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ACTIVE VERSUS PASSIVE POLICIES OF UNEMPLOYMENT: GROWTH AND PUBLIC FINANCE PERSPECTIVES

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Abstract

This paper develops a general equilibrium endogenous growth model in an overlapping generations framework, and compares, in terms of economic growth, a passive unemployment policy (unemployment insurance) with an active unemployment policy (government expenditures targeted towards improving the job-finding probability of an unemployed). Besides, the standard result of unemployment being growth reducing, under realistic parameterization, we show that the government, under an active policy, can generate higher growth without any compromise on its own consumption, when compared to the unemployment benefit regime. The result, however, depends crucially on the efficiency with which the resources are spent in creating employment.

Journal of Economic Literature Classification: E24, H55, J64, O41.

Keywords: Active and Passive Policies of Unemployment; Unemployment Benefits; Endogenous Growth.

1. Introduction

This paper develops a general equilibrium endogenous growth model in an overlapping generations framework, and compares, in terms of economic growth, unemployment insurance (passive policy of unemployment) with a policy where government expenditures are targeted towards improving the probability of an unemployed in finding employment (active policy of unemployment). Specifically speaking, the latter policy of the government involves training or educating the unemployed for developing skills necessary to be absorbed into the labor force, or removing the rigidities in the labor market or reducing search costs, or all of the above. So the active unemployment policy, unlike, the unemployment insurance policy, aims to target unemployment directly, and, in turn, seek to absorb the unemployed into the work force.

Surprisingly, even though the relationship between social security, unemployment and growth is important to the layman and policymakers alike, the topic has mostly been ignored in the theoretical literature. However, two recent studies by Saint-Paul (1992) and Belan *et al.* (1998), which theoretically analyzes the role of pension funds and growth, have helped to draw the interest of growth theorists in this regard. Moreover, recent papers by Aghion and Howitt (1994), Bräuninger (2000), Pissarides (2000), and Lingens (2003), study the role of unemployment on economic growth. While, Aghion and Howitt (1994) and Pissarides (2000) considers unemployment caused by search frictions, Bräuninger (2000) and Lingens (2003) examined unemployment caused by wage bargaining. However, all these studies reach the identical conclusion of unemployment deteriorating growth. But, Daveri and Tabellini (2000) argue that slowdown in economic growth causes a rise in unemployment, which, in turn, is caused by the increase in the tax on labor income. Since labor income taxes include social security contributions, understandably, there exists an indirect link from pension funds to unemployment and growth. Most importantly, however, their conclusions explained the upward trend in European unemployment between 1965 and 1995, when the labor tax rates increased by 14 percentage points.

The only two papers that explicitly consider the relation between social security, unemployment and growth are Corneo and Marquardt (2000) and Bräuninger (2005). Though the models are very similar in spirit, their conclusions differ remarkably. While, Bräuninger (2005) indicates that unemployment has a negative impact on growth, Corneo and Marquardt (2000) shows that unemployment does not affect growth. Moreover, unlike in the Corneo and Marquardt (2000) study, where an increase in unemployment benefits does not affect unemployment, Bräuninger (2005) shows that unemployment increases with the rise in the unemployment benefits. Our model, however, does not try to link unemployment insurance with growth. Alternatively, it shows that if government expenditures are targeted towards generating employment (through training or by reducing labor market rigidities that prevent the firms from hiring or by lowering down search costs), rather than providing unemployment insurance, the government can not only generate a higher level of economic growth, compared to the unemployment insurance policy in place, but can achieve it without compromising on its own consumption. But, this only happens, if the government achieves a critical level of efficiency in carrying out such expenditures. However, it must be noted that nothing precludes our model from analyzing the impact of a change in unemployment and unemployment insurance on economic growth. To the best of our knowledge, this is the first attempt to compare the policy of unemployment insurance with an active governmental policy aiming to reduce the probability of remaining unemployed, in terms of growth and from a public finance perspective. Note, thus far, general equilibrium modeling of unemployment has mainly focused on the link between labor market policies, wage formulation and the level of unemployment.[3]

The rest of the paper, besides the introduction and conclusions, is organized as follows: Section 2 lays out the economic environment under the passive and active policies of unemployment, respectively. Section 3 lays out the equilibrium, and Section 4 solves and compares the model, in terms of growth, under the two alternative policies.

