Human capital, income distribution and economic growth in a Neo-Kaleckian model

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Abstract

This paper introduces human capital accumulation through the provision of universal public education by a balanced-budget government in a neo-Kaleckian model of capacity utilization, distribution and growth. The level of education, as represented by the stock of human capital, affects both workers' productivity in output production and thereby their bargaining power in the labor market. In the short-run equilibrium of the model, the difference in tax rates on wage and profit income has distributive implications for consumption and investment behavior and may change the demand regime of the economy. In the case of the stable long-run equilibrium of the two-dimensional dynamic system featuring the wage share and the physical capital to human capital ratio, an exogenous rise in the tax rate (and hence in the tax spending in public education) raises (lowers) the steady-state value of the wage share (ratio of physical capital to human capital). The steady-state value of the labor employment rate (which also measures the rate of utilization of the aggregate stock of human capital), however, may either rise or fall in response to such increase in the tax rate.

1. Introduction

As it is well known, the role of human capital accumulation for economic growth has been extensively explored by neoclassical growth theory, especially as its inclusion acted as an early possible solution to the failure of the original Solow model to predict the observed persistence of large differences in income per capita among countries (Mankiw, 1995). In the standard approach, developed seminally by Mankiw, Romer and Weil (1992), human capital is included, together with physical capital and labor, as an additional factor in the production function, so that the level of output per worker – labor productivity – depends both on the level of physical capital and that of human capital per worker. As individuals are assumed to invest constant fractions of total income in human and physical capital, a faster accumulation of human capital can be shown to increase the equilibrium values of capital and income per capita.

On the one hand, for assuming that the economy grows at full potential, approaches of this kind tend to neglect the role played by human capital accumulation for aggregate demand. On the other hand, demand-driven approaches, and particurly developments in the neo-Kaleckian growth literature, have traditionally relegated any attention to education as narrowly supply-sided, thus ignoring its effects on the dynamics of labor productivity, the bargaining power of workers, and ultimately the functional distribution of income and thereby the components of aggregate demand. One notable exception is Dutt (2010), who formalizes the process of skill acquisition in a neo-Kaleckian framework so that both the number of high-skilled and low-skilled workers and their wages vary over time and affect the interaction between income distribution and economic growth.

This paper also aims to explore the theoretical underpinnings of the accumulation of human capital within a neo-Kaleckian model of growth and distribution, but it focuses on a different set of transmission channels and mechanisms. In the model herein, what varies over time with the decision to spend in public education by a balanced-budget government is the average human capital (or skills) of the available labor force, which itself determines the level of labor productivity of employed workers. Since the stock of human capital is uniformly distributed in the available labor force, which is always in excess supply, it follows that unemployed labor also means unutilized human capital. As it turns out, the economy operates with excess

capacity not only in physical capital and labor, as in the standard neo-Kaleckian model, but also in human capital.

Furthermore, we consider a conflicting claims framework for the determination of the real wage, with workers' bargaining power depending positively both on the employment rate and the rate of human capital accumulation. The ambiguous effect of an increase in government spending on public education on both the functional distribution of income and the rate of economic growth that arises in this simple setup not only provides more complexity to the theoretical attempts to reconcile demand-driven growth and the supply side of the economy, but are also likely to have relevant empirical and policy implications.

In fact, this paper is related to the extensive literature on overeducation (see, eg., Borghans and Grip, 2000, and Skott, 2006). Nonetheless, overeducation is typically described in such literature as the extent to which an individual worker possesses a level of education in excess of that which is required for her particular job (i.e., occupational mismatch), whereas in the paper herein the labor force is overeducated in the sense that not all of the human capital uniformly embodied in it is fully utilized due to labor unemployment. At the macroeconomic level, therefore, as in the standard literature on overeducation as occupational mismatch, in the model herein aggregate performance is worse than would be the case if the skills of the educated workers were fully utilized in production. Meanwhile, as in such standard literature overeducation and occupational mismatches have implications for the wage distribution, our incorporation of a conflicting claims framework for the determination of the average real wage, with workers' bargaining power varying positively with the rates of employment and human capital accumulation, can be seen as offering an alternative, conflicting-claims-based explanation for the dynamics of the wage returns on education. Therefore, while insufficient effective demand causes the aggregate stock of human capital to be underutilized, a weaker workers' bargaining power have a negative impact on the wage return on education. In fact, in the model herein the wage share as the ratio of the real wage to labor productivity measures the wage return on education.

