. We have explored a particular fiscal policy that consists of increasing public capital and we have shown that this policy enhances growth and may increase the employment rate. While the first result does not depend on the wage formation process, the second result crucially depends on this process. This means that the effects of government policies on employment crucially depend on the assumptions made on the wage equation. This suggests the interest of further research on the actual wage equations.

References

Aghion, P. and Howitt, P. (1994). "Growth and Unemployment", *Review of Economic Studies* 61: 477-94.

Aghion, P. and Howitt, P. (1998). Endogenous Growth Theory, *The MIT Press.*

Aschauer, D. (1989). "Is Public Expenditure Productive?", Journal of Monetary Economics, 23: 177-200.

Barro, R. (1990). "Government Spending in a Simple Model of Endogenous Growth", *Journal of Political Economy* 98: 103-125.

Bean, C. and Pissarides, C.A. (1993). "Unemployment, Consumption and Growth", *European Economic Review* 37: 837-54.

Blanchard, O. and Katz, L.F. (1997). "What We Know and Do Not Know About the Natural Rate of Unemployment", *The Journal of Economic Perspectives* 11: 51-72.

Blanchard, O. and Katz, L.F. (1999). "Wage Dynamics: Reconciling Theory and Evidence", *NBER Working Paper* 6924.

Blanchard, O. and Wolfers, J. (2000). "The Role of Shocks and Institutions in the Rise of European Unemployment: the Aggregate Evidence", *The Economic Journal* 110: C1-C33.

Collard, F. and de la Croix, D. (2000). "Gift Exchange and the Business Cycle: The Fair Wage Strikes Back", *Review of Economic Dynamics* 3: 166-193.

De la Croix, D., Palm, F.C. and Urbain, J. (2000). "Labor Market Dynamics when Effort Depends on Wage Growth Comparisons", *Empirical Economics* 25: 393-419.

De la Croix, D., Palm, F.C. and Pfann, G.A. (1996). "A Dynamic Contracting Model for Wages and Employment in Three European Economies", *European Economic Review* 40: 429-448.

Daveri, F. and Tabellini, G. (2000). "Unemployment, Growth and Taxation in Industrial Countries" *Economic Policy* 30: 47-88.

Demetriades, P. and Mamuneas, T. (2000). "Intertemporal Output and Employment Effects of Public Infrastructure Capital: Evidence from 12 OECD Economies", *The Economic Journal* 110: 687-712.

Eriksson, C. (1997). "Is There a Trade-Off between Employment and Growth?" *Oxford Economic Papers* 49: 77-88.

Pereira, A. and Roca-Sagales, O. (1999). "Public Capital Formation and Regional Development in Spain", *Review of Development Economics*, 3: 281-294.

Pissarides, C.A. (1990). Equilibrium Unemployment Theory, *Blacwell.*

Raurich, X. and Sorolla, V. (2003). "Growth, Unemployment and Public Capital", Spanish Economic Review, 5: 49-61.