2. Economic Environment

This section presents a modified version of Diamond's (1965) overlapping generations model, by accounting for unemployment. The economy is populated by three types of agents, namely, consumers, who can be employed, or unemployed, firms and an infinitely-lived government. The following subsections lay out the economic environment in detail, by considering each of the agents separately and accounting for the two alternative economic policies, discussed above.

2.1. Passive Policy of Unemployment: Unemployment Benefits

2.1.1. Consumers

The economy is characterized by an infinite sequence of two period lived overlapping generations of economic agents. Time is discrete and is indexed by t = 1, 2,.... At each date t, there are two coexisting generations of young and old agents. At t = 1, there exist N people in the economy, called the initial old, who live for only one period. Hereafter N is normalized to 1.

Each consumer is endowed with one unit of working time (n_t) when young. However, a fraction (u) of the population is unemployed, and, hence, there are $(1-u)$ working individuals in the economy. The employed agents are assumed to retire when old. The employed agent supplies the one unit of labor inelastically and receives a competitively determined real wage of w_t. Note if employed, the consumer has to pay a tax at the rate of τ_t. The unemployed consumer, on the other hand, receives an unemployment benefit to the order of $\theta_t w_t$, with $0<\theta<1$, where θ is the replacement ratio. We assume that the agents consume only when old.[4] Thus, the net of tax wage earnings of the employed and the unemployment benefit of the unemployed, obtained when young, is entirely allocated to savings in the form of investment in the firms of the economy. The proceeds from the savings, are then used to obtain second period consumption by both the employed and the unemployed, individually.

With $(1+r_{t+1})$ as the gross real rate of interest, the problems of the employed (e) and the unemployed (u), respectively, can be formally described as follows:

$$\max U(c_{t+1}^e) \tag{1}$$

s. to.

$$s_t^e \leq (1-\tau_t)w_t \tag{2}$$

$$c_{t+1}^e \leq (1+r_{t+1})s_t^e \tag{3}$$

$$\max U(c_{t+1}^{e}) \tag{4}$$

s. to.

$$s_t^u \leq \theta_t w_t \tag{5}$$

$$c_{t+1}^u \leq (1+r_{t+1})s_t^u \tag{6}$$

With the agents consuming only when old, the specification of the utility function does not matter, since the problem is solved from the constraints directly. However, the usual assumptions of positive but diminishing marginal utility, along with the INADA conditions, still holds.

2.1.2. Firms

All firms are identical and produce a single final good using a constant returns to scale, Cobb-Douglas-type, production function, given as follows:

$$y_t = Ak_t^{\alpha}(L_t\overline{k_t})^{1-\alpha} \tag{7}$$

where y_t is the output; L_t is the inelastic labor supply, by the employed, for production in period t ; k_t is the per-firm capital stock in period t; $\overline{k_t}$ denotes the aggregate capital stock in period t; A is a positive scalar, and; $0 < \alpha < 1$, is the elasticity of output with respect to capital. Following, Romer (1986), the aggregate capital stock enters the production function in (7) to account for a positive externality indicating an increase in labor productivity as the society accumulates capital stock. It must be noted that in equilibrium, $k_t = \overline{k_t}$.

At time t the final good can either be consumed or stored. Firms operate in a competitive environment and maximize profit taking the wage rate and the rental rate on capital as given, besides, $\overline{k_t}$. The producers convert the available household savings into fixed capital formation. Notice that the production transformation schedule is linear so that the same technology applies to both capital formation and the production of consumption goods. We follow Diamond and Yellin (1990) and Chen *et al.* (2000) in assuming that the goods producer is a residual claimer, i.e., the producer ingests the unsold consumption good in a way consistent with lifetime maximization of value the of firms. This ownership assumption avoids unnecessary Arrow-Debreu redistribution from firms to households and simultaneously maintains the general equilibrium nature.