Finally, as the accumulation of human capital is carried out through the provision of universal public education by a government running a balanced budget, this paper also relates to the literature that incorporates taxation and public expenditures in the Neo-Kaleckian framework,

such as Laramie and Mair (1996, 2000, 2003), Mair and Laramie (1997), Dutt (2011, 2013), Commendatore and Pinto (2011) and Commendatore, Panico and Pinto (2011).

The paper is structured as follows. Section 2 introduces the model structure. Section 3 solves for the short-run equilibrium, assuming that nominal wages, prices and the stocks of physical and human capital are given. Section 4 then introduces long-run dynamics and analyzes the impact of an increase in public spending in education on the steady-state equilibrium where the wage share and the ratio of the stock of physical capital to human capital are stationary. Finally, Section 5 concludes the paper.

2. The model

The model will deal with a closed economy that produces a single good for both investment and consumption purposes. We start by assuming that the government holds a balance budget and spends all tax receipts (out of wage and profit income) on public universal education, but will discuss how this assumption can be generalized within the same model structure. As in Mankiw, Romer and Weil (1992), three homogeneous factors of production are used in the production process: labor, physical capital and human capital. The latter is assumed to remain uniformly embodied in the available labor force. These three inputs are combined through a fixed-coefficient technology:

$$X = min\left[K\nu, La(h)\right] \tag{1}$$

where X is the output level, K is the stock of physical capital, L is the employment level, $h \equiv H / N$ is the human capital stock to labor force ratio (or average human capital) and $a(h)$ is the output to labor ratio (or labor productivity), which varies with the average human capital. For simplicity, the technical coefficient ν will be normalized to one hereafter. In the production function in (1), we also assume that $a(0) = 0$, $a'(h) > 0$ and $a''(h) \leq 0$. Note that unemployed workers are as skilled (or human capital endowed) as employed ones, so that the rate of employment, which is determined by effective demand, also measures the degree of human capital utilization. However, we abstract from human capital depreciation or labor deskilling.

The economy is composed of two classes, capitalists and workers, who earn profits and wages, respectively. The functional division of aggregate income is then given by:

$$X = \frac{W}{P} L + rK \tag{2}$$

where W is the money wage, P is the price level and r is the rate of profit on physical capital, which is the flow of money profits divided by the value of the physical capital stock at output price. From (1) and (2), the share of labor in income, σ, is given by:

$$\sigma = \frac{V}{a(h)} \tag{3}$$

where $V = W / P$ stands for the real wage.

Firms produce (and hire labor) according to aggregate effective demand, and we model only the case in which excess capacity prevails. Labor employment is determined by production:

$$L = \frac{X}{a(h)} \tag{4}$$

Firms operate in oligopolistic markets and set the price level as a mark-up over unit labor costs, as in Kalecki (1971):

$$P = (1+z)\frac{W}{a(h)} \tag{5}$$

where $z = \frac{1-\sigma(h)}{\sigma(h)} > 0$ is the markup, which is thus inversely related to the wage share.

Prices will rise over time whenever the desired markup of firms exceeds their actual markups, namely when the actual wage share exceeds the desired wage share. Formally, we have:

$$\hat{P} = \mu_P(\sigma(h) - \sigma_f) \tag{6}$$

where $\hat{P}$ is the inflation rate and $\mu_P > 0$ is the speed of adjustment. Therefore, inflation is determined within a framework of conflicting income claims, thus arising whenever income claims of workers and capitalists exceed available income.

The desired markup by firms will be assumed to depend on the state of the goods market, so that higher capacity utilization, which reflects more buoyant demand conditions, will induce firms to desire a higher profitability. We can express the wage share implied by firms' desired markup as:

$$\sigma_f = \varphi - \theta u \tag{7}$$

where φ and θ are positive parameters. Several arguments can be invoked to support a procyclical behavior of the markup. Eichner (1976) argues that during expansions, firms may want to invest more by generating higher internal savings and therefore desire a higher markup. Rowthorn (1977) claims that higher capacity utilisation allows firms to raise prices with less fear of being undercut by their competitors, who would gain little by undercutting due to higher capacity constraints. Gordon, Weisskopf and Bowles (1984) argue that marked-up prices are inversely related to the perceived elasticity of demand, which is a negative function of industry concentration and of the fraction of potential competitors that are perceived to be quantity-constrained and hence not engaged in or responsive to price competition. In the downturn, markup will fall because the fall in capacity utilization gives rise to a smaller share of potential competitors being perceived to be under capacity constraints, and hence to an increase in the perceived elasticity of demand facing the firm.

