“Texto para discussão

65

Endogenous technological innovation, capital accumulation and distributional dynamics

Gilberto Tadeu Lima

agosto 1998

Instituto de Economia
UNICAMP”

ISSN 0103-9466

Endogenous technological innovation, capital accumulation and distributional dynamics

Gilberto Tadeu Lima
Professor do Instituto de Economia
da UNICAMP, Campinas, São Paulo, Brasil
E-mail: glima@eco.unicamp.br

Texto para Discussão. IE/UNICAMP, Campinas, n. 65, agosto 1998.

Equipe de Produção

Normalização: Célia Maria Passarelli Quitério
Editoração: Neide Pereira Baldovinotti
Capa: João Baptista da Costa Aguiar
Impressão e Acabamento: Gráfica Central da UNICAMP

Ficha catalográfica elaborada pelo Centro de Documentação – CEDOC
do Instituto de Economia da UNICAMP

Lima, Gilberto Tadeu
Endogenous technological innovation, capital accumulation and distributional dynamics/Gilberto Tadeu Lima. – Campinas, SP: UNICAMP. IE, 1998.
29p. (Texto para Discussão. IE/UNICAMP, n. 65)

ISSN 0103-9466

1. Inovação tecnológica. 2. Acumulação de capital. 3. Crescimento. 4. Distribuição (Teoria econômica). I. Título. II. Série.

UNICAMP
Universidade Estadual de Campinas
Instituto de Economia (www.eco.unicamp.br)
Caixa Postal 6135 - CEP: 13083-970 - Campinas - SP - Brasil
(019) 788.5708 (019) 289.1512 public@eco.unicamp.br

Endogenous technological innovation, capital accumulation and distributional dynamics

Gilberto Tadeu Lima[1]

Abstract

This paper develops a non-linear dynamic model of capital accumulation, growth and distribution in which endogenous technological innovation plays a paramount role. The rate of technological innovation is determined by distribution in a non-linear manner, it being quadratic in distributive shares. This specification is intended to capture a resonable non-monotonicity in the influence of the wage share on firms' propensity to adopt labor-saving innovations, namely, that the innovation rate is lower for both low and high levels of wage share, it being higher for intermediate ones. While at low levels of wage share the availability of funding for innovation is high but the incentives to innovate are low, at high levels of wage share the incentives to innovate are high but the availability of funding is low. As it turns out, firms' desired investment will as well be non-linear in the wage share, which implies that whether a higher wage share will raise the accumulation rate depends on the prevailing distribution. Given such non-linearity, the paper also develops a qualitative phase-diagrammatic analysis of a possible configuration for the system leading to multiple equilibria and endogenous cyclical behavior.

Key-words: Technological innovation; Capital accumulation; Growth; Distribution (Economic theory).

Resumo

O artigo formula um modelo dinâmico não-linear de acumulação de capital, crescimento e distribuição em que um processo endógeno de inovação tecnológica desempenha um papel fundamental. A taxa de inovação tecnológica é determinada não-monotonicamente pela distribuição, sendo uma função quadrática da parcela dos salários na renda. Esta especificação pretende capturar uma plausível não-linearidade na influência da parcela salarial na propensão a adoção de inovações poupadoras de trabalho por parte das firmas, qual seja, a taxa de inovação é mais baixa para níveis baixos e elevados de participação salarial, sendo mais elevada para níveis intermediários da mesma. A justificativa é que para baixos (elevados) níveis de parcela salarial a disponibilidade de fundos é alta (baixa) mas o incentivo a inovar em tecnologia poupadora de trabalho é reduzido (elevado). Com isso, o investimento desejado das firmas também será não-linearmente influenciado pela distribuição, implicando que a direção do efeito de uma mudança da parcela salarial sobre a taxa de crescimento igualmente dependerá da distribuição prevalecente. Como essa não-linearidade torna possível a ocorrência de equilíbrios múltiplos e trajetórias cíclicas endogenamente determinadas para as variáveis relevantes, o artigo também realiza uma análise qualitativa de uma possível configuração sistêmica com essas características.

Palavras-chave: Inovação tecnológica; Acumulação de capital; Crescimento; Distribuição (Teoria econômica).

Introduction

This theoretical essay elaborates a non-linear model of capital accumulation and distribution in which endogenous technological innovation plays a significant role. The rate of technological innovation is determined by

(1) I am grateful to Amitava Krishna Dutt for his useful comments and suggestions throughout the elaboration of this essay. I also benefitted in different ways from productive conversations with Jaime Ros, Esther-Mirjam Sent, James Rakowski, Kali Rath, Peter Skott and Gerald Silverberg. Needless to say, they should not be implicated in any manner for the final content of this essay.

distribution in a non-linear way, it being quadratic in distributive shares. This simplified technological innovation function is intended to capture a plausible non-linearity in the influence of the wage share on firms' propensity to adopt labor-saving innovations, namely, that the latter is lower for both low and high levels of wage share, it being higher for intermediate levels of wage share. While at low (high) levels of wage (profit) share the availability of funding for innovation is high but the incentives to innovate are low, at high (low) levels of wage (profit) share the incentives to innovate are high but the availability of funding is low. As it turns out, firms' desired investment will also be non-linear in the wage (profit) share, which implies that both the direction and the intensity of the effect of changes in the distributive shares on the growth rate will depend on the prevailing level of these shares. For instance, whether a higher wage (profit) share will raise the accumulation rate becomes dependent on the prevailing distribution, the same dependence applying to the stability properties of the corresponding dynamic system.

This essay is organized in the following manner. Section 1 describes the building blocks of the model, whereas Section 2 analyzes its behavior in the short run. The behavior of the model in the long run is discussed in Section 3, and Section 4 examines one of the possible long-run multiple equilibria dynamics leading to