The representative firm at any point of time t maximizes the discounted stream of profit flows subject to the capital evolution constraint ($k_{t+1} \leq (1-\delta_k)k_t + i_{kt}$). Given that w_t and $1+r_{t+1}$ is the real wage rate and the gross rate of return on capital, respectively, and defining δ_k as the constant rate of depreciation of physical capital, we have, following profit maximization, for all periods[5]:

$$w_t = A(1-\alpha)k_t\left(L_t\right)^{(-\alpha)} \tag{8}$$

$$(1+r_{t+1}) = \frac{\rho A\alpha\left(L_t\right)^{(1-\alpha)}}{1-\rho(1-\delta_k)} \tag{9}$$

With ρ as the firm owner's discount factor, equation (9) provides the condition for the optimal investment decision of the firm. The firm compares the cost of increasing investment in the current period with the future stream of benefit generated from the extra capital invested in the current period, i.e., (9) equates the marginal benefit of capital with its marginal cost. Equation (8), on the other hand, simply states that the firm hires labor up to the point where the marginal product of labor equates the real wage. So conditions (8) and (9) yields the familiar conditions that profit maximization of the firms lead to a constellation in which inputs get paid their marginal products which, in turn, exhaust the output.

2.1.3. Government

In this section we describe the activities of an infinitely-lived government. The government purchases g_t units of the consumption good and is assumed to costlessly transform these one-for-one into what is called government good. A part of the government good, $g_{1t} = (\theta_t \times uw_t)$, is then used to provide the unemployment benefit, while the remaining amount of $g_{2t} = g_t - (\theta \times uw_t)$ is used, purely, for government consumption and, hence, is useless to the agents. The government is assumed to finance these expenditures by income taxation. Recalling that N is unity, the government's budget constraint at date t, in per capita terms, can be formally defined as follows:

$$g_t = \tau_t w_t \times (1-u) \tag{10}$$

$$\text{or, } g_{2t} = (\tau_t(1-u) - \theta_t u)w_t \tag{11}$$

2.2. Active Policy of Unemployment

The basic set up of the economy continues to be the same as above. However, with a fraction of the government expenditure now directed towards enhancing the chances of the unemployed getting hired by the firm, the optimization problem of the agents needs to be redefined. These government expenditures can take the form of training the unemployed, if in fact, the unemployment is due to the lack of appropriate skills required to be absorbed into the labor force. Or, alternatively, these spending can be directed towards reducing the fixed costs incurred by the firms in hiring labor or search costs on the side of the unemployed. We are, at this stage, not really interested in identifying reasons behind unemployment, but analyze how the economy performs under an active unemployment policy.

Let p be the probability of the unemployed agent in finding a job. We assign the following structure to the probability:

$$p_t = \eta_t^{\gamma} \tag{12}$$

where η_t is the fraction of the aggregate wage income[6] devoted to training or reducing transaction costs in the labor market for each unemployed member, and; $0 < \gamma < 1$, captures the fact that the probability of finding a job for the unemployed agent increases at a decreasing rate with such expenditures. Note the probability only equals unity, in the hypothetical case of the government spending the entire of the aggregate wage income for such purposes.

We are now ready to discuss the problems of the individual agents under the alternative policy.

2.2.1. Households

The optimization problem for the employed and the unemployed, respectively, can be redefined as follows:

$$\max U(c_{t+1}^{e}) \tag{13}$$

s.t.

$$s_t^e \leq (1-\tau_t)\overline{w_t} \tag{14}$$

$$c_{t+1}^{e} \leq \overline{(1+r_{t+1})} s_t^e \tag{15}$$

$$\max[p \times U(c_{t+1}^{u})] \tag{16}$$

s.t.

$$s_t^u \leq (1-\tau_t)\overline{w_t} \tag{17}$$

$$c_{t+1}^{u} \leq \overline{(1+r_{t+1})} s_t^u \tag{18}$$

where s^i and c^i , i = e and u measures the savings and consumption decision of the employed and the when the unemployed finds employment, respectively; $\overline{w}$ and $\overline{1+r}$ are the redefined real wage and gross real rental, respectively, that the agents will receive, based on the expected labor supply.

