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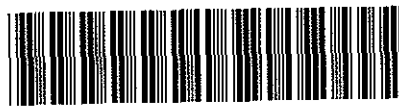
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Growth, Trade and Unemployment

by

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Growth, trade and unemployment

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Abstract

Can the substitution of workers by capital cause long run unemployment? If so, under what conditions? This paper presents an endogenous growth model where capital and labor produce two final goods in two sectors, respectively named "advanced" and "mature". Investments in the advanced sector generate knowledge externalities. The demand for workers increases with output in the advanced sector and falls in the mature productions, where inputs are gross substitutes. Trade leads to specialization. Countries specializing in mature industries experience low growth and steady-state unemployment, while economies specializing in advanced productions have full employment and higher growth rates

Keywords: growth, unemployment, international trade, factors' elasticity of substitution *JEL:* O41, E24, F12, D2

I. Introduction

When do machines substitute workers in production? When does the extent of the substitution exceed the expansion of output, so that the demand for labor falls? These issues have been at the heart of the economic literature on long run unemployment at least since the publication of the Ricardo's *Principles*. Yet very few models, especially on economic growth, deal with them explicitly. While a wide economic literature on either unemployment or growth exists, there are few studies on the interactions between the two. Most models make specific assumptions on technology and the degree of substitutability of inputs, but their effects on the economy's long run employment levels and growth rates are rarely investigated.

Turning now to the first question, it is not difficult to think that the mere *possibility* of substitution between factors in production may ultimately depend on the nature of the services supplied by the same factors. Capital goods can execute simple or very complex tasks, but they all share a common aspect: machines do not invent or innovate; all they do has been previously determined and programmed. In contrast, the distinctive character of human labor is intelligence and intuition. It is the capacity to find new ways of achieving certain goals, of modifying them and inventing new ones; it is learning, adaptation and innovation. Hence, productions that depend on human knowledge and ideas are also necessarily based on labor and human capital. An obvious example of intensive utilization of "human" inputs is the R&D sector, but they are also necessary in other sectors of the economy, where products and processes are often modified. Instead, the services of capital and labor have a substantially similar nature when the tasks they perform are completely standardized. There, at least in principle, machines can replace workers.

Many economic activities that in the past required a great deal of human labor have now been mechanized or automatized. Nowadays robots assemble cars, while forty years ago

they were constructed by human beings working along the assembly line. Textiles and other productions had been mechanized in earlier times. Computers, software programs and printing machines are replacing many human activities in the services sector. Because of them, the demand for typists has now fallen to nearly zero, and more secretarial work is likely to be performed by computer machines in a very near future.

Now, routine and repetition only imply that workers *may* be substituted by capital in mature productions, not that they will necessarily be. The appropriate technologies must first be available in the market, then capital costs must become relatively lower than labor costs. More generally, as stated by Schumpeter (Schumpeter, 1934), after a wave of technological changes and innovation, the number of job vacancies tends to grow in the new sectors of the economy and fall in the mature industries. The "old" sectors may either close down production entirely or, when there is still demand for their products in the market, modify and adapt their productive methods to the new environment. When mature industries restructure the production processes by choosing the new, labor-saving technologies, the absolute level of the sectoral demand for workers may fall even in the presence of an expanding output. This comes to the second question above. We all know from textbooks that substitution effects are stronger than income effects when inputs are gross substitutes. Less known and less explored by the literature are the conditions underlying gross substitutability in production and, principally, its implications for long run employment and growth.

Recent growth theory has associated positive long run growth of the economy with some form of knowledge accumulation (Jones and Manuelli, 1997). Human capital, learning or innovation are the ultimate sources of growth of many endogenous growth models. In most of them, however, capital and "human" inputs are gross complements in production; under normal assumptions and perfect competition, this kind of interaction is generally

consistent with a positive correlation between the level of demand for labor and the level of output.

In the writings of Pissarides (1990), Bean and Pissarides (1993), Aghion and Howitt (1994, 1998, ch.4), Mortensen and Pissarides (1998) both positive and negative interactions between employment and growth are considered. These authors offer a very effective representation of technological changes. Long run growth depends on innovation, which is a mixed force of "creative destruction". The introduction of new products in the economy creates new jobs and destroys old ones. Unemployment arises when the process is so rapid and pervasive that destructive effects prevail. Specifically, mostly it is assumed that labor is the only input and old sectors close down production altogether. However, it may be thought that the alternative hypothesis, of mature industries keeping on production and adopting capital-intensive techniques, could also be consistent with the general setting.

This paper presents an endogenous growth model where two final goods are produced in two different sectors, respectively named "advanced" and "mature". Investment in the advanced sector generates knowledge externalities that positively affect labor productivity within the same sector; there are no externalities in the mature industry. Inputs are net substitutes in both productions. However, because of externalities, labor services are of central importance in the advanced sector, while the output of the mature sector can be produced entirely with capital. The model does not explain when or how these technologies have been adopted; it can be thought that it happened at a certain point of time in the past, after a generalized technological change.

International trade affects the long run employment levels and growth rates of countries. There is full employment in autarky. With trade, some countries specialize in the mature productions. As a consequence, they experience low real growth rates and long run unemployment. In contrast, countries producing the advanced goods have full employment

and higher growth rates. The paper is organized as follows. Section II.1 presents the model and the autarkic equilibrium configurations. Section II.2 analyses the effects of international trade on employment and growth. Section III concludes.

II. The model

II.1. Autarky

Production Two final goods Y_1 and Y_2 are produced with constant elasticity of substitution technologies (CES) and two inputs, capital, K , and labor, L . Capital is produced in sector 1, while the aggregate labor force, L , is constant. Production in sector 1 generates knowledge externalities. Following Romer (1986) and Arrow (1962), it is assumed that knowledge creation is a side product of investment within the same sector. A firm that increases its capital learns simultaneously how to produce more efficiently. This learning by doing, or learning by investing, leads to a labor augmenting technology for firm i in sector 1. The productive technology of firm i in sector 1 is:

$$Y_{i1} = [(\phi K_i)^{-\nu} + (A_i u L_i)^{-\nu}]^{-1/\nu} \quad (1)$$

where A_i is the index of knowledge available to the firm, and ϕ and u are, respectively, the proportions of K and L utilized in the production of good 1. As knowledge accumulates as a consequence of each firm's investment, an increase in the capital stock of a firm producing in sector 1 leads to a parallel increase in its stock of knowledge, A_i . Each firm's knowledge is a public good that any other firm within the sector can access at zero cost. Hence, the change in each firm's technology term, \dot{A}_i , corresponds to the sector's overall learning and is therefore proportional to the change in the capital stock, \dot{K} . In what follows it is assumed that $A_i = \phi K$; consequently, A_i may be replaced by ϕK in equation (1), and the production function for firm i can be written as $Y_{i1} = [(\phi K_i)^{-\nu} + (\phi K_e u L_i)^{-\nu}]^{-1/\nu}$, with the term ϕK_e intended to capture the external effect of the stock of capital within sector 1. The term (AuL)

$= (\phi K_e u L)$ is effective labor or "human capital". Firms behave competitively and knowledge accumulation is entirely external; therefore, for given ϕK and $u L_i$, each firm faces diminishing returns to K_i . However, if each producer in the sector expands K_i , ϕK rises accordingly and provides a spillover benefit that raises the productivity of all firms producing good 1.

In equilibrium all firms make the same choices, hence the industry's production function is:

$$Y_1 = [(\phi K)^{-\nu} + (\phi K_e u L)^{-\nu}]^{-1/\nu} \quad (1')$$

In this economy, $K_e = K$, i.e. the external effect of investment on the productivity of L in sector 1 equals the capital stock. Therefore, at the sector level, the production function of equation (1') is linear in K and increasing returns in both factors.

