

GROWTH AND UNEMPLOYMENT (WITHOUT MARKET FRICTIONS)

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Abstract

This paper introduces structural unemployment into an otherwise standard growth model. Structural unemployment represents obsolescence of skills, a form of unemployment necessary to maximize aggregate output. The theory unambiguously identifies the winners and losers of more rapid technical change. Faster labor-augmenting technical change (whether exogenously or endogenously determined) increases economic growth. However, a higher opportunity cost of capital increases the unemployment of unskilled workers.

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[†]This paper was written in 2002, while I was a student at the University of Chicago. A few editorial changes have been made but no attempt has been made to update the list of references to include the many more recent papers which bear on the subject of this paper. Most of the recent work on unemployment and long term growth has been on the empirical front, and on “frictional” models. I direct the readers interested on this subject to a recent and important contribution by Pissarides and Vallanti [14].

1 Introduction

This paper introduces structural unemployment into an otherwise standard neoclassical growth model. The objective of the paper is to study the unemployment impact of technical change. This subject has a long history in economics dating back to David Ricardo [15]. In the famous chapter 31 (“On Machinery”) of his revised *Principles of Political Economy*, Ricardo noted that technical progress requires the introduction of labor-saving machinery and argued “[t]hat the opinion entertained by the labouring class, that the employment of machinery is frequently detrimental to their interests, is not founded on prejudice and error, but is conformable to the correct principles of political economy,” Ricardo ([15], pp. 392).

Unemployment has many faces. The unemployment we study is structural in the sense that it is not driven by market frictions, e.g., there are no search or matching frictions. Unemployment is also efficient, e.g., there are no policy interventions that could counteract it. Moreover, unemployment in this paper does not rely on wage rigidities or informational asymmetries that limit the functioning of the labor market. On the contrary, the market system works so effectively that workers get perfectly sorted. Sorting across skills, however, must restore to unemployment. As in Akerlof ([4], pp. 37) “unskilled workers, no matter how low they bid their wages, may still be unable to bid jobs away from skilled workers [...] not because their output on those jobs is negative, but because they underutilize the jobs themselves.”

The structure of the basic model may be described very simply. We consider an economy with workers of different skills. The distribution of skills is given. Firms produce with capital and labor, and capital is essential for production. That is, all workers are productive but they require capital to produce. More skilled individuals receive more capital and, as a Ricardian rent, they earn higher wages. The central assumption is that the marginal product of capital is bounded. As in Akerlof [3] and [4], this assumption implies that low skilled workers will be unemployed since they cannot cover the opportunity costs of capital.¹ Unemployment is necessary to maximize aggregate output.

¹Akerlof [3] and [4] are static frameworks. In neither of these models, there are dynamic considerations

In the model, an increase in the rate of return to capital increases structural unemployment. The rate of return to capital is increasing in the rate of technical change, whether exogenously determined or endogenously given by human capital accumulation. The central prediction of the model is that faster labor-augmenting technical change increases structural unemployment. Technical change, both by intention and through unintended side effects, creates winners and losers.

The predictions of the theory are not unique to the model we present, but the rate of return to capital appears to be central for understanding differences in unemployment rates. High rates of return to capital were associated with high rates of unemployment in the OECD countries during the early 1990s; see, e.g., Blanchard and Wolfers [7]. Phelps ([13], chapter 4) also suggested that the increase in real interest rates in the 1980s was an important factor in rise of European unemployment rates; see also Gordon [10].

Structural unemployment is perhaps more relevant for poor countries. Available data on labor markets and unemployment in less developed countries is not very reliable; see Agénor and Montiel ([1], chap. 2). However, the available evidence suggests higher returns to physical and human capital in less developed countries and by higher unemployment, underemployment or open unemployment rates (higher underutilization). In poor countries, open unemployment include a large fraction of the labor force; see, e.g., Agénor and Montiel ([1], Section 2.3.2) and Turnham [16].