2.2.2 Firms

As before, given the production function in (7), life-time profit maximization of the firm, on imposing $k_t = \overline{k_t}$, will yield the following conditions. See the Appendix for further details:

$$\overline{w_t} = A(1-\alpha)k_t\left(L_t\right)^{(-\alpha)} \tag{19}$$

$$\overline{(1+r_{t+1})} = \frac{\rho A\alpha\left(L_t\right)^{(1-\alpha)}}{1-\rho(1-\delta_k)} \tag{20}$$

Note, given that the size of employable labor would be different under the active policy, when compared to the passive policy, the corresponding real wage rate and the gross real rate of return will also be different in equilibrium, under the two alternative policy regimes. The returns have thus now been defined with an over-line.

2.2.3. Government

As in the case of unemployment benefits, the government finances its expenditure through income taxes only. Keeping in mind that, the unemployed when employed with probability will need to pay tax on their earnings, the government budget constraint, under the active policy, can be written as follows:

$$g_t = \tau_t \overline{w_t} \times (1-u) + p_t \tau_t \overline{w_t} \times (u) \tag{21}$$

Equation (21) can be rewritten as follows:

$$g_{2t} = \tau_t[(1-u) + p\times u]\overline{w_t} - g_{1t} \tag{22}$$

where g_{2t}, measures the size of government expenditure spent on enhancing the chances of the unemployed in getting hired by the firm. Given that consistency with endogenous growth requires all (real)variables to grow at the same rate, we can set $g_{1t} = \eta_t \times (u)\overline{w_t}$, without any loss of generality. This would imply, from (22), that $g_{2t} = (\tau_t\{\times(1-u) + p\times u\} - \eta_t \times u)\overline{w_t}$. Also recall, from (12), $p_t = \eta_t^{\gamma}$. We will assume that the government pursues time invariant policy rules, which will mean that the tax rate, τ_t, θ_t and η_t and, hence, p_t are constant over time.

3. Equilibrium

A valid perfect-foresight, competitive equilibrium for the economy with unemployment benefit [active policy of unemployment] is a sequence of allocations $\{c^e_{t+1}, c^u_{t+1}, n_t, s^e_t, s^u_t, i_{kt}\}_{t=0}^{\infty}$ and policy variables $\{\tau_t, g_{1t}, \theta_t[\eta_t]\}_{t=0}^{\infty}$ such that[7]:

- Taking τ_t, w_t [$\overline{w_t}$], θ_t [η_t], $(1+r_{t+1})$ [$\overline{(1+r_{t+1})}$], both the employed and the unemployed consumer optimally chooses c^i_{t+1} and s^i_t, $i = e$ and u, such that (1) [13] is maximized subject to (2) and (3) [14 and 15] and (4) [16] is maximized subject to (5) and (6) [17 and 18] respectively;
- The real allocations solve the firm's date–t profit maximization problem, such that (8) and (9) [19 and 20] holds;
- All markets clear for all $t \geq 0$, with the labor market clearing on the demand side. In case of the active policy, realizing that $N = 1$, $L_t = (1-u)$, where as, in case of the active policy $L_t = [(1-p)\times(1-u) + p\times 1]$;
- The government budget, equation (10) [21 and 22], is balanced on a period-by-period basis.

4. Comparison of Growth Paths under the Two Alternative Policies

Using the fact that the goods market equilibrium holds, i.e., $i_{kt} \times N_t = [(1-u)s^e_t + us^u_t]\times N_t$ (under the passive policy), $i_{kt}\times N_t = [(1-u)\times s^e_t + u\times p\times s^u_t]\times N_t$ (under the active policy) and the capital evolution constraint implies $k_{t+1} = (1-\delta_k)k_t + i_{kt}$, we can derive the steady-state level of growth rate, under the passive and active policies of unemployment, from the combinations of equations (2), (5) and (8) and, (14), (17) and (19), respectively. Formally, the derived equilibrium growth-paths can be outlined as follows:

$$\Omega^{pp} = [(1-u)(1-\tau) + u\theta]A(1-\alpha)\left(1-u\right)^{(-\alpha)} + (1-\delta_k) \tag{23}$$

$$\Omega^{ap} = A(1-\alpha)[pu + (1-u)(1-\tau)]\times[p + (1-p)(1-u)]^{-\alpha} + (1-\delta_k) \tag{24}$$

where, Ω^i, $i = pp$ and ap, stands for the gross growth rate corresponding to the passive and active policies, respectively.
The following observations can be made from equation (23) and (24):