At a point in time the money wage is given, and with labor being always in excess supply, employment is determined by labor demand and ultimately by aggregate effective demand. Over time, however, the money wage will change in line with the gap between the wage share desired by workers, σ_w, and the actual wage share. The nominal wage adjustment process can be expressed as:

$$\hat{W} = \mu_W (\sigma_w - \sigma(h)) \tag{8}$$

where $\hat{W}$ is the proportionate rate of change in money wage and $\mu_W > 0$ is the speed of adjustment. The wage share desired – and bargained for – by workers is assumed to depend on their bargaining power in the labor market. Either a higher growth rate of human capital accumulation or a higher employment rate, by raising workers' bargaining power, will lead workers to desire a higher wage share, so that:

$$\sigma_w = \eta + \lambda e + \delta \hat{h} \tag{9}$$

where η, δ and λ are positive parameters and $e = L / N$ is the employment rate, which is linked to the state of the goods market in the following way:

$$e = uk \tag{10}$$

where k stands for the ratio of physical capital stock to labor force in productivity units, that is, $k = K/(Na(h))$. This formal link between u and e is necessary since the fixed-coefficient nature of the technology implies that an increase in output in the short run will be necessarily accompanied by an increase in employment. Moreover, as the aggregate human capital stock is uniformly distributed in the available labor force, the employment rate also measures the degree of utilization of the aggregate human capital stock.

Firms make decisions to accumulate physical capital independently according to a standard Neo-Kaleckian-Steindlian desired investment function, so that the desired growth rate of the stock of physical capital, assuming no depreciation, is given by:

$$g^i = \alpha + \beta u + \gamma r \tag{11}$$

where α, β and γ are all positive parameters, $u = X/K$ is the rate of (physical capital) capacity utilization and r is the net rate of profit on physical capital (that is, the after-tax rate of profit on physical capital).

The net profit rate r is given by:

$$r = (1-\tau_p)(1-\sigma(h))u \tag{12}$$

Substituting expression (12) for r in (11) yields:

$$g^i = \alpha + [\beta + \gamma(1-\tau_p)(1-\sigma(h))]u \tag{11'}$$

Given that we are dealing with a single good economy, the 'production' of human capital (or labor skills) does not constitute another production process or productive sector. Indeed, it is assumed here that the single good that can be used for both physical capital accumulation and consumption can also be used for human capital accumulation.[1]

At a point in time, the technological parameters are given, having resulted from previous human and physical capital accumulation. Over time, however, human capital accumulation takes place, which results in labor productivity growing at a proportionate rate $\hat{a}$. Formally:

[1] Indeed, a more inclusive model could drop the assumption of homogeneous labor – e.g. by bringing in low-skilled and high-skilled workers, who would be paid differently, as in Dutt (2011). However interesting, a more inclusive specification along these lines will be the subject of future research – for which we invite the reader to stay tuned.

$$\hat{a} = \phi(\hat{h}) \tag{13}$$

Where $\hat{h}$ is the growth rate of the human capital to labor force ratio and $0 < \phi'(\hat{h}) \leq 1$.

Following the tradition of Kalecki (1971), Kaldor (1956), Robinson (1956, 1962) and Pasinetti (1962), we assume that workers and capitalists have different consumption behavior. Moreover, the costs of human capital accumulation are paid by the government through the collection of taxes levied on wage and profit income (the same qualitative results could be obtained if either workers themselves or capitalists running training programs would pay for schooling directly). Workers provide labor and earn wage income, which is taxed at rate τ_w, and consume a constant fraction of their disposable income. The propensity to save out of after-tax wages is given by s_w. Workers are always in excess supply, with the number of potential workers (available labor force) growing at the exogenous rate n. Firm-owner capitalists receive profit income, pay a fraction τ_P in taxes, and spend a smaller fraction than workers in consumption. The propensity to save out of after-tax profit income is given by $s_P > s_w \geq 0$. Therefore, we further assume that spending with consumption and taxes does not exceed income for both classes, as there is no borrowing.