Good 2 is produced with a CES technology with the same parameter ν of sector 1. Here, however, production does not generate knowledge externalities and returns to scale are decreasing, both at the firm and the sectoral level. The sectoral production function, corresponding to the sum of many individual and identical productions functions, is:

$$Y_2 = \left\{ [(1-\phi)K]^{-\nu} + [(1-u)L]^{-\nu} \right\}^{-\frac{\alpha}{\nu}} \quad 0 < \alpha < 1 \quad (2)$$

The value of the parameter α , representing the function's degree of homogeneity is below unity. Since ν is the same in the two sectors, the two production functions have the same elasticity of substitution, corresponding to $\sigma = 1/(1+\nu)$.

The two productive factors are good substitutes in both productions of the economy. Specifically, it is assumed that they are net substitutes; i.e. the value taken by σ is above unity, $\sigma = 1/(1+\nu) > 1$, and $-1 < \nu < 0$. This concept of substitutability indicates that, for a given level of output, the quantities of each input utilized in productions change more than proportionately when their relative prices change. In other terms, a lower relative price of

capital leads to a sensible fall in the number of workers employed to produce that given output. This measure of substitutability, however, says nothing about the sign of the total variation, i.e. on the quantity of labor services utilized once the change in output, that follows the price variation, is considered. This final effect refers to the gross elasticity of substitution, which is the measure that lies behind the interactions taking place between the uncompensated demand for labor, the accumulation of capital and the growth of output.

How are these two concepts, of net and gross elasticity of substitution, related? In a pioneering paper, Arrow et al. (1961) made clear that a value of the elasticity parameter higher than unity, $\sigma > 1$, is a sufficient condition for net substitutability. In that case, output can be entirely produced with one of the two inputs; the other, consequently, can be considered "inessential". Later, Dasgupta and Heal (1974) and Krautkramer (1986), analyzed the possibility of positive long run growth in the presence of exhaustible resources, when technologies are CES and σ is above 1. They evidenced that the productive share of the exhaustible, or "scarce", input tends to vanish with accumulation. Hence growth was feasible. The result was interesting but also puzzling: as the productive share of the scarce resource vanished, its marginal productivity and demand grew to infinity.

On the contrary, when inputs are gross substitutes the absolute level of the demand for the scarce input, not just its share, decreases with output growth. The condition of gross substitution in production is:

$$\frac{1}{1+\nu} = \sigma > \frac{1}{1-\alpha} \quad (3)$$

i.e. inputs are gross substitutes when the net elasticity of substitution, σ , is higher than the reciprocal of one minus the function's degree of homogeneity. This inequality can be derived from the Hicks-Allen formulation of the (net) elasticity of substitution (Chambers, 1988; Puu

1966). It holds only for values of α lower than unity. Hence, gross substitutability is ruled out for homogeneous functions of degree higher or equal than 1.

The present economy is characterized by a value of σ that is above $1/(1-\alpha)$. Hence, inputs are net substitutes in both sectors, but they are gross substitutes only in sector 2. A parallel condition for gross substitutability corresponds to a negative sign of second order crossed derivatives in production.¹

These derivatives take a negative sign in the production of the mature good. They correspond to $Y_{2LK} = Y_{2KL} = \alpha(v+\alpha) \frac{Y_2^{\frac{2v+1}{\alpha}}}{[(1-u)L(1-\phi)K]^{\frac{1}{\sigma}}} < 0$. The sign is negative because $(v+\alpha) < 0$, which, in turn, derives from inequality (3).² Hence, the marginal productivity of labor is an inverse function of the capital stock. Also, labor can be defined as fully inessential for the production of good 2: both its productive share and its demand diminish as capital accumulates.³

The same derivatives in the production of good 1 take a positive sign. As indicated also by inequality (3), inputs there are gross complements (see Appendix A). The productive technology of sector 1, however, differs from usual case of inputs inessentiality. Inputs are inessential in CES functions with $\sigma > 1$ and constant returns to scale (Arrow et al., 1961), but

¹ The Hicks-Allen elasticity of substitution may be written as $\sigma = \frac{-f_i f_j (f_i x_i + f_j x_j)}{(f_{ii} f_j^2 - 2f_{ij} f_i f_j + f_{jj} f_i^2) x_i x_j}$,

where $y = f(x_i, x_j)$ is the production function, subscripts of $f(\bullet)$ indicate partial derivatives and $\alpha \leq 1$ is the degree of homogeneity. With gross substitution it must be that $\sigma > \frac{-\alpha y}{(f_{ii} x_i^2 + 2f_{ij} x_i x_j + f_{jj} x_j^2)}$. The latter

inequality, which in the case of homogeneous functions corresponds to (3), is satisfied only for $f_{ij} < 0$.

² Subscripts denote the derivatives of sectoral output with respect to the inputs utilized in the same sector, hence Y_{ji} corresponds to the derivative of the output produced in sector i ($i=1,2$) with respect to the share of factor j ($j=K,L$) utilized in i .

³ Variables with subscripts, as K and L , indicate partial derivatives, while total differentiation is indicated by $d(\bullet)$.

not in the present case, of increasing returns. More specifically, because of externalities, production in sector 1 is characterized by gross complementarity and by the constancy of the scarce input productive share. It is easy to see that $Y_{1L}uL/Y_1$ has a constant value as K goes to infinity. This means that the importance of the labor inputs in production does not diminish with accumulation.

In sum, increasing returns to scale (IRS) in sector 1, decreasing returns to scale (DRS) in sector 2 and competitive firms characterize the economy. It is well known in the literature on production and trade that economies of this kind may have non-concave production possibilities frontiers (PPF) and inefficient equilibrium solutions. Most of the literature, however, focuses on output-generated externalities (Herberg and Kemp, 1969; Panagariya, 1981; Helpman, 1984) while in this model of the economy externalities depend on the stock of K and hence on a productive input. This leads to both input and output inefficiencies. In general, there is output inefficiency when the market-determined equilibrium production mix is sub-optimal; with optimality, a higher proportion of the IRS sector's output would be produced. There is an input-inefficiency when, in addition, the inputs' mix is sub-optimal: a redistribution of the two inputs across sectors would increase the overall production. In the present case, an increase in the proportion of K employed in sector 1 would increase total output.

The shape of the PPF depends on the optimal allocation of factors across sectors, while relative prices and the market allocation of inputs are determined by the agents' calculations of marginal productivities. The market allocations of inputs are given by:

$$\left(\frac{1-\phi}{1-u}\right)^{\frac{1}{\sigma}} = \left(\frac{\phi}{u}\right)^{\frac{1}{\sigma}} (\phi K)^{-v} \quad (4)$$

The equation highlights some important features of the economy. In the first place, factors' proportions are not constant but depend on the level of the capital stock. However, except for the special case of $(\phi K) = 1$, sector 2 is more physical capital intensive than sector 1, while sector 1 is human capital intensive. In the second place, for any given value of K , ϕ is a function of u in R^+ . This can be seen by rewriting equation (4) as $\frac{1-\phi}{\phi^\sigma} = \frac{1-u}{u} K^{-\nu\sigma}$, or equivalently as $\tau\phi^\sigma + \phi - 1 = 0$, where $0 < \tau = \frac{1-u}{u} K^{-\nu\sigma} < \infty$. This function has a positive root, with a value that increases with u (u and ϕ positive and lower than unity). Hence ϕ is a positive and monotone function of u in R^+ .

Given perfect competition and the equalization of marginal productivities of inputs across sectors, $Y_{1K} = pY_{2K}$ and $Y_{1L} = pY_{2L}$, relative prices are:

$$p^{-1} = \frac{\alpha Y_2^\alpha [(1-\phi)K]^{-\frac{1}{\sigma}}}{Y_1^\sigma (\phi K)^{-\frac{1}{\sigma}}} = \left(\frac{\phi}{1-\phi} \right)^\sigma \frac{\alpha Y_2^\alpha}{Y_1^\sigma} \quad (5)$$

Now, as the derivation of the shape of the *PPF* includes the effects of externalities, the marginal productivity of capital in sector 1 is higher than in agents' calculations. Hence, the optimal allocation of resources across sectors is:

$$\left(\frac{1-\phi}{1-u} \right)^\sigma = \left(\frac{\phi}{u} \right) \frac{(\phi K_e)^{-\nu}}{1+(uL)^{-\nu}} \quad (4')$$

With a higher marginal productivity of capital in sector 1 a higher proportion of the input goes to the production of good 1. Note that in the usual case of output-generated externalities, equations (4) and (4') coincide. The slope of the *PPF* is given by:

$$\frac{dY_2}{dY_1} = \frac{(\phi K) \alpha Y_2^{\alpha \frac{\nu+1}{\sigma}}}{[(1-\phi)K]^\sigma Y_1} = [1+(uL)^{-\nu}]^{-1} \left(\frac{\phi}{1-\phi} \right)^\sigma \frac{\alpha Y_2^\alpha}{Y_1^\sigma} \quad (6)$$

The second order conditions of efficient production show that the *PPF* is convex in the proximity of $Y_1 = 0$ (the *IRS* commodity), it is concave in the proximity of $Y_2 = 0$ (the *DRS* commodity) and has only one inflection point (see Appendix A).