(i) From (23) and (24), it is not evident if unemployment ambiguously reduces growth. For this purpose we take the derivative of (23) with respect to u to obtain: $-\frac{A(1-\alpha)}{(1-u)^{(1+\alpha)}}[(1-u(1-\alpha))(1-(\tau+\theta))-\alpha(1-\tau)]$. For realistic values of τ (= 0.25), θ (= 0.10), α (= 0.4), the value of the above derivative is negative, unless for an impractical unemployment rate of 89.74 percent. In case of the active policy, the derivative of (24) with respect to u yields: $-(1-p)(1-(1-p)u)^{-\alpha}(1-\tau)[1-\alpha]$, which is always negative;

(ii) Under both policies, there exists no reverse causality from growth to unemployment, as in Corneo and Marquardt (2000) and Bräuninger (2005);

(iii) An increase in the unemployment benefit brought about by a reduction in the unproductive public expenditures, g_{2t}, and not financed via an increase in tax rate, increases the rate of growth, unambiguously. However, an increase in the unemployment benefit financed through an increase in the tax rate will reduce the rate of growth;

(iv) For the above set of parameter values, along with δ_k = 0.05 and an unemployment rate (u) of $\frac{1}{3}$, the value of A, required to produce a growth rate of 2.5 percent, chosen to match world figures[8], under the passive policy, is equal to 0.1993. For the same set of parameters, the probability of finding employment for the unemployed that ensures that the growth rate under the active policy is also equal to 2.5 percent, can be obtained by setting equations (23) and (24) to be equal and solving for p. Mathematically, the following equation holds:

$$\frac{0.75\left(\frac{2}{3}+\frac{p}{3}\right)}{\left(1+\frac{-1+p}{3}\right)^{0.4}}-0.627242=0 \qquad (25)$$

(v) The above equation can only be solved in a non-algebraic fashion. So to obtain the value of p, we plot the left-hand-side of equation (25) as a function of p, denoted by *f*, as shown in Figure 1, and measure where the function intersects the X-axis, or where the function reaches zero for a value of p. A grid search around this point reveals p to be equal to 0.227125. Hence, a probability of approximately 23 percent, under our chosen set of parameter values, can ensure a growth rate of 2.5 percent under the active policy;

[INSERT FIGURE 1]

(vi) More importantly, from a public finance perspective, if the value of γ = $\frac{1}{2}$, η would be equal to $(0.227125)^2$ or 0.0515858, since p = η^{γ}. This means that it is possible for the government to generate the same growth rate by spending lesser fraction of the wage income, when compared to the 10 percent spent under the passive policy. It is easy to show that unless γ $\geq$ 0.643735, under the given set of parameterization, the government will always spend less than 10 percent of the wage income for generating a growth rate of 2.5 percent under the active policy;

(vii) However, it is also important to deduce the fraction of the wage income that is available purely for government consumption. In the case of passive policy this is 6.67[9] percent of the wage income, while, in case of the active policy this is 13.40 percent of wage income.[10] So under the active policy, the government not only spends lesser resources to generate the same level of growth rate as in the passive policy, but more importantly, does so by consuming greater fraction of the resources available, based on the same tax rate. Note, given a value of p = 0.227125, the government will continue to consume greater fraction of the wage income, under the active policy, unless, the value of γ increases, or alternatively, the efficiency measure of the government declines to, 0.696141;

(viii) Further, taking the derivative of Ω^{ap} with respect to p, yields the following result: $\frac{Au(-1+\alpha)^2(1-\tau)}{(1-(1-p)u)^{\alpha}}$, which is always positive. Then, understandably, an increase in the probability of the unemployed in finding employment increases the growth rate of the economy. This increase in the probability can come about due to either an increase in η, i.e., the government spends more resources for generating employment for the employed, or a fall in γ, i.e., the government becomes more efficient. However, if the increase in η is financed via an increase in tax rate, the growth rate will fall;