Aggregate investment in human capital accumulation by the government running a balance budget (normalized by the stock of physical capital) is therefore fully induced by wage and profit income given the differential tax rates:

$$\frac{I_H}{K} \equiv g^h = \left[\tau_w \sigma(h) + \tau_p (1 - \sigma(h))\right] u \tag{14}$$

It is important to emphasize that spending in education by the government will increase the human capital endowed by the entire labor force, and not only that of employed workers.

3. Short-run equilibrium

The short-run is defined as the time period in which the stock of physical capital, K, the stock of human capital, H, the supply of labor, N, the output-labor ratio, a, the price level, P, and the money wage, W, can all be taken as given. The equilibrium in the goods market can be expressed by:

$$X = C + I_H + I_K \tag{15}$$

where C stands for aggregate consumption, and I_H and I_K for investment in human and physical capital, respectively.

Or, since aggregate taxes $T = I_H$ for a balanced budget of the government, we have:

$$S = I_K \tag{15'}$$

where $S = X - T - C$ stands for aggregate savings.

Normalizing (15') by the physical capital stock yields:

$$g^s = g^i \tag{15''}$$

where aggregate savings as a proportion of the physical capital stock is given by:

$$g^s = \left[s_p(1-\tau_p)(1-\sigma(h)) + s_w(1-\tau_w)\sigma(h) \right] u \tag{16}$$

Substituting g^i from (12) and g^s from (16) yields:

$$\left[s_p(1-\tau_p)(1-\sigma(h)) + s_w(1-\tau_w)\sigma(h) \right] u = \alpha + \left[\beta + \gamma(1-\tau_p)(1-\sigma(h) \right] u \tag{17}$$

Since aggregate output is given by aggregate effective demand, and labor is always in excess supply, the rate of (physical capital) capacity utilization fully adjusts for the goods market short-run equilibrium in (17) to obtain. The short-run equilibrium value of capacity utilization is thus given by:

$$u^* = \frac{\alpha}{\left[(s_p - \gamma)(1-\tau_p)(1-\sigma(h)) + s_w(1-\tau_w)\sigma(h) - \beta \right]} \tag{18}$$

For Keynesian stability, we need that $(\partial g^s / \partial u) > (\partial g^i / \partial u)$, which is equivalent to a positive denominator in (18), or equivalently:

$$(s_p - \gamma)(1-\tau_p)(1-\sigma(h)) + s_w(1-\tau_w)\sigma(h) > \beta$$

It can be shown that the paradox of thrift will hold, as in the standard neo-Kaleckian model: increases in the propensity to save of workers and capitalists reduce the level of economic activity. As it is a one-good economy and the government spends all its tax revenues on the provision of universal education, not only consumption, but increases in tax rates also raise the multiplier and thus the degree of capacity utilization in the short run.

The impact of raising the wage share on aggregate effective demand (and hence on capacity utilization) can be examined through the following partial derivative:

$$\frac{\partial u^*}{\partial \sigma} = \frac{\alpha[(s_p - \gamma)(1-\tau_p) - s_w(1-\tau_w)]}{[(s_p - \gamma)(1-\tau_p)(1-\sigma(h) + s_w(1-\tau_w)\sigma(h) - \beta]^2} \tag{19}$$

Since we need $\alpha > 0$ for a positive u^*, the condition for the economy to be in a wage-led effective demand (and hence physical capital capacity utilization) regime is:

$$s_p - s_w\left[\frac{1-\tau_w}{1-\tau_p}\right] > \gamma$$

In other words, we need a relatively large difference between marginal propensities to save between capitalists and workers and a relatively small sensitivity of investment to the net profit rate for the economy to be in a wage-led effective aggregate demand regime. Moreover, since the government spends all tax receipts in the provision of education, if the tax rate is higher (lower) on profits than on wages, the term in brackets will be higher (lower) than one, increasing the likelihood of a profit-led (wage-led) demand regime.

Therefore, from (10), since the ratio of physical capital stock to labor force in productivity units, k, is given in the short run, a wage-led (profit-led) aggregate effective demand regime implies that the rate of employment (and hence the rate of human capital capacity utilization) is also wage (profit) led.