In most two-sector models with an *IRS* and a *DRS* sector and output-generated externalities, equilibrium is given by a lack of tangency between the price line and the *PPF*. It evidences the inefficiency of the outputs' mix but, since the inputs' mix is efficient, equilibrium is on the frontier (Helpman, 1984). The present model is characterized by both input's and output's inefficiency, hence equilibrium, to be specified after consumers' preferences are known, will lie below the efficient productive frontier.

The equilibrium allocations of inputs that correspond to given stock of K lead to a whole sub-optimal productive possibilities frontier. It is depicted by equation (6) and in what follows will be denominated *PPF_m*, while *PPF_o* will indicate the optimal frontier. Starting from any point of the *PPF_m*, excepting $Y_1 = 0$, the level of total output can be improved by modifying the shares of inputs across sectors. Specifically, for any given value of u , a higher share of capital, ϕ , going to sector 1 increases the production of good 1 more than it decreases the production of good 2. Hence the *PPF_m* runs below the optimal frontier, *PPF_o*.

The shape of the efficient frontier is determined by re-writing equation (4') as $\zeta\phi^\sigma + \phi - 1 = 0$, where $0 < \zeta = \frac{1-u}{u} \frac{K^{-\nu\sigma}}{1+(uL)^{-\nu}} < \infty$. Also in this case the function has a positive

root that is a monotone function of u in R^+ , but now, for any given u , the coefficient ζ takes a lower value than the coefficient τ above; consequently, each value of the root is higher. In

other terms, the optimal value of ϕ , the share of the capital stock going to sector 1, is higher than in the market-determined case (see Appendix B). When a higher value of ϕ is inserted in equation (6), the absolute value of $\frac{dY_2}{dY_1}$ diminishes. This implies that the shape of the PPF_o is smoother than the shape of the PPF_m . The two productive frontiers are depicted in Figure 1. They meet at point $Y_1 = 0$, where externalities have no effects, and reach the maximum distance at $Y_2 = 0$.

At equilibrium, the equalization between prices and the PPF_m is given by:

$$p^i = - \left[\frac{Y_1}{\phi K} \right]^{-\nu} \frac{dY_2}{dY_1} = - \left[1 + (uL)^{-\nu} \right] \frac{dY_2}{dY_1} \quad (7)$$

The term $[1 + (uL)^{-\nu}]$ is higher than one; as a consequence the price line is steeper than the PPF_m and the economy equilibrium is located at the right of the inflection point. The price line is also steeper than the PPF_o . The economy's equilibrium position is depicted in Figure 1.

Physical capital is produced in industry 1, i.e. good 1 can be indifferently used for consumption or for capital accumulation:

$$\dot{K} = Y_1 - C_1 \quad (8)$$

Investment is irreversible, $\dot{K} \geq 0$, $K(0) > 0$. C_1 is the consumption of good 1.⁴ To simplify matters, it is assumed no capital depreciation. Capital goods are used to produce physical capital and both final goods.

⁴ The dot notation is used for the time derivative, so $\dot{K}_t = dK_t / dt$. Time subscripts are omitted in the text.

The supply of labor coincides with the labor force, except for very low levels of the wage rate, where it becomes perfectly elastic. More specifically, it is assumed that above a certain threshold, workers experience no labor disutility. The negative amount of utility may be thought of as a fixed cost of working, related, for example, to commuting. The reservation wage is just above zero. In what follows it will be designated by \underline{w} . For any value of w above \underline{w} , the labor supply coincides with the labor force, for $w = \underline{w}$, it is perfectly elastic, for $w < \underline{w}$ it is nil.⁵

Consumption Infinitely lived agents with the same utility function maximize the intertemporal consumption of goods 1 and 2:

$$U = \int_0^{\infty} e^{-\rho t} \ln [v(C_1, C_2)] dt, \quad (9)$$

C_2 represents the consumption of good 2, and $0 < \rho < 1$ is the rate of time preference. The instantaneous utility function is a Cobb Douglas:

$$v(C_1, C_2) = C_1^{\beta} C_2^{1-\beta} \quad (9')$$

At any given point of time, relative prices equal marginal utilities:

$$p = \frac{u_1(c_1, c_2)}{u_2(c_1, c_2)} = \frac{1 - \beta C_1}{\beta C_2} \quad (10)$$

⁵ For the sake of simplicity we have omitted the specification of labor disutility. However, an instantaneous utility function separable in consumption income and leisure, with a constant disutility of labor or utility of leisure, easily leads to a reservation wage without modifying the model's main results.

Good 1 is the *numeraire*, so $p = (1, p_2/p_1)$. Solving for the consumption ratio, it follows that $\frac{C_2}{C_1} = \frac{1-\beta}{\beta} p^{-1}$. Hence both goods will be produced.

Since $v(C_1, C_2)$ is homogenous of degree one, the corresponding expenditure function can be written as $E = \pi(p_1, p_2)v$, where π can be thought of as a cost of living index (it is formally the unit cost function for (5')). It follows that utility can be expressed as $v = E/\pi(p_1, p_2)$, or expenditure deflated by the cost of living index. By substituting it in (9), the expression for utility becomes:

$$U_t = \int_0^{\infty} e^{-\rho t} [\ln E - \ln(p_1, p_2)] dt \quad (9'')$$

In this economy, the representative consumer maximizes (9'') subject to (8), with $K(0) \geq 0$. This implies that the optimal growth rate for expenditure is solely a function of the interest rate and the rate of time preference:

$$\frac{\dot{E}}{E} = r - \rho \quad (11)$$

Equilibrium Given the above assumptions on utility and production, equilibrium is unique and lies in the concave section of the productive frontier. The equalization of demand and supply in the system corresponds to: $\frac{1-\beta}{\beta} \frac{C_1}{C_2} = \frac{Y_{1K}}{Y_{2K}}$. Substituting C_1 by the capital accumulation equation and dividing numerator and denominator of the LHS by K , the expression becomes $\frac{(1-\beta)Y_1/K - \gamma_K}{\beta Y_2/K}$. By substituting at the RHS the marginal productivity of capital in each sector, it is:

$$\phi x - x^{\frac{1}{\sigma}} + \rho = \frac{M}{\alpha} (1-\phi) x^{\frac{1}{\sigma}} \left\{ 1 + \left[\frac{(1-u)L}{(1-\phi)K} \right]^{-\nu} \right\} \quad (12)$$

$x = [1+(uL)^{\nu}]^{1/\nu}$ and $M = \beta/(1-\beta)$. Since the RHS of the expression is necessarily positive, the LHS must also be positive. Therefore, the minimum value of u (strictly positive) satisfies this condition, and ϕ is determined accordingly (see Appendix B). Hence, equilibrium exists. Regarding uniqueness, we already know that given K/L , parameters ϕ and u are positively and uniquely related. Furthermore, by simultaneously solving equations (12) and (4) it follows that, given K/L and the other parameters of the system, there is a unique couple of u and ϕ that satisfies both equations. Now, letting K/L vary, it is possible to see that, along the equilibrium configurations, to higher values of K/L correspond higher values of u (up to the latter's limit value of 1). No other simultaneous adjustment of u , or ϕ , following an increase in K , can simultaneously satisfy both equations. The positive correlation between u and K across equilibrium solutions is consistent with the positive value of the second order cross derivatives of production in sector 1 and the negative value of the same derivatives in sector 2. In other terms, the equilibrium share of the labor force employed in sector 1 increases with the economy's capital stock.