(ix) Suppose, we reset the value of η = 0.1, but retain $\gamma = \frac{1}{2}$, then p is equal to 0.316228. Replacing this value of p in equation (24), but retaining all the other parameter values under the passive policy, yields a growth rate of 2.68 percent, which is higher than the 2.5 percent. From the government budget constraint, this further implies that the fraction of resources now available for government consumption is 0.093019, which is still greater than the fraction of resources (0.0666667) available to the government for consumption, under the passive policy. Note as long as the value of γ is less than equal to 0.556534, the government will continue to consume more resources under the active policy, when compared to the passive policy, given η = 0.1 and p = 0.316228. However, the fraction of resources consumed by the government now, which is 9.30 percent, is less than the 13.40 percent consumed under the original scenario where the government spent 5.17 percent of the wage income to generate a growth rate of 2.5 percent;

(x) Alternatively, suppose that the government becomes efficient in allocating resources to generate employment opportunities for the unemployed. So if $\gamma = \frac{1}{4}$, then with η retained at 0.0515858, the value of p increases to 0.476576, which translates into a growth rate of 2.993 percent and a value of 0.154796 for government consumption as a fraction of wage income. Both these values are clearly higher, when compared to the corresponding values under the passive policy, as well as the active policy, with an initial value of p = 0.227125. Further, if $\gamma = \frac{1}{4}$, the value of η required to generate a p of 0.227125, is 0.00266, which is less than the value of η (0.0515858) with $\gamma = \frac{1}{2}$. In this situation, though we still continue to have a growth rate of 2.5

percent, the fraction of wage income consumed by the government is equal to 0.182933, which is clearly higher than the corresponding values under the passive policy and also the active with a value of η = 0.0515858 and $\gamma = \frac{1}{2}$.

So, in summary, we observe that the active policy can yield both higher growth rate, and have the government consume a greater fraction of the wage income, when compared to the passive policy, but this requires the government to attain a certain level of efficiency in allocating resources for generating employment for the unemployed.

5. Conclusions and Areas of Further Research

This paper develops a general equilibrium endogenous growth model in an overlapping generations framework, and compares, in terms of economic growth and a public finance perspective, a passive policy of unemployment (unemployment insurance) with an active policy of unemployment (government expenditures are targeted towards enhancing the probability of the unemployed in finding employment). Under realistic parameterization of the model, we show that the government, under the active policy, can generate higher growth when compared to the unemployment benefit regime. More importantly, though, the government can achieve this by not compromising on the size of its consumption. The result, however, depends on the efficiency with which the government spends the revenue collected for generating employment for the unemployed. Besides, this our model obtains the standard result of unemployment being growth reducing. However, we show that there exists no reverse causality from growth to unemployment, as in Corneo and Marquardt (2000) and Bräuninger (2005).

Even though our study identifies the active policy to clearly have the edge over the passive policy in terms of generating more growth, it is silent regarding the structure of the labor market. This paper, stresses on the lack of skill and high fixed costs of hiring as the source of unemployment. Ideally, one would need to model the cause of unemployment explicitly, to make concrete policy recommendations. That is, in order for the government to realize the problematic area, an improved model is desired that clearly outlines the possible reasons of labor market rigidities, and, hence, unemployment. This is an area that needs further investigation. Moreover, it would also be interesting to allow for productive public expenditures, along the lines of Barro (1990), besides, expenditures on unemployment benefit or enhancing the probability of the unemployed in finding a job. This, in turn, would lead to interesting trade off issues, where the government would need to devise an optimal scheme for the allocation of the direct (infrastructural) and indirect (unemployment-related) productive expenditures.

Endnotes

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3. See Pissarides (2000) and Linden and Dor (2001) for further details. In this regard it must be pointed out that there exists a large econometric literature dealing with issues of unemployment. The empirical studies are mainly based on the estimation of a matching function or a Beveridge curve, augmented with some labor market policy indicators. This approach, however, lacks proper theoretical foundations.
4. This assumption makes computations easier and also seems to be a good approximation of the reality (Hall (1988)).
5. See the Appendix for the solution of the firm's optimization problem.
6. See Subsection 2.2.3 for details.
7. The terms in [] corresponds to the active policy.
8. See Basu (2001) for further details.
9. Note from equation (11), we have $g_{2t}/w_t = (\tau \times (1-u) - \theta)$.
10. Recall, from equation (22), $g_{2t}/\overline{w_t} = \tau(1-u+p\times u)-\eta$.