The paper is related to old and new growth literatures. The model revisits some insights in the old Harrod-Domar literature. As in the Harrod-Domar model, technological conditions lead to unemployment. The model, however, does not require the Leontief production function assumed by the Harrod-Domar model. On the new side, we follow Lucas [12] and use human capital as the engine of growth. The model complements a literature that connects endogenous growth with unemployment. The pioneer study is Aghion and Howitt [2], who proposed a model of creative destruction and search frictions. Their model is very rich. However, it has limited predictability for the relationship between unemployment and technical change because it provides multiple channels of causation.

that relate unemployment to long term growth rates.

This paper provides a much simpler and direct view.

The rest of paper is as follows. Section 2 presents a simple model. Section 3 allows for human capital accumulation. Section 4 briefly concludes.

2 A simple model of structural unemployment

This section presents a simple model of growth and unemployment. The first sub-section discusses the notion of unemployment in this economy. The second and third sub-sections discuss the dynamic aspects of the model.

Structural unemployment. Time is continuous, indexed by t . There is a continuum of skills indexed $i \in [0, 1]$. The mass of workers with skill i is constant over time and given by $L(i)$. Population is normalized to one. We assume that $L(i)$ is constant over time to introduce limited flexibility in the type of skills that can be formed at any point in time. In the next section we consider human capital accumulation.

Labor $L(i)$ and capital $K_t(i)$ are combined to produce output. The production function is $F(K_t(i), L(i))$. $F : \mathbb{R}_+ \times [0, 1] \rightarrow \mathbb{R}_+$ is strictly concave, twice differentiable, homogeneous of degree one, subject to diminishing returns on each factor and $\lim_{K \rightarrow \infty} F_K(K, L) = \lim_{L \rightarrow \infty} F_L(K, L) = 0$. Capital and labor are essential to produce output. We will consider workers who receive no capital as unemployed workers. These workers will clearly be in excess supply.

Productivity differs across skills by a term $\phi(i) \geq 0$. Total output for workers of skill i is $\phi(i)F(K_t(i), L(i))$. The productivity term $\phi(i)$ gives skilled workers a comparative advantage in the use of capital since we assume that $\phi(i)$ is strictly increasing in i with $\phi(0) = 0$.

At any period t , and for a given amount of aggregate capital $K_t > 0$, capital must be assigned across skills. This assignment problem is described by

$$\max_{K_t(i), L(i)} \int_0^1 \phi(i)F(K_t(i), L(i)) di, \tag{1}$$

subject to the availability of capital

$$\int_0^1 K_t(i) di \leq K_t, \quad (2)$$

and subject to the given mass of workers in each skill group, $L(i)$.

Associated with each resource constraint, there is a set of multipliers or shadow prices r_t and $w_t(i)$. (These shadow prices are the rental price of capital and the wage rate in a competitive equilibrium.) The most important aspect of the optimal allocation is stated below:

Lemma 1 *Suppose that the marginal product of capital is bounded from above as capital tends to zero. Then, it is optimal to have unemployed workers.*

Proof. Let $k_t(i) = K_t(i)/L(i)$. Similarly, let $f(k_t(i)) = F(K_t(i)/L(i), 1)$. The Lagrangian for the assignment problem is

$$\mathcal{L} = \int_0^1 \phi(i) f(k_t(i)) L(i) di - \int_0^1 w_t(i) L_t(i) di - r_t \left[\int_0^1 k_t(i) L(i) di - K_t \right]. \quad (3)$$