From (12) and (18), the short-run equilibrium value of the net rate of profit on physical capital is then given by:

$$r^* = \frac{\alpha(1-\tau_p)(1-\sigma(h))}{[(s_p - \gamma)(1-\tau_p)(1-\sigma(h)) + s_w(1-\tau_w)\sigma(h) - \beta]} \tag{20}$$

The effect of increases in the wage share on the short-run equilibrium value of the rate of profit on physical capital is given by:

$$\frac{\partial r^*}{\partial \sigma} = \frac{\alpha(1-\tau_p)[\beta - s_w(1-\tau_w)]}{[(s_p - \gamma)(1-\tau_p)(1-\sigma(h)) + s_w(1-\tau_w)\sigma(h) - \beta]} \tag{21}$$

It can be checked that the paradox of costs, namely a positive effect of increases in the wage share on the rate of profit on physical capital, may or may not hold, depending on the sign of

the numerator. A lower propensity to save by workers and a higher tax rate on wages, with the latter increasing spending in education, increases the likelihood of a paradox of costs.

4. Long-run equilibrium

In the long run we assume that the short-run equilibrium values of the variables are always attained, with the economy moving over time due to changes in the stock of physical capital, K, the stock of human capital, H, the supply of labor, N, the output to labor ratio, a, the price level, P, and the money wage rate, W. One way of following the behavior of the system over time is by examining the dynamic behavior of the short-run state variables σ, the wage share, and k, the ratio of physical capital stock to labor supply in productivity units. From the definition of these variables, we have the following state transition functions:

$$\hat{\sigma} = \hat{W} - \hat{P} - \hat{a} \tag{22}$$

And:

$$\hat{k} = \hat{K} - \hat{a} - n \tag{23}$$

We will make a few simplifying assumptions hereafter, which facilitates our analytical study of the model dynamics and steady-state properties. First, we will assume that the labor force is not growing and will then normalize it to one, so that $N = 1$. Second, we will assume that labor productivity has a one-to-one correspondence with the average stock of human capital, so that $a(h) = H$. Third, we will assume that the tax rate on wages and profits is exactly the same, so that $\tau_w = \tau_P = \tau$, thus avoiding direct effects of changes in income distribution on human capital accumulation. Finally, we will also make the more extreme assumptions that workers consume all after-tax wages, so that $s_w = 0$ and that profit earners save all of their after-tax income, so that $s_p = 1$.

Adopting the last two simplifying assumptions gives the following new expressions for the short-run equilibrium level of physical capital capacity utilization and its response to changes in the wage share, from (18) and (19):

$$u^* = \frac{\alpha}{\left[(1-\gamma)(1-\tau)(1-\sigma(h)) - \beta\right]} \tag{18'}$$

And:

$$\frac{\partial u^*}{\partial \sigma} = \frac{\alpha(1-\gamma)(1-\tau)}{\left[(1-\gamma)(1-\tau)(1-\sigma(h)) - \beta\right]^2} \tag{18''}$$

Since $0 < \tau < 1$, and a necessary condition for a positive and stable equilibrium value for u^* is $\gamma < 1$, it follows that the numerator in (18'') is positive and the economy is wage-led. Also, an increase in the tax rate raises physical capital capacity utilization in the short-run equilibrium, as the corresponding tax collection is entirely spent on financing human capital accumulation. Intuitively, since investment in human capital adds to aggregate effective demand and the tax collection which is fully spent on such investment has a prior claim on both profit and wage income, an increase in the tax rate has a positive net effect on aggregate effective demand. Meanwhile, it follows from (10) that, since k is given in the short run, the employment rate also varies positively with the wage share, the tax rate and the parameters of the physical capital accumulation function in (11). Therefore, an increase in the wage share or the tax rate also raises the rate of utilization of the aggregate human capital stock (recall that such stock is uniformly distributed in the labor force). As it turns out, the rates of utilization and growth of the aggregate human capital stock vary positively with the wage share and the tax rate. Per (12), meanwhile, it follows that the gross profit rate on physical capital also varies with the tax rate, whereas whether the net value of such rate will do likewise depends on the relative strength of the opposite forces in operation: a positive one coming through physical capital capacity utilization and a negative one coming through the direct impact on the tax rate on the net profit rate on physical capital. Hence, the model allows for the possibility of occurrence of another kind of paradox of costs, now applying to the higher costs associated to a higher tax rate, in that the net rate of profit on physical capital may actually rise in response to a higher tax rate.