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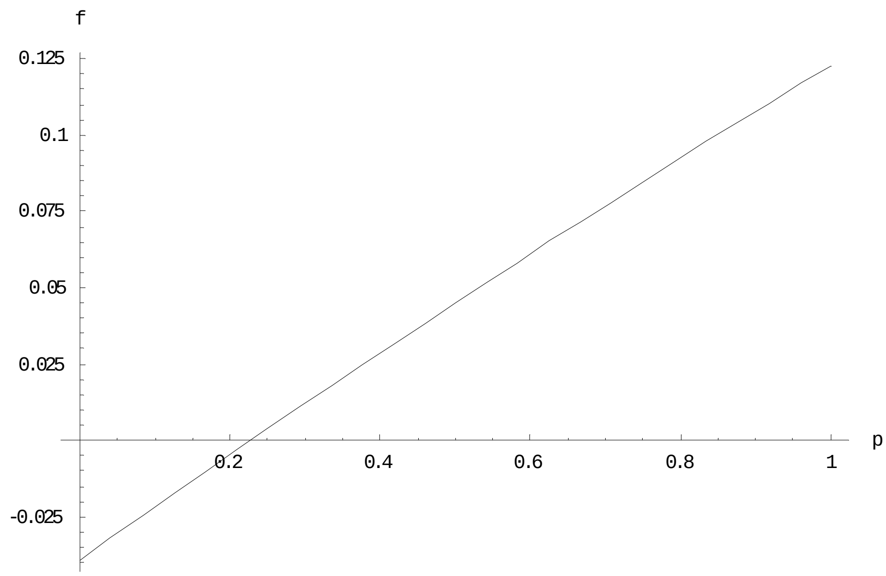
Figure 1. Calculation of Probability under the Active Policy



Appendix

The representative firm at any point of time t maximizes the discounted stream of profit flows subject to the capital evolution constraint. Formally, the problem of the firm can be outlined as follows:

$$\max_{i_{kt}, L_t} \sum_{i=0}^{\infty} \rho^i [y_t - w_t L_t - (1+r_{t+1}) i_{kt}] \quad \text{(A1)}$$

$$k_{t+1} \leq (1-\delta_k) k_t + i_{kt} \quad \text{(A2)}$$

The firm's problem can be written in the following recursive formulation:

$$V(k_t) = \max_{L_t, k_{t+1}} [y_t - w_t L_t - (1+r_{t+1}) i_{kt}] + \rho V(i_{kt} + (1-\delta_k) k_t) \quad \text{(A3)}$$

The upshot of the above dynamic programming problem is the following first order conditions.

$$i_{kt} : (1+r_{t+1}) = \rho V'_{t+1} \quad \text{(A4)}$$

$$L_t : y_{Lt} = w_t \quad \text{(A5)}$$

The Benveniste-Scheinkman condition is:

$$V'_t = [y_{k_t} + \rho (1-\delta_k) V'_{t+1}] \quad \text{(A6)}$$

Guessing $V(k)$ to be linear in k, i.e., $V(k_t)$ = V_0 + $V_1 k_t$, we have from (A4) and (A6):

$$V_1 = \frac{\rho y_{k_t}}{1-\rho(1-\delta_k)} = \rho(1+r_{t+1}) \quad \text{(A7)}$$

where y_{Lt} and y_{k_t} are the marginal product of capita with respect to labor and capital, respectively. Moreover, substituting (A7) into the above expression for V_k, and using (A3) and (A5), we can prove that V_0 = 0.

Using (A5) and (A7), we obtain the efficiency conditions given by (8) and (9). Note with the production structure in (7) and $k_t = \overline{k_t}$ to hold in equilibrium, y_{Lt} = $A(1-\alpha)k_t\left(L_t\right)^{(-\alpha)}$ and y_{k_t} = $A\alpha\left(L_t\right)^{(1-\alpha)}$.

Following the same steps as above, and replacing w_t with $\overline{w_t}$ and $(1+r_{t+1})$ with $\overline{(1+r_{t+1})}$ under the active policy regime, we end up with equations (19) and (20).