Dynamics. Equations (4) and (4') above evidenced that sectoral inputs' shares vary with the size of the capital stock (or, equivalently, with K/L). Initially, the general form of the system's dynamic equilibrium solutions is determined by taking the values of these shares as given. Subsequently, the long run values of the shares themselves are derived. Finally, the model's steady state solutions are fully specified.

The two sectors' outputs growth rates can be determined by differentiating with respect to time the two production functions. Equation (1') can be written as $Y_1 =$

$\phi K [1 + (uL)^{-\nu}]^{1/\nu\sigma}$. Its differentiation with respect to time shows that sectoral output and capital grow at the same rate: $\dot{Y}_1/Y_1 = \dot{K}/K$. Instead, the differentiation of equation (2) evidences that the production of good 2 grows at a rate that is lower than the capital rate of growth: $\dot{Y}_2/Y_2 = \alpha \{1 + [(1-u)L/(1-\phi)K]^{-\nu}\}^{-1} \dot{K}/K$. For $K \rightarrow \infty$, the production of good 2 becomes a constant fraction, lower than one, of the capital growth rate, $\dot{Y}_2/Y_2 = \alpha \dot{K}/K$.

The price time variation can be derived from the equilibrium conditions $p = \frac{1-\beta}{\beta} \frac{C_1}{C_2} = \frac{Y_{1K}}{Y_{2K}}$. As above, the second term of the equality may be re-written as:

$p = [(1-\beta)/\beta] \times [(Y_1 - \dot{K})/K] / (Y_2/K)$. The growth rate of capital is constant at the steady state; therefore all terms at the numerator of the RHS are constant and the long run rate of price variation is $\dot{p}/p = \dot{K}/K - \dot{Y}_2/Y_2$. The complete specification of the growth rate

of output in sector 2 shows that the relative price variation is a function of the capital growth rate, $\frac{\dot{p}}{p} = \left\{ 1 - \frac{\alpha}{1 + [(1-u)L/(1-\phi)K]^{-\nu}} \right\} \frac{\dot{K}}{K}$, and that for $K \rightarrow \infty$, it becomes a constant fraction, $1-\alpha$, of the capital growth rate.

Hence output in sector 1 grows at the capital growth rate, output in sector 2 grows at a lower pace and the price variation equals the difference between the two. These growth rates can be specified in terms of the economy parameters only after specifying the capital growth rate. To this end, let us consider equation (11), on the expenditure growth path. The real interest rate for loans denominated in capital goods (or in good 1), r_1 , is different from that of good 2 denominated loans, r_2 . With perfect competition and constancy of the marginal productivity of capital in the sector that produces capital goods, equilibrium in the capital market requires that $r = r_1$, with $r_1 = Y_{1K}$. A standard arbitrage argument implies that

the interest rate for good 2 denominated loans in terms of good 1 is related to r_1 by $r_2 + \dot{p}/p = r_1 = [1 + uL^{-\nu}]^{-1/\nu\sigma}$. In terms of good 1, the rate of interest equals the marginal productivity of capital in this sector; the substitution of the latter in equation (11) leads to the equilibrium growth rate for expenditure, which is:

$$\frac{\dot{E}}{E} = [1 + uL^{-\nu}]^{1/\nu\sigma} - \rho \quad (13)$$

Since capital grows at a constant rate at the steady state, the two terms at the RHS of equation (8) divided by K , $\dot{K}/K = Y_1/K - C_1/K$, must grow at the same rate. In other terms, investments and the consumption of good 1 vary at the same rate. At the same time, because of Cobb-Douglas preferences, the consumption and expenditure of good 1 grow at the same rate. Therefore, also capital and expenditure grow at the same rate: $\dot{K}/K = C_1/C_1 = \dot{E}/E = [1 + (uL)^{-\nu}]^{1/\nu\sigma} - \rho$. The growth rates of good 2 and prices are now easily determined, they are, respectively: $\dot{Y}_2/Y_2 = \alpha \{ [1 + (uL)^{-\nu}]^{1/\nu\sigma} - \rho \}$ and $\dot{p}/p = (1-\alpha) \dot{K}/K = (1-\alpha) \{ [1 + uL^{-\nu}]^{1/\nu\sigma} - \rho \}$.

For given values of u these growth rates are constant and, given the above assumption of $0 < \rho < 1$, they are also strictly positive. Hence output, consumption and capital always grow at positive rates that can take any value between the lower bound, given by the minimum value of u in equation (12), which is strictly positive, (hence the lowest feasible growth rate is higher than $1-\rho$) and the upper bound corresponding to $[1 + L^{-\nu}]^{1/\nu\sigma} - \rho$ (where $u=1$).

Long run sectoral equilibrium inputs' shares can now be determined. Equation (4) shows that, as the capital stock expands, sector 2 becomes more and more capital intensive

with respect to sector 1. With the relative price of capital decreasing, workers shift from sector 2, where the demand for their services falls, to sector 1, where productivity and wages continuously increase. The process ends with the labor force being entirely employed in the production of good 1. At this point the mature good is produced only with physical capital, while the "advanced" good is produced with physical and human capital. This sectoral distribution of the productive inputs characterizes the steady state: u takes the value of 1, while the long run equilibrium value of ϕ is below unity (Appendix B).

In sum, capital accumulates at a rate that is always positive; this determines a continuous increase of labor productivity in sector 1 and a continuous fall in sector 2. Workers move to sector 1 and the supply of labor in sector 2 shrinks. Along this reallocation process, wages are equalized across sectors, but at the steady state their values diverge: they are positive and increasing in sector 1 and zero in sector 2. Workers are fully employed and the minimum wage, w , represent a non-binding condition.

At this point, by substituting the long run value of u in the growth rate equations, the economy steady state solutions can be fully characterized: they are $\gamma_{C1} = \gamma_{Y1} = \gamma_K = \gamma_E = [1+L^\nu]^{1/\nu\sigma} - \rho$, and $\gamma_{C2} = \gamma_{Y2} = \alpha\gamma_K = \alpha[1+L^\nu]^{1/\nu\sigma} - \rho$. In the long run, variables grow at constant but unequal rates. The variation of prices is $\gamma_p = (1-\alpha) \{[1+L^\nu]^{1/\nu\sigma} - \rho\}$.

Steady state optimal growth rates are: $\gamma_{C1} = \gamma_{Y1} = \gamma_K = \gamma_E = [1+L^\nu]^{1/\nu} - \rho$, and $\gamma_{C2} = \gamma_{Y2} = \alpha[1+L^\nu]^{1/\nu} - \rho$; with $\sigma > 1$, they are all higher than market rates. Therefore, in autarky the economy is characterized by steady state positive growth, under-investment and underproduction of good 1 but full employment.

II.2. International trade

World markets are characterized by perfectly free trade and a continuum of small countries having the same preferences, technology and labor endowments, L . Therefore, prices in all countries equal world prices, $(1, p^*)$, and each country takes p^* , the terms of

trade, as given. There is complete international mobility of capital and commodities and no international labor mobility. International trade starts with countries having reached the steady state. Internal relative prices are not constant at the steady state, they will generally differ between countries, and hence goods will be exchanged. The determination of the patterns of trade will depend on preferences and the shape of the productive frontier.

Since countries' productive frontiers are partly convex and partly concave, in principle the effects of trade on production may be both of complete specialization and of differentiation. It will now become clear that, depending on each country's comparative advantage, either result may apply. Panagariya (1981) evidences the static effects of international trade on economies where production takes place with an *IRS* and a *DRS* sector and labor is the only productive input. The author shows that a small open economy will never specialize completely in the *IRS* commodity, but may specialize completely in the *DRS* industry. The model by Herberg and Kemp (1969) describes a two-sector economy with two productive inputs. They consider a closed economy where, as in Panagariya (1981), externalities are output-generated. In what follows it is shown that some of these authors' results apply to the present description of the economy, where externalities are output generated and there is economic growth.