Meanwhile, taking those simplifying assumptions along with (13), the aggregate stock of human capital grows over time according to:

$$\hat{h} = \hat{H} = \tau u k \tag{24}$$

where u^* is given by (18'). Equation (22) also relies on the assumption that there is no depreciation in the stock of human capital, meaning that there is no de-skilling of the labor force with the passage of time or the lack of employment, no matter the duration of the latter.

Intuitively, the introduction of de-skilling could possibly add a stabilizing force to the system in the presence of unemployment.[2]

Taking the simplifying assumptions into (16) yields the following savings function:

$$g^s = [(1-\tau)(1-\sigma(h))]u \tag{16'}$$

Substitution of (16') and (24) into (23) yields:

$$\hat{k} = [(1-\tau)(1-\sigma(h))]u^* - \tau u^* k \tag{24}$$

where u^* is given by (18'').

Meanwhile, substituting from (9) and (10) into (8), from (7) into (6), from (22) into (13), and then from the ensuing expression into (22), we obtain:

$$\hat{\sigma} = \mu_W(\eta + \lambda uk - \sigma) - \mu_P(\sigma - \varphi + \theta u) - (1-\mu_W\delta)\tau uk \tag{25}$$

where u^* is given again by (18'').

Equations (24) and (25), after using (18''), constitute a planar autonomous two-dimensional system of differential equations in which the rates of change of σ and k depend on the levels of σ and k and on the parameters of the system.

Solving (24) for the steady-state where $\hat{k} = 0$ gives a locus of points relating the wage share and the ratio of physical capital to human capital:

$$k = \frac{(1-\tau)(1-\sigma)}{\tau} \tag{26}$$

The slope of this nullcline is thus given by:

$$\frac{dk}{d\sigma} = -\frac{(1-\tau)}{\tau} < 0$$

whose absolute value smaller than one, given that $0 < \tau < 1$. In other words, along this locus, higher ratios of physical-to-human capital are associated with lower levels of the wage share.

[2] Indeed, a more inclusive model could drop the assumption of a non-depreciating human capital stock – e.g. by bringing in de-skilling or, say, 'unlearning by not doing' associated with unemployment. A more inclusive specification including this further channel is already part of our research agenda and some corresponding results will come out soon – for which we invite the reader to stay tuned.

Furthermore, a higher tax-financed government spending in public education implies a higher absolute value for the above derivative.

Meanwhile, solving for $\hat{\sigma} = 0$ yields the following locus of points:

$$k = \frac{(\mu_w \eta + \phi \mu_p) - (\mu_w + \mu_p)\sigma - \theta \mu_p u^*}{[(1 - \mu_w \delta)\tau - \mu_w \lambda] u^*} \tag{27}$$

Given u^* from (18"), the slope of the $\hat{\sigma} = 0$ isocline is thus given by:

$$\frac{dk}{d\sigma} = \left[\mu_w \lambda - (1 - \mu_w \delta)\tau\right] \left\{ (\mu_w + \mu_p) u^* + \frac{\partial u^*}{\partial \sigma} [(\mu_w \eta + \phi \mu_p) - (\mu_w + \mu_p)\sigma] \right\} \tag{28}$$

With the economy being wage-led, we have $\frac{\partial u^*}{\partial \sigma} > 0$. Therefore, the slope of the locus $\hat{\sigma} = 0$ will depend on the relative bargaining power of workers and capitalists, and on the level of the wage share itself.

The first term in brackets in (28) will be negative if and only if the bargaining power of workers is sufficiently low, so that $\mu_w < \frac{\tau}{\delta \tau + \lambda}$, and will be positive otherwise.

The second term in (28) will be positive if and only if the wage share is below a certain value, as given by:

$$\sigma < \frac{u^*}{(\partial u^* / \partial \sigma)} + \frac{\mu_w \eta + \phi \mu_p}{\mu_w + \mu_p}$$

The slope of the nullcline will thus be negative in the regions where the bargaining power of workers is sufficiently weak (strong) and the wage share is sufficiently low (high). It will be positive otherwise, namely when workers' bargaining power is sufficiently weak (strong) and the wage share is sufficiently high (low).