The first order (Kuhn-Tucker) conditions for $k_t(i)$ and $L(i)$ are $[\phi(i) f_k(k(i)) - r_t] k_t(i) = 0$, and $[\phi(i) f(k_t(i)) - r_t k(i) - w_t(i)] L(i) = 0$. If the marginal product of capital satisfies $f_k(0) = \rho < \infty$, then it is optimal to set capital and labor to zero for all skills i for which $\phi(i)\rho - r \leq 0$. Given the optimal allocation of capital and labor, the shadow price of capital is uniquely given by (2):

$$\int_{\varphi(r_t/\rho)}^1 k_t(i) L(i) di = K_t. \quad (4)$$

The shadow prices $w_t(i)$ can be determined once $k_t(i)$ and r_t are known. ■

The previous result is simple. It is socially optimal to assign capital only to those workers who can produce, at least, as much output at the margin to cover the cost of the capital needed to produce. All workers are productive, e.g., $\phi(x) \geq 0$. However, if some workers are unable to cover the opportunity cost r_t , they should be unemployed. These workers will divert the use of capital from more skilled workers.

The marginally employed skill is $\varphi(r_t/\rho) \equiv \phi^{-1}(r_t/\rho)$, e.g., workers are employed if $i \geq \varphi(r_t/\rho)$ and unemployed if $i < \varphi(r_t/\rho)$. The unemployment rate is

$$u_t = 1 - \int_{\varphi(r_t/\rho)}^1 L(i) di. \quad (5)$$

Since $\phi(i)$ is strictly increasing in i , $\varphi(r_t/\rho)$ is strictly increasing in r_t/ρ with $\varphi(0) = 0$. Hence, a higher cost of capital increases the skill required to obtain employment. Unemployment also increases.

Unemployment requires a bounded marginal product of capital ρ . If $\rho = \infty$, all workers will be employed since $\varphi(0) = 0$. It is not difficult to find production functions that generate positive structural unemployment. Consider the CES function $f(k(i)) = \{\alpha [k(i)]^\varepsilon + (1 - \alpha)\}^{1/\varepsilon}$, with an elasticity of substitution below one. Straightforward computations show that the marginal (and average) productivity of capital is bounded as capital goes to zero; see Barro and Sala-i-Martin ([5], pp. 43-44): $\lim_{k(i) \rightarrow 0} f_k(k(i)) = \lim_{k(i) \rightarrow 0} f(k(i))/k(i) = \alpha^{1/\varepsilon} > 0$. Then, $\rho = \alpha^{1/\varepsilon} > 0$. Consider also $f(k(i)) = 1 - \exp\{-k(i)\}$. Then, $f(0) = 0$, $\lim_{k(i) \rightarrow \infty} f_k(k(i)) = 0$ and $\lim_{k(i) \rightarrow 0} f_k(k(i)) = 1$. This production function will also generate unemployment.

Another example is the Leontief production function $f(k(i)) = \min\{k(i), 1\}$. In this case $\rho = 1$. Unemployment is defined as in (5) with $\rho = 1$. The Leontief case brings another element into the discussion. That is, the possibility of having simultaneously an excess supply of labor and an excess of capital. The next Lemma examines this case:

Lemma 2 *Suppose that $f(k_t(i)) = \min\{k_t(i), 1\}$. Then, if $K_t > 1 - u_t$, it is optimal to have unemployed workers coexist with idle capital.*

Proof. The optimal allocation is $k_t(i) = 1$ for all $i \geq \varphi(r_t/\rho)$. Then, the mass of workers with skills in $i \in [0, \varphi(r_t))$ will be unemployed (in excess supply). The opportunity cost r_t does not depend on the aggregate capital stock because the optimal allocation is determined solely based on technological conditions. The total capital used is

$$\int_{\varphi(r_t)}^1 k_t(i) L(i) di = \int_{\varphi(r_t)}^1 L(i) di = 1 - u_t.$$

If the total capital available, K_t is larger than $1 - u_t$, there will be an excess of capital of $K_t + u_t - 1$. Obviously, if $K_t < 1 - u_t$, capital will be rationed and more workers will be unemployed. If $K_t = 1 - u_t$, there will be an excess supply of workers but no excess supply of capital. ■

Unemployment and idle capital are socially efficient under the Leontief production function. It does not pay to give low skilled workers capital, even if some capital is idle, because these workers will not produce enough output to cover the opportunity cost of capital. Also, it does not pay to give currently employed workers more capital because the technology of production will not permit these workers use the extra capital. The previous result, however, is knife-edge. If some substitution between capital and labor is allowed, capital will no longer be in excess supply. If substitution is allowed, r_t will no longer be an exogenous parameter. In the rest of the paper we allow for some, but limited, substitution between capital and labor.

Capital accumulation. So far, the aggregate capital stock K_t has been treated as constant. We next consider an optimal accumulation plan. The size and initial distribution of capital are given by K_0 and $k_0(i)$ for all $i \in [0, 1]$. A social planner chooses consumption per capita $c_t(i)$, the static assignment of capital per capita $k_t(i)$, and the aggregate capital accumulation rate \dot{K}_t to maximize social welfare. The planner evaluates welfare according to an iso-elastic utility, with elasticity $\sigma \in (0, 1]$. The rate of time preference $\theta > 0$ is equal across skill groups.

The social planner problem is

$$\max_{c_t(i), k_t(i), \dot{K}_t} \int_0^1 \int_0^\infty \left\{ \frac{c_t(i)^{1-\sigma}}{1-\sigma} \right\} L(i) \exp\{-\theta t\} dt di,$$

subject to

$$\dot{K}_t + \int_0^1 c_t(i) L(i) di \leq \int_0^1 \phi(i) f(k_t(i)) L(i) di, \quad (6)$$

$$\int_0^1 k_t(i) L(i) di \leq K_t, \quad (7)$$

for all $t \geq 0$.

The feasibility condition (6) assumes implicitly that the planner can transfer resources across skill groups in a lump-sum way. Transfers to the skill group i are denoted by $\tau_t(i)$. These transfers provide “insurance” for low skilled workers and satisfy $\int_0^1 \tau_t(i) di = 0$. Expression (7) is just a restatement of (2).

Let $C_t = \int_0^1 c_t(i)L(i)di$ denote aggregate consumption. The dynamic properties of the allocation are listed below:

Lemma 3 *Given $k_0(i) > 0$, $\{K_t, c_t(i)\}$ solve the dynamic allocation problem if and only if they satisfy the following pair of differential equations: (6) and*

$$\frac{\dot{c}_t(i)}{c_t(i)} = \frac{\dot{C}_t}{C_t} = \frac{r_t - \theta}{\sigma}, \quad (8)$$

for all $i \in [0, 1]$, where r_t is the Lagrange multiplier on (7).

Proof. The proof is standard; see, e.g., Barro and Sala-i-Martin [5]. Notice that the derivative of the Lagrangian (3) with respect to K_t is simply r_t , e.g., the marginal product of capital. Notice also that all skill groups consume equal amounts, and that the static allocation of $k_t(i)$ is characterized by Lemma 1. ■

Consider the *steady state*. By concavity, the steady state is unique. The shadow price of capital is $r^* = \theta$, capital per employed workers is $\phi(i)f_k(k^*(i)) = r^* = \theta$, and the shadow price of skill i is $w^*(i) = \phi(i)f(k^*(i)) - r^*k^*(i)$. The aggregate capital stock is

$$\int_{\varphi(r^*/\rho)}^1 k^*(i)L(i)di = K^*, \quad (9)$$

and the steady state unemployment rate satisfies

$$u^* = 1 - \int_{\varphi(r^*/\rho)}^1 L(i)di. \quad (10)$$

The steady state unemployment rate is an increasing function of the discount rate θ and a decreasing function of the upper bound of the marginal product of capital, ρ . Wages or the shadow prices of skill differ across skill groups. The distribution of $w^*(i)$ satisfies

$w_i^*(i) = \phi_i(i)f(k^*(i)) > 0$ for employed skills. Thus, as a Ricardian rent, more skilled workers are more valuable socially due to their complementarity with physical capital.

Other comparative statics are straightforward. An economy with more unskilled workers (relative to skilled workers) will mechanically have higher unemployment rates. We can also compare the wage distribution between two economies with differences in the degree of complementarity between skilled labor and capital. Higher complementarity between capital and skilled labor, i.e., higher $\phi_i(i)$, increases unemployment and the relative wages of high skilled workers.

Labor-augmenting technical change. There is no long run growth in the previous economy. It is possible to include exogenous labor-augmenting or labor-saving technical change at a rate g without introducing major complications to the model.

The production function is now $F(K_t(i), A_t L(i))$, where $A_t = A_0 \exp\{gt\}$. In this case, A_t represents a continuous improvement in labor efficiency. In terms of the model, all we need to characterize this new allocation is to re-normalize all variables in terms of effective labor, e.g., $k_t(i)/A_t$ and $c_t(i)/A_t$.

Along a balanced growth path, the opportunity cost of capital r^* will combine the pure rate of time preference θ , plus the product of the elasticity of the marginal utility with respect to consumption, σ , and the growth rate of technical change

$$r^* = \theta + \sigma g. \tag{11}$$

This *modified golden rule*, is well-known; see, e.g., Barro and Sala-i-Martin ([5], pp. 73). The main implication for structural unemployment is straightforward:

Lemma 4 *The unemployment rate u^* is increasing in the rate of technical progress g .*

This Lemma thus shows that faster labor-augmenting technical change leads to higher structural unemployment. To prove this result, it is enough to note that the opportunity cost of capital (11) is increasing in g , and that u^* in (10) is increasing in r^* . r^* is increasing in g because faster technical change makes “the future” look better. In order to induce workers to postpone consumption, the opportunity cost must increase.

3 Unemployment and human capital accumulation

In this section, we extend the previous framework to consider endogenous human capital accumulation.² We assume homogeneity on the embodiment of human capital on the population, e.g., the labor input of skill group i is $h_t(i)L(i)$. Then, in spite of its accumulation, human capital allows the inequality in the distribution of skills to be perpetuated over time.

Augment the production function to include human capital. That is, the production function is $F(K_t(i), v_t(i)h_t(i)L(i))$, with $v_t(i) \in [0, 1]$ as the amount of time devoted to production from the workers in skill group i .

We consider linear human capital accumulation, as in Lucas [12]. Given $h_0(i) \geq 0$ for all $i \in [0, 1]$, human capital accumulates by

$$\dot{h}_t(i) = B(1 - v_t(i))h_t(i). \quad (12)$$

The fraction of time dedicated to human capital accumulation is given by $1 - v_t(i)$. The return to this investment is given by $B > 0$. Linearity in the accumulation of human capital greatly simplifies the dynamics of the economy. This assumption implies that in a balanced growth path, all employed workers will devote the same amount of time to accumulate human capital. Unemployed individuals have no incentive to accumulate human capital since the value of those investments is zero. All workers may increase their human capital. However, the relative fraction of low skilled workers will remain the same. Low skilled workers, in other words, may acquire more human capital but, in relative terms, they would still be less skilled than other skill groups.

The ratio of consumption and physical capital to human capital for the skill group i are $c_t(i)/h_t(i)$ and $k_t(i)/h_t(i)$, respectively. Let $V_t(i)$ denote the value of an additional investment in human capital for workers of skill i at date t . Due to the linear accumulation

²Jones and Manuelli [11] have shown that $\lim_{k \rightarrow \infty} f_k(k) > 0$ generates sustained growth. In a CES function it is impossible to satisfy both unemployment and growth conditions at the same time. In order to obtain a bound as capital tends to zero (and unemployment) the elasticity of substitution must be less than one. In order to obtain a bound as capital tends to infinity (and growth) the elasticity of substitution must be bigger than one.

technology (12), the marginal valuation of human capital equals the average value of human capital. This average value is given by the present value of income

$$V_t(i) = \int_t^\infty w_s(i)v_s(i) \exp\{-\hat{R}_s(i)\} ds, \quad (13)$$

where $\hat{R}_s(i) = \int_0^s [r_x - B(1 - v_x(i))] dx$, is the effective discount rate for a typical worker in skill group i ; see, e.g., Chamley ([9], pp. 587).

Since the value of human capital depends on the wage (or the shadow price of skill), unemployed workers place no value on $h_t(i)$ and devote no time to human capital accumulation. The value of human capital in (13) satisfies

$$w_t(i)v_t(i) = [r_t - B(1 - v_t(i))] V_t(i) - \dot{V}_t(i).$$

The left-hand side represents the current earnings in production and the right-hand side represents future gains from human capital accumulation (future income gains properly discounted and value capitalizations).

By arbitrage arguments, the optimal investment in human capital must balance the losses in production, given by the shadow price $w_t(i)$, with the gains from higher human capital in the future. These future gains multiply the marginal valuation of human capital by its return: $V_t(i)B$. Thus, along an optimal human capital accumulation plan, $w_t(i) = V_t(i)B$; see, e.g., Chamley ([9], eq. 4). Substituting this expression into (13) yields

$$\dot{V}_t(i) = [r_t - B] V_t(i). \quad (14)$$

Consumption and capital evolve as in the previous section. Since these variables are normalized by the human capital of each skill group,

$$\frac{\dot{c}_t(i)}{c_t(i)} - \frac{\dot{h}_t(i)}{h_t(i)} = \frac{r_t - \theta}{\sigma} - B(1 - v_t(i)), \quad (15)$$

$$\frac{\dot{k}_t(i)}{k_t(i)} - \frac{\dot{h}_t(i)}{h_t(i)} = \frac{\phi(i)f(k_t(i), v_t(i)h_t(i))}{k_t(i)} - \frac{c_t(i)}{k_t(i)} - B(1 - v_t(i)). \quad (16)$$

Along a balanced growth path, $c_t(i)$, $k_t(i)$ and $h_t(i)$ grow at the same constant rate g , and $V_t(i)$ and the output-capital ratio are constant. Then, from (14), (15), and (16) it is possible to see there exists at most one locally-stable balanced-growth-path equilibrium with $r^* = B$ as the rental price of capital, and $g = B(1 - v^*)$, as the growth rate of income per worker; see, e.g., Barro and Sala-i-Martin ([5], pp. 183-184).³

The growth rate of income per worker can be written as $g = (B - \theta)/\sigma$. This growth rate is independent of the workers' allocation of time because it is optimal for all employed workers to devote a fixed and equal amount of time to human capital investments. (This result is a consequence of the linearity in the human capital accumulation technology.) This fraction is given by $v^*(i) = v^* = 1 - [1 - \theta B^{-1}]/\sigma$. Thus, since the level of human capital is maintained as the economy grows along the balanced growth path, the distribution of income for employed workers will remain constant. The mean level of income, however, will change.

Income per capita for skill workers $i \geq \varphi(B/\rho)$ grows at a constant rate g . Since $V^*(i) = 0$ for all $i < \varphi(B/\rho)$ in (14), unemployed workers do not accumulate human capital. Transfers are needed to ensure positive consumption for unemployed workers.

Along the balanced growth path, the growth rate of income per worker and the unemployment rate are

$$g = \frac{B - \theta}{\sigma},$$

$$u^* = 1 - \int_{\varphi(B/\rho)}^1 L(i) di.$$

These two expressions capture the central message of the paper. *An increase in the return to human capital B creates winners and losers.* Who wins? High skilled workers who will now devote more time to accumulate human capital. Their wages and earnings will grow at faster rates. Who loses? Unskilled workers who will now become unemployed.

³The problem is concave for values of σ and θ for which $r^* > g$; see, e.g., Chamley ([9], Theorem 1) and Benhabib and Perli [6]. The transitional dynamics under endogenous human capital accumulation are not straightforward; see Barro and Sala-i-Martin ([5], pp. 185), Benhabib and Perli [6], and Caballé and Santos [8]. We focus on the balanced growth path only.

4 Conclusions

This paper provided an example in which labor-augmenting technical change determines structural unemployment. The paper examined a simple neoclassical growth model and an augmented model of endogenous human capital accumulation. In the model, limited substitution possibilities between capital and labor generate a steady state or a balanced growth path with structural unemployment. The analysis has been conducted in terms of a constant distribution of skills, and structural unemployment has been used to represent obsolescence of skills. The fact that low skill workers are unable to provide enough output to cover the opportunity cost of capital implies that it is socially optimal to leave these workers unemployed.

In equilibrium, faster labor-augmenting technical change increases the opportunity cost of capital. This makes it more difficult for low skilled workers to justify, from an economic point of view, their use of a job. More workers will then become structurally unemployed. The central message that comes across this paper, a message that dates back to David Ricardo's [15] famous chapter on machinery, is that even if the overall effect of faster labor-augmenting technical change is to improve aggregate economic conditions, advances in technology create losers not only winners.

References

- [1] Agénor, P. and Montiel, P. (1996) **Development Macroeconomics**, Princeton University Press.
- [2] Aghion, P. and Howitt, P. (1994) "Growth and Unemployment," *Review of Economic Studies*, Vol. 61, 477-494.
- [3] Akerlof G. (1969) "Structural Unemployment in a Neoclassical Framework," *Journal of Political Economy*, Vol. 77, 399-407.
- [4] Akerlof G. (1981) "Jobs as Dam Sites," *Review of Economic Studies*, Vol. 58, 37-49.

- [5] Barro, R. and Sala-i-Martin, X. (1995) **Economic Growth**, McGraw Hill.
- [6] Benhabib, J. and Perli, R. (1994) “Uniqueness and Indeterminacy: On the Dynamics of Endogenous Growth,” *Journal of Economic Theory*, Vol. 63, 113-142.
- [7] Blanchard, O. and Wolfers, J. (2000) “The Role of Shocks and Institutions in the Rise of European Unemployment: The Aggregate Evidence,” *Economic Journal*, Vol. 110, C1-33.
- [8] Caballé J. and Santos M. (1993) “On Endogenous Growth with Physical and Human Capital,” *Journal of Political Economy*, Vol. 101, 1042-1067.
- [9] Chamley, C. (1993) “Externalities and Dynamics in Models of “Learning or Doing”,” *International Economic Review*, Vol. 34, 583-609.
- [10] Gordon, R. (1998) “Is There a Tradeoff Between Unemployment and Productivity Growth,” in **Unemployment Policy: Government Options for the Labour Market**, in Snower, D. and de la Dehesa, G. (Eds.), Cambridge University Press.
- [11] Jones, L. and Manuelli, R. (1990) “A Convex Model of Equilibrium Growth: Theory and Policy Implications,” *Journal of Political Economy*, Vol. 98, 1008-1038.
- [12] Lucas, R. (1988) “On the Mechanics of Economic Development,” *Journal of Monetary Economics*, Vol. 22, 3-42.
- [13] Phelps, E. (1994) **Structural Slumps**, Harvard University Press.
- [14] Pissarides, C.A., and Vallanti, G. (2007) “The Impact of TFP Growth on Steady-State Unemployment,” *International Economic Review*, Vol. 48, 607-640.
- [15] Ricardo, D. (1821, [1951]) **On the Principles of Political Economy and Taxation**, Cambridge University Press.
- [16] Turnham, D. (1993) **Employment and Development: A New Review of Evidence**, OECD Development Centre.