Sectoral cost functions are useful to determine the specialization patterns. For given terms of trade, each country production and exchange decisions depend on the relative costs of producing the two goods. These private relative costs of production can be written as $C_{1Y}/p_2 = C_{1Y}/C_{2Y}$ and $C_{2Y}/p_1 = C_{2Y}/C_{1Y}$, i.e. as the marginal cost of producing each good in terms of the price of the other good. Given perfect competition and pure externalities, prices equal marginal costs. Taking into account the private determination of marginal productivities (equations (C.3) and (C.4) of Appendix C), relative marginal cost functions are:

$$C_{1Y_1} = \left\{ M^{\frac{1}{\nu\sigma}} - \frac{1}{\sigma\nu} M^{\frac{1}{\nu\sigma}-1} (\phi K)^{-2} \left(\frac{\phi K}{Y_1} \right)^{\frac{1}{\sigma}} \right\} \left\{ \frac{1}{\alpha} Y_2^{\frac{1}{\alpha}-1} T^{\frac{1}{\sigma\nu}} \right\}^{-1} \quad (14)$$

$$C_{2Y_2} = \frac{1}{\alpha} Y_2^{\frac{1}{\alpha}-1} T^{\frac{1}{\sigma\nu}} \left\{ M^{\frac{1}{\nu\sigma}} - \frac{1}{\sigma\nu} M^{\frac{1}{\nu\sigma}-1} (\phi K)^{-2} \left(\frac{\phi K}{Y_1} \right)^{\frac{1}{\sigma}} \right\}^{-1} \quad (15)$$

where $M = r^{\sigma\nu} + (\phi K)^{-1} w^{\sigma\nu}$ and $T = r^{\sigma\nu} + w^{\sigma\nu}$

The marginal cost of producing good 1, C_{1Y_1} , decreases as the sectoral output expands, (though it is perceived as constant by firms), while the marginal costs of production of sector 2, C_{2Y_2} increase with production.

Now, as the economy approaches complete specialization in the *IRS* commodity, the output of the *DRS* good approaches zero. Equation (14) yields:

$$\lim_{Y_2 \rightarrow 0} C_{1Y_1} = \infty \quad (14')$$

That is, as the economy approaches complete specialization in the *IRS* good, the private marginal cost of producing it approaches infinity. Therefore, unless the price of the *IRS* good is infinity, firms will not find it profitable to produce it near the point of complete specialization; for finite prices, complete specialization in it will necessarily be finite.

Also, note that complete specialization in the *DRS* commodity implies that the output of the *IRS* commodity be zero. In this case,

$$\lim_{Y_1 \rightarrow 0} C_{2Y_2} = 0 \quad (15')$$

As the economy approaches the point of complete specialization in the *DRS* commodity, the private marginal cost of producing the latter approaches zero. Therefore, so long as the price of the *DRS* commodity exceeds zero, firms will find it profitable to produce near the complete specialization point. It follows that complete specialization in the *DRS* industry can take place.

FIGURE 2

For any given level of the terms of trade p^* , countries with internal relative prices, p , higher than p^* will maximize the value of their production by relatively specializing in good 1. Symmetrically, economies with $p < p^*$ will choose to produce more of good 2, but in this case specialization will be complete. Equation (13) shows that, at equilibrium, relative prices are steeper than the *PPF* and equation (14) that the relative marginal costs of specializing in good 2 tend to the limit value of zero. Therefore, as depicted in Figure 2, in countries where $p < p^*$, the production of good 1 will not take place along the range where the price line is flatter than the *PPF*. The shifting of resources to sector 2 induced by trade will be complete.

Hence, for any given p^* we can calculate the world supply of good 1 by summing (or integrating) the countries' production of this good, and the same may be done for good 2. Clearly the supply of good 2 is an increasing function of p^* , and of good 1 a decreasing function, so that the ratio Y_2/Y_1 of total quantities supplied increases as p^* increases.

Now, world demand with identical homothetic preferences is just the same decreasing function of p^* that described each country's demand in autarky: $p^* = [(1-\beta)/\beta]C_1/C_2$. Hence this static model determines the equilibrium terms of trade. It is now useful to consider the

possibility that some of the countries may shift from their initial pattern of specialization. It is not difficult to see that if this happens, it will concern countries specializing in good 1, because their terms of trade are deteriorating. With Cobb Douglas preferences, the inequality that rules out this possibility is $(\gamma_{c1} - \gamma_{c2})/\gamma_{c1} \leq 1$ (where γ_{ci} , $i=1,2$, are the growth rates of the consumption of goods 1 and 2 and the goods' elasticity of substitution is equal to 1). A sufficient condition for the inequality to hold is $\dot{Y}_2/Y_2 \geq 0$. Therefore, in this economy there is no producer switching. The steady state dynamics of prices can be read directly from the demand schedule: $\dot{p}^*/p^* = \gamma_{c1} - \gamma_{c2}$, or

$$\frac{\dot{p}^*}{p^*} = (1-\alpha) \frac{\dot{K}}{K} = (1-\alpha) \left[(1+L^{-\nu})^{\frac{1}{\nu\sigma}} - \rho \right] \quad (16)$$

i.e., the world price variation is a positive function of the quantity of labor, L , employed in the production of good 1 by the representative country that relatively specializes in this sector. The real growth rate of countries producing good 1, γ_{Y1} , is $[1+L^{-\nu}]^{1/\nu\sigma} - \rho$, while that of countries specialized in the production of good 2, in terms of the same good, γ_{Y2} , is $\alpha[1+L^{-\nu}]^{1/\nu\sigma} - \rho$. Therefore, the real growth rates of countries specialized in mature and advanced productions differ; however, given the Cobb-Douglas form of preferences, nominal growth rates are equal: $\dot{Y}_2/Y_2 = \alpha \dot{Y}_1/Y_1 + \dot{p}/p$.

Moreover, this sectoral specialization affects countries' employment levels. Countries having a comparative advantage in the mature industry will completely specialize in it. They will import good 1 both for consumption and for investment. Since this good's relative price continuously falls in the international markets, firms will choose to substitute workers with imported capital goods. It is not difficult to show that these countries' demand for the

services of labor falls as output expands. The labor demand schedule can be derived from the cost function of sector 2 (equation (C.4) of Appendix C); it positively depends on the level of

income and the relative price of capital goods: $L^d = Y_2^\alpha \left[\left(\frac{r}{w} \right)^{\nu\sigma} + 1 \right]^{\frac{1}{\nu}}$. Its variation

through time is: $\frac{\dot{L}^d}{L^d} = \frac{\dot{K}}{K} + \sigma \frac{\left(\frac{r}{w} \right)^{\nu\sigma}}{\left(\frac{r}{w} \right)^{\nu\sigma} + 1} \frac{\dot{r}}{r}$. Labor demand positively depends on the growth

rate of the price of capital, r , and on capital accumulation. The price of capital equals the price of good 1 and, in terms of good 2, continuously diminishes. Specifically, it varies exactly in the opposite direction and at the same speed of the terms of trade. Thus

$\frac{\dot{L}^d}{L^d} = \left\{ 1 - \sigma \frac{\left(\frac{r}{w} \right)^{\nu\sigma}}{\left(\frac{r}{w} \right)^{\nu\sigma} + 1} (1-\alpha) \right\} \frac{\dot{K}}{K}$. With (r/w) decreasing through time and $\nu < 0$, the term

$(r/w)^{\nu\sigma}$ tends to infinity. L'Hôpital's rule applied to the equation's coefficient shows that the labor demand long run variation is

$$\frac{\dot{L}^d}{L^d} = -(1-\alpha) \left[\sigma - \frac{1}{1-\alpha} \right] \frac{\dot{K}}{K} \quad (17)$$

With $\sigma > 1/(1-\alpha)$, the demand for labor falls as output expands.⁶ Hence, workers will be replaced by capital goods.