The Jacobian matrix of partial derivatives for this dynamical system is given by:

$$J_{11} = \frac{\partial \hat{k}}{\partial k} = -\tau u^* \tag{29}$$

$$J_{12} = \frac{\partial \hat{k}}{\partial \sigma} = -(1 - \tau) u^* + \frac{\partial u^*}{\partial \sigma} \left[(1 - \tau)(1 - \sigma) - \tau k \right] \tag{30}$$

$$J_{21} = \frac{\partial \hat{\sigma}}{\partial k} = \left[\mu_w \lambda - \left(1 - \mu_w \delta\right)\tau\right] u^* \tag{31}$$

$$J_{22} = \frac{\partial \hat{\sigma}}{\partial \sigma} = -\left(\mu_w + \mu_p\right) + \left[\mu_w \lambda - \left(1 - \mu_w \delta\right)\tau\right] \frac{\partial u^*}{\partial \sigma} k \tag{32}$$

Indeed, not all of these partial derivatives, when evaluated at the stationary point(s), can be unambiguously signed. Note that the sign of J_{11} is clearly negative, so that the physical to human capital ratio in the long-run equilibrium is locally stable. Since we know from (26) that the slope of the $\hat{k} = 0$ locus is itself negative, and that the same slope can be expressed as $-J_{12} / J_{11}$, it follows that J_{12} is also necessarily negative.

The first term in (32) is negative. Since the economy is wage-led, the sign of the second term depends on three factors: (i) the bargaining power of workers in the labor market, as well as the relative sensitivity of desired nominal wages to the level of economic activity; (ii) tax spending in human capital accumulation; and (iii) the level of the physical capital to human capital ratio.

Locally unstable dynamics for the wage share will only tend to arise when the bargaining power of workers is relatively high and/or tax spending in human capital is relatively low for high levels of k.

We will confine our analysis hereafter to the parameter configuration for which the condition $\mu_w < \frac{\tau}{\delta\tau + \lambda}$ is satisfied, ignoring any long-run equilibrium solution outside of that region. This is a sufficient condition for $\left[\mu_w \lambda - \left(1 - \mu_w \delta\right)\tau\right] < 0$, so that $J_{22} < 0$, meaning that the wage share is locally stable, and for $J_{21} < 0$.

The slope of the $\hat{\sigma} = 0$ nullcline, which can also be expressed as $-J_{21} / J_{22}$ is thus negative in this region. Hence, we know that the first term in (28) is negative and that the second term must be positive, which happens for lower values of the wage share. The trace of the Jacobian is definitely negative, and the determinant will be positive around the stable equilibrium E represented in Figure 1. At the other equilibrium point, the $\hat{\sigma} = 0$ nullcline is positively sloped, so that it is located in a region where our parameter configuration is not statisfied.

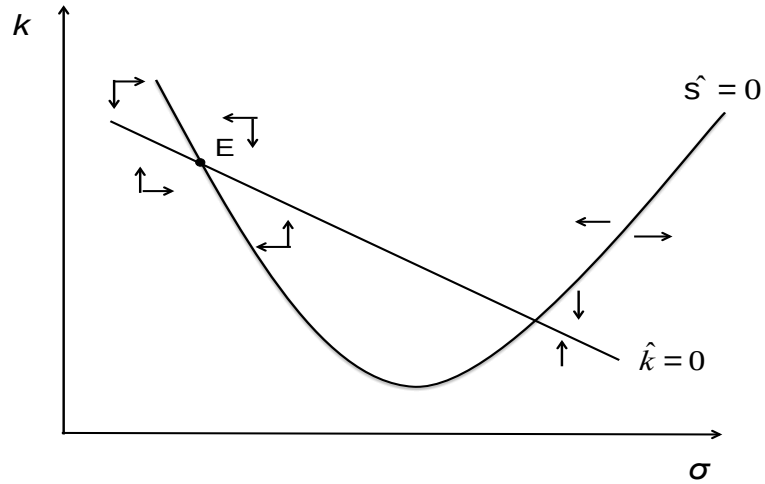

Figure 1: Stable steady-state equilibrium for the wage share and the ratio of physical capital to human capital

The long-run effects of an exogenous increase in the tax rate whose resulting tax collection is fully spent on public education provision can be assessed by inspecting Figure 2. The absolute value of the slope of the $\hat{k} = 0$ nullcline decreases, per (26), so that initially the equilibrium point moves from E to E', at which k is lower and σ is higher. But the $\hat{\sigma} = 0$ nullcline also shifts to become more negatively sloped in our region of interest, per (28), which then amplifies the initial impact of the exogenous increase in the tax rate. In the new equilibrium configuration given by E'', therefore, the ratio of physical capital to human capital is lower, while the wage share is higher. Consequently, in the new equilibrium configuration given by E'' physical capital capacity utilization is unambiguously higher (per (18'')), while whether the employment rate (which also measures the human capital capacity utilization) is higher or lower depends on the relative strength of the rise in the wage share and the fall in the physical capital to human capital ratio.

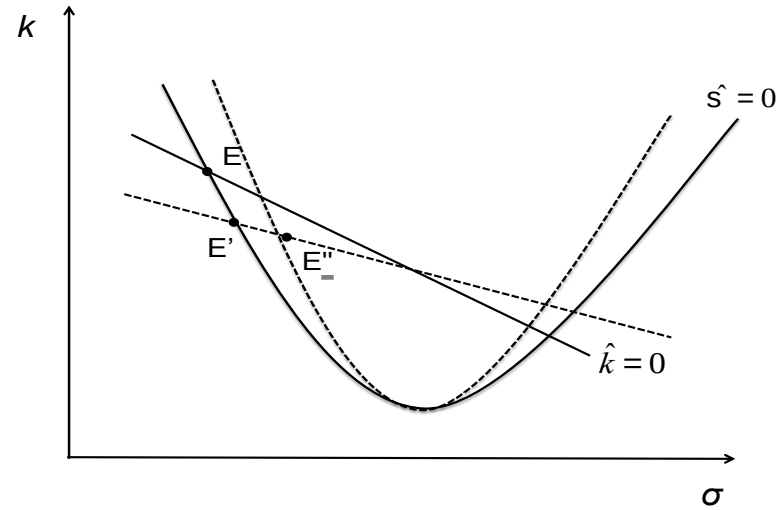

Figure 2: Effects of an increase in the tax rate on the long-run equilibrium for the wage share and the ratio between physical capital and human capital

The rationale for this result can be interpreted as follows. First, the faster accumulation of human capital due to a higher education provision leads to a decrease in the ratio of physical capital to human capital. The higher level of education (or skills) strengthens the bargaining power of workers, which increases the wage share. The higher wage share leads in turn to an increase in consumption and the rate of physical capital capacity utilization, as the latter is wage-led, which strenghtens workers' bargaining power even further, while also leading to higher productivity growth. The accumulation of physical capital may be slower or faster in the transition to the new steady-state. This depends on the relative response to the lower profit rate, which is initially reduced by higher taxes and then further reduced by the higher wage share, while the increase in the physical capital capacity utilization, which is wage-led, exerts an upward pressure on the gross and net rate of profit on physical capital. However, since the transitional dynamics from the initial steady-state configuration at E to the final one at E'' involves a monotonically falling (increasing) ratio of physical capital to human capital (wage share), if such dynamics occurs with the two stocks of capital growing at positive (negative) rates, the growth rate of the stock of human capital is higher (lower in absolute value) than the growth rate of the stock of physical capital.

6. Conclusion

This paper introduces human capital (or skills) accumulation through the provision of public education by a balanced-budget government in a neo-Kaleckian model of capacity utilization,

distribution and growth. The level of education, as represented by the stock of human capital, affects both workers' productivity in output production and thereby their bargaining power in the labor market.

In the short-run equilibrium, standard neo-Kaleckian results arise, and the difference in tax rates on wage and profit income has distributive implications for consumption and investment behavior and may change the demand regime of the economy. In particular, if the tax rate on profits is higher than that on wages, a wage-led economy may become profit-led.

The paper also analyzes the long-run equilibrium levels and stability properties of the two-dimensional system featuring the wage share and the physical capital to human capital ratio. The possibility of multiple equilibria and the stability properties of such dynamic system are shown to depend on the strength of workers' bargaining power relatively to capitalists', on the level of the tax rate on wages and profits levied by the government and on the initial level of the wage share.

In the case of the stable long-run equilibrium, an exogenous rise in the tax rate (and hence in the tax spending in public education) raises (lowers) the steady-state value of the wage share (ratio of physical capital to human capital). The steady-state value of the labor employment rate (which also measures the rate of utilization of the aggregate stock of human capital), however, may either rise or fall in response to such increase in the tax rate.

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