⁶ The same relation applies in autarky. There the variation of r in terms of good 2 equals the marginal productivity of capital in that sector, i.e. $\dot{r}/r = [(v+\alpha) - (1+v)] \dot{K}/K = -(1-\alpha) \dot{K}/K$.

Now, as previously stated, the labor supply schedule is horizontal at a low but strictly positive wage level, w . This reservation wage does not constitute an effective restriction in countries that produce both goods but it does represent a binding constraint in economies specialized in the mature productions. There, steady states are characterized by unemployment and low growth wages. Differently, countries producing the "active learning" commodity have higher real growth rates of income and full employment.

Unemployment in this model depends on the economies' productive specialization, rather than on rigidities in the labor markets. Unlike the often-made assumptions on wage rigidity, here wages are not fixed above the equilibrium value corresponding to full employment but are well below it. It is rather the latter that, falling as output expands, encounters the minimum wage and determines unemployment. In this context, lower levels of the minimum wages could delay the time of workers' lay-offs, but would not reverse the underlying tendency of the demand for labor to fall.⁷

The static welfare effects of trade are as usual: both groups of countries gain from the exchange of commodities. Incomes' levels, however, differ. Economies that started the growth process earlier and now specialize in good 1, in autarky had higher incomes. The gains from trade may be unevenly distributed across countries, but not to the point of canceling or reversing the initial differences. Hence countries with initially higher incomes will remain richer. At the same time, since nominal growth rates are equal across countries, trade has no dynamic welfare effects. Unemployed workers of countries producing mature goods perceive the incomes deriving from the property of the capital goods, which grow at the same nominal rate of the other countries' incomes. Nevertheless, with international labor

⁷ Note that under the traditional assumptions of inputs' net substitutability but gross complementarity (*CES* technologies with $\sigma > 1$ and constant returns to scale; Arrow et al. 1961) the reservation wage would not have any effect. There, even with a decreasing labor share, the labor demand grows with output. Hence, no fixed (or decreasing) minimum wage could prevent full employment in the long run.

mobility these workers would choose to migrate to the richer economies where they would also perceive wages and, consequently, have higher incomes.

The model's policy implications can only be very simply sketched; they naturally relate to the economy's productive structures. The welfare of countries specialized in mature productions increases with higher employment and output levels. In this context, however, traditional incomes' and commercial policies are ineffective in the long run. Given the continuous fall of the demand for labor services, a reduction in the level of the minimum wage could delay but not cure the unemployment problem. Similarly, given the constant deterioration of the advanced goods' terms of trade in international markets, the "infant industries" born as a consequence of the trade barriers, would not become competitive, even in the long run. Hence, an acceleration of the knowledge accumulation rate appears to be a necessary condition for a country to close the employment and income gaps, but it implies the production of advanced goods that are competitive in the world markets.

III. Concluding remarks

Machines tend to be used to substitute workers in productions where the distinctive characters of human activity, intelligence and intuition, are not needed. This happens especially in economies where capital goods can be conveniently utilized to replace labor. By contrast, economies where human capital is relatively abundant tend to specialize in the advanced productions, where the latter input is more needed. Hence, world markets are characterized by countries that produce advanced goods and have high growth rates and employment levels and by countries that specialize in standardized or mature productions and experience steady state unemployment and low growth.

This paper has assumed that consumers have Cobb Douglas preferences. With slightly different assumptions, for example *CES* preferences and a high elasticity of substitution, the

share of expenditure in the mature good might gradually fall to zero. This could be consistent with the Schumpeterian theories of innovation: after a wave of technological change, market demands and supplies shift towards the new goods; consequently, old productions relatively decline, without, however, closing down completely. Furthermore, under this same assumption, economies with different productive specializations would grow at different nominal, other than real, growth rates.⁸

In addition, no international labor mobility has been assumed, but it follows from the premises that in the absence of barriers workers of the mature economies would migrate to the richest countries. In this case, incentives to the emigrated workers to return home might positively affect the growth rates and employment levels of the mature economies. Trained workers possess the skill levels proper to the richest countries and might successfully and competitively produce the advanced goods.

⁸ This result is present in Lucas (1988), where economies with labor as the only input are considered.

References

- Acemoglu, D. (2000) "Technical Change, Inequality and The Labor Market", *NBER*, July.
- Aghion P., P. Howitt (1991) "Unemployment: A Symptom of Stagnation or a Side-Effect of Growth?", *European Economic Review*, vol. 35, pp. 533-541.
- Aghion P., P. Howitt (1992) "Growth and Unemployment", *Review of Economic Studies*.
- Aghion P., P. Howitt (1998) *Endogenous Growth Theory*, Cambridge Ma., MIT Press.
- Arrow K.J., H.B. Chenery, B.S. Minhas, R.M. Solow (1961) "Capital-labor substitution and economic efficiency", *Review of Economics and Statistics*, 225-250.
- Bean C. (1990) "Endogenous growth and the pro-cyclical behavior of productivity", *European Economic Review*, 355-363.
- Bean C., C. Pissarides (1993), "Unemployment, Consumption and Growth", *European Economic Review*, 37, 837-859.
- Chambers, R.G. (1988), *Applied production analysis*, Cambridge, UK: CUP.
- Dasgupta P, G. Heal (1974) "The Optimal Depletion of Exhaustible Resources" *Review of Economic Studies*.
- Helpman, E. (1984) "Increasing Returns, Imperfect Markets and Trade Theory", in R.W. Jones and P.B. Kenen, eds., *Handbook of International Economics*, vol. I, North Holland, Amsterdam, 325-365.
- Herberg H., Kemp M.C. (1969) "Some Implications of Variable Returns to Scale", *Canadian Journal of Economics*, 403-415.
- Jones L.E., Manuelli R.E. (1997) "Endogenous Growth Theory: An Introduction", *Journal of Economic Dynamics and Control*, 1-22.
- Krautkraemer, J.A. (1986) "Optimal Growth, Resource Amenities and the Preservation of Natural Environment", *Review of Economic Studies*, 153-170.
- Lucas R.E. (1988), "On the Mechanics of Economic Development" *Journal of Monetary Economics*, 22, 3-42.
- Mortensen D.T., Pissarides C.A. (1998) "Technological Progress, Job Creation and Job Destruction", *Review of Economic Dynamics*.
- Panagariya, A. (1981) "Variable Returns to Scale and Patterns of Specialization", *American Economic Review*, 221-230.
- Pissarides C.A. (1990) *Equilibrium Unemployment Theory*, Oxford: Basil Blackwell
- Puu, T. (1966) "Les Effets de Substitution et d'Expansion dans la Théorie de la Production", *Revue d'Economie Politique*, vol.76; 57-91.

Ricardo, D. (1975) *On the Principles of Political Economy and Taxation*, Cambridge University Press, Cambridge U.K.

Schumpeter, J.A. (1934) *The Theory of Economic Development*, Cambridge Mass.; Harvard University Press.

Appendix A: The productive possibilities frontier (PPF)

In what follows "market" and "efficient" maximization will be distinguished. To solve the problem $\text{Max } Y_2 = \{[(1-\phi)K]^\nu + [(1-u)L]^\nu\}^{1/\nu}$, s.t. $[\phi K]^{-\nu} + (\phi K_e uL)^{-\nu} = Y_1$, where $K_e = K$, private agents calculate the marginal productivity of capital without taking into account the effects of externalities. This will determine equilibrium prices. The PPF, on the other hand, will be determined by taking into account the effects of externalities.

The market-determined marginal productivities of capital and labor in the two sectors are:

$$Y_{1K} = \left(\frac{Y_1}{\phi K}\right)^{\frac{1}{\sigma}} = \left\{1 + \left[\left(\frac{\phi K_e}{\phi K}\right) uL\right]^{-\nu}\right\}^{-1/\nu\sigma} = [1 + (uL)^{-\nu}]^{-1/\nu\sigma} \quad (A1a)$$

$$Y_{1L} = \left(\frac{Y_1}{uL}\right)^{\frac{1}{\sigma}} (\phi K_e)^{-\nu} \quad (A1b)$$

$$Y_{2K} = \alpha \frac{Y_2^{\frac{\nu+1}{\alpha}}}{[(1-\phi)K]^\sigma}; \quad (A2a) \quad Y_{2L} = \alpha \frac{Y_2^{\frac{\nu+1}{\alpha}}}{[(1-u)L]^\sigma} \quad (A2b)$$

where, given that $\sigma < 1/(1-\alpha)$, $(\nu/\alpha + 1) < 0$,

Total differentiation of the FOC (dK, dL are partial derivatives) gives:

$$p^{-1} = \frac{\alpha Y_2^{\frac{\nu+1}{\alpha}} [(1-\phi)K]^{-\frac{1}{\sigma}}}{Y_1^{\frac{1}{\sigma}} (\phi K)^{-\frac{1}{\sigma}}} \left[\frac{dK + \left(\frac{(1-u)L}{(1-\phi)K}\right)^{\frac{1}{\sigma}} dL}{dK + \left(\frac{uL}{\phi K}\right)^{\frac{1}{\sigma}} K_e^{\frac{\sigma-1}{\sigma}} dL} \right]$$

The market efficient conditions of production of equation (4) imply that

$$p^{-1} = \left(\frac{\phi}{1-\phi}\right)^{\frac{1}{\sigma}} \frac{\alpha Y_2^{\frac{\nu+1}{\alpha}}}{Y_1^{\frac{1}{\sigma}}}. \text{ The derivation of the optimal production possibilities frontier (PPF)}$$

includes the effects of externalities. This increases the marginal productivity of capital in sector 1 as well as ϕ , the sectoral equilibrium share of capital. The latter is evidenced in Appendix B. The marginal productivity of capital is:

$$Y_{1K} = [1 + (uL)^{-\nu}]^{\frac{1}{\nu}} = \frac{Y_1}{\phi K} \quad (A1a')$$

It has a higher value than the marginal productivity of capital perceived by the agents (equation (A1a)). Second order derivatives (SOC) are:

$$Y_{1KK} = 0; \quad (A3a)$$

$$Y_{1LL} = -\frac{1}{\sigma} \left[\frac{1}{(uL^\nu + 1)} \right]^{\frac{1}{\nu\sigma}} (uL)^{\nu-1} \phi K = -\frac{1}{\sigma} Y_1 (uL)^{\nu-2} < 0 \quad (A3b)$$

$$Y_{1KL} = Y_{1LK} = \left[\frac{1}{(uL^\nu + 1)} \right]^{\frac{1}{\nu\sigma}} = \left(\frac{Y_1}{\phi K uL}\right)^{\frac{1}{\sigma}} > 0 \quad (A3c)$$

$$Y_{2KK} = \frac{\alpha \left\{ (v+\alpha)Y_2^{\frac{2v}{\alpha}+1} - \frac{1}{\sigma}Y_2^{\frac{v}{\alpha}+1} [(1-\phi)K]^v \right\}}{[(1-\phi)K]^{\frac{2}{\sigma}}} < 0 \quad (A4a)$$

$$Y_{2LL} = \frac{\alpha \left\{ (v+\alpha)Y_2^{\frac{2v}{\alpha}+1} - \frac{1}{\sigma}Y_2^{\frac{v}{\alpha}+1} [(1-u)L]^v \right\}}{[(1-u)L]^{\frac{2}{\sigma}}} < 0 \quad (A4b)$$

$$Y_{2LK} = Y_{2KL} = \alpha(v+\alpha) \frac{Y_2^{\frac{2v}{\alpha}+1}}{[(1-u)L(1-\phi)K]^{\frac{1}{\sigma}}} < 0 \quad (A4c)$$

The shape of the PPF follows from the differentiation of the FOC, including the effects of externalities,

$$\frac{dY_2}{dY_1} = \frac{\alpha Y_2^{\frac{v}{\alpha}+1} [(1-\phi)K]^{\frac{1}{\sigma}}}{Y_1 (\phi K)^{-1}} \left[\frac{dK + \left(\frac{(1-u)L}{(1-\phi)K} \right)^{\frac{1}{\sigma}} dL}{dK + [1+(uL)^{-v}]^{-1} \left(\frac{uL}{\phi K} \right)^{\frac{1}{\sigma}} K_e^{\frac{\sigma-1}{\sigma}} dL} \right]$$

Equation (4'), on optimal conditions of production, implies that

$$\frac{dY_2}{dY_1} = - \left(\frac{\phi}{1-\phi} \right)^{\frac{1}{\sigma}} \frac{\alpha Y_2^{\frac{v}{\alpha}+1}}{Y_1} (\phi K)^{-v}$$

The bordered Hessian is:

$$\begin{bmatrix} Y_{2KK} + \lambda Y_{1KK} & Y_{2KL} + \lambda Y_{1KL} & -Y_{1K} \\ Y_{2LK} + \lambda Y_{1LK} & Y_{2LL} + \lambda Y_{1LL} & -Y_{1L} \\ -Y_{1K} & -Y_{1L} & 0 \end{bmatrix}$$

λ is the positive multiplier of the Lagrangean function.

The determinant of the bordered Hessian is:

$$|H| = (-Y_{1K})(-Y_{1L})Y_{2KL} + (-Y_{1K})(-Y_{1L})\lambda Y_{1KL} - (-Y_{1K})^2(Y_{2LL} + \lambda Y_{1LL}) - (-Y_{1L})^2(Y_{2KK} + \lambda Y_{1KK}) + (-Y_{1L})(-Y_{1K})(Y_{2LK}) + (-Y_{1L})(-Y_{1K})(\lambda Y_{1LK})$$

All terms at the RHS of the equality are positive, except for the first and the fifth (that are equal). The algebraic sum of all terms except those including λ is positive if:

$$|(Y_{1L})^2 Y_{2KK} + (Y_{1K})^2 Y_{2LL}| > |2(Y_{1K})(Y_{1L})Y_{2KL}|$$

The LHS of the equality can be re-written considering (A1a'), (A1b') and (A4a-c).

This shows that the inequality holds with positive sign:

$$(Y_{1L} Y_{2KK}^{1/2} + Y_{1K} Y_{2LL}^{1/2})^2 - 2 Y_{1L} Y_{1K} (Y_{2KK} Y_{2LL})^{1/2} > 2(Y_{1K})(Y_{1L})Y_{2KL}$$

with $(Y_{2KK} Y_{2LL})^{1/2} > Y_{2KL}$. Hence $|H| > 0$.

The curvature of the PPF follows from

$$\frac{dY_2}{dY_1} = -\lambda \quad \text{and} \quad \frac{d^2 Y_2}{dY_1^2} = -\frac{d\lambda}{dY_1}$$

$$\frac{d\lambda}{dY_1} = \frac{Y_{2KK}(Y_{2LL} + \lambda Y_{1LL}) - (Y_{2KL} + \lambda Y_{1KL})^2}{|H|}$$

As seen above, $Y_{2KK}Y_{2LL} > Y_{2KL}^2$. Hence, for $Y_2 \rightarrow 0$, $\frac{d\lambda}{dY_1} \geq 0$, while for $Y_1 \rightarrow 0$ $\frac{d\lambda}{dY_1}$

≤ 0 . The opposite signs hold for $\frac{d^2 Y_2}{dY_1^2}$. As all second order derivatives are monotone, the

sign of the expression changes only once. Therefore, the PPF (in both its expressions, the PPF_m and the PPF_o) is convex in the vicinity of $Y_1=0$, concave in the vicinity of $Y_2=0$ and has only one flex point.

Appendix B: the capital share

The equilibrium value of ϕ can be derived from the solution of equations (12) and (4),

$$\text{it is } \phi = \frac{x^{\frac{1}{\sigma}} + \frac{M}{\alpha} x^{\frac{1}{\sigma}} - \rho}{x + \frac{Mx}{\alpha} - \frac{Mx}{\alpha} \frac{(1-u)}{u^{\frac{1}{\sigma}}} L^v} \quad \text{At the steady state: } \phi = \frac{x^{\frac{1}{\sigma}} + \frac{M}{\alpha} x^{\frac{1}{\sigma}} - \rho}{x + \frac{M}{\alpha} x^{\frac{1}{\sigma}}}$$

The numerator is always positive because $\rho < 1$. In the first expression, given that $\phi > 0$, the denominator must be positive. This means that u must be sufficiently high to fulfill this condition (which also implies that the RHS of equation (12) is positive). Therefore, the minimum equilibrium value taken by u is higher than zero and is a positive function of β and α . In other terms, it increases with the share of good 1 in utility and the degree of the returns to scale in sector 2. The second equation shows that at the steady state u equals one but ϕ is lower than unity. In other terms, the labor force is entirely employed in region N but capital is utilized in both sectors.

$$\text{The optimal value of } \phi \text{ includes the effects of externalities; it is } \phi = \frac{x + \frac{M}{\alpha} x - \rho}{x + \frac{Mx}{\alpha} - \frac{Mx(1-u)}{\alpha} \frac{1}{u^{\frac{1}{\sigma}}} L^v}$$

It is higher than the market equilibrium value. Hence, because of the input externalities, the market share of capital going to sector 1 is below optimality.

Appendix C: The cost functions

Total and marginal cost functions can be determined by taking into account the inputs' relative prices that follow from firms' profits maximization and multiplying them by

the inputs' levels. In sector 1 this corresponds to: $\frac{r\phi K}{w u L} = \left(\frac{\phi K}{\phi K_e u L} \right)^{-v}$. Adding 1 to both

sides, and multiplying them by (uL) , the equality is: $\frac{C_1}{w} = \frac{Y^{-v} (uL)^{\frac{1}{\sigma}}}{(\phi K_e)^{-v}}$. Now, (uL) can be

written as a function of the other variables. The same applies to ϕK . Hence:

$$uL = \left[\frac{C_1 (\phi K_e)^{-v} Y^v}{w} \right]. \text{ The production function of sector 1 can then be re-written as:}$$

$$Y = \left[\left(\frac{C_1 Y_1^v}{r} \right)^{-\sigma v} + (\phi K_e)^{-v} \left(\frac{C_1 (\phi K_e)^{-v} Y_1^v}{w} \right)^{-\sigma v} \right]^{\frac{1}{v}}$$
, and the total cost function is

$$C_1 = Y_1 \left[r^{\sigma v} + (\phi K_e)^{-1} w^{\sigma v} \right]^{\frac{1}{\sigma v}} \quad (C.1)$$

Firms in sector 1 perceive costs as constant. In fact, they are negatively dependent on productive externalities, which are $(\phi K_e)^{-1}$.

The same procedure leads to the determination of the cost function of industry 2:

$$C_2 = Y_2^\alpha \left[r^{\sigma v} + w^{\sigma v} \right]^{\frac{1}{\sigma v}} \quad (C.2)$$

The cost of producing commodity 1 in terms of the price of the other good (given

perfect competition, prices are equal to marginal costs) is: $\frac{C_1}{P_2} = \frac{Y_1 \left[r^{\sigma v} + (\phi K_e)^{-1} w^{\sigma v} \right]^{\frac{1}{\sigma v}}}{\frac{1}{\alpha} Y_2^{\alpha-1} \left[r^{\sigma v} + w^{\sigma v} \right]^{\frac{1}{\sigma v}}}$

Therefore, the marginal cost of producing good 1 in terms of good 2 is:

$$C_{1r_1} = \frac{\left[r^{\sigma v} + (\phi K_e)^{-1} w^{\sigma v} \right]^{\frac{1}{\sigma v}} - \frac{1}{\sigma v} \left[r^{\sigma v} + (\phi K_e)^{-1} w^{\sigma v} \right]^{\frac{1}{\sigma v}-1} K^{-2} \left(\frac{\phi K}{Y_1} \right)}{\frac{1}{\alpha} Y_2^{\alpha-1} \left[r^{\sigma v} + w^{\sigma v} \right]^{\frac{1}{\sigma v}}} \quad (C.3)$$

and the marginal cost of producing good 2 in terms of good 1 is:

$$C_{2r_2} = \frac{\frac{1}{\alpha} Y_2^{\alpha-1} \left[r^{\sigma v} + w^{\sigma v} \right]^{\frac{1}{\sigma v}}}{\left[r^{\sigma v} + (\phi K_e)^{-1} w^{\sigma v} \right]^{\frac{1}{\sigma v}} - \frac{1}{\sigma v} \left[r^{\sigma v} + (\phi K_e)^{-1} w^{\sigma v} \right]^{\frac{1}{\sigma v}-1} K^{-2} \left(\frac{\phi K}{Y_1} \right)^{\frac{1}{\sigma}}} \quad (C.4)$$

Figure 1: The PPF_m and the PPF_o .

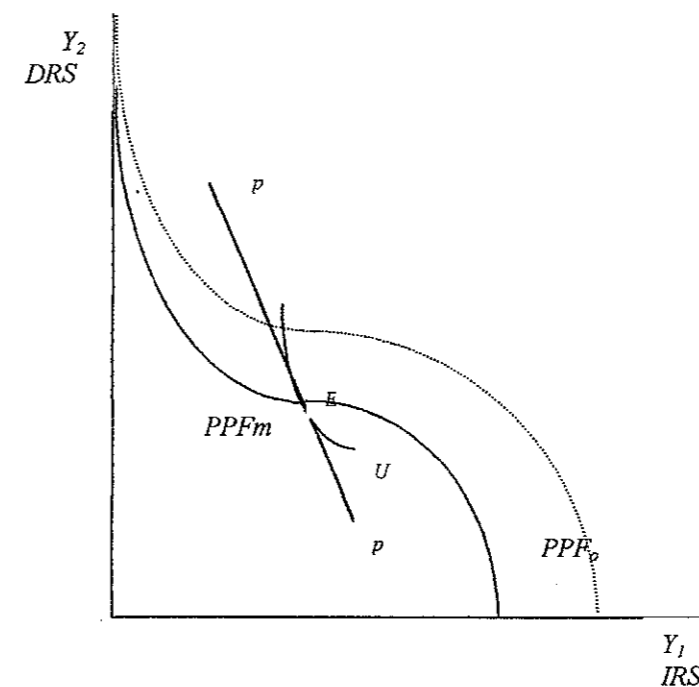
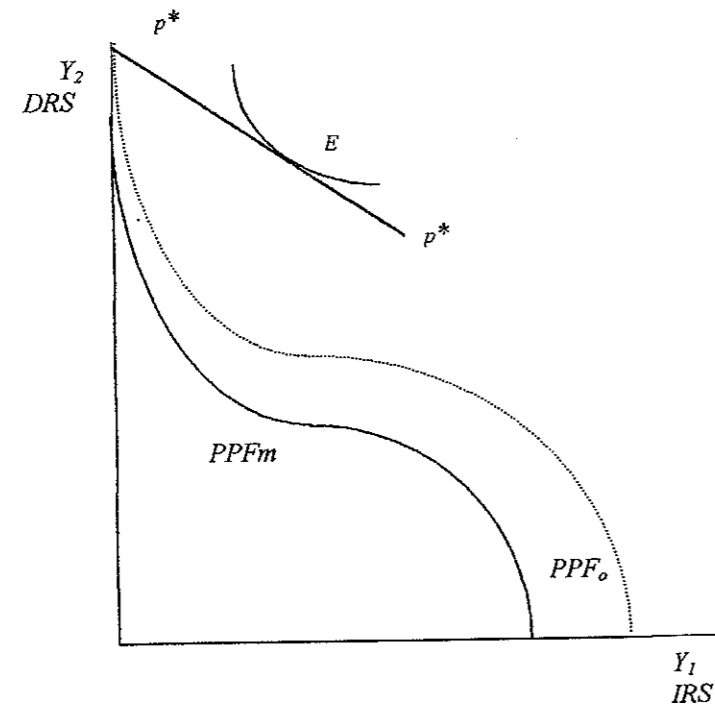


Figure 2: Trade and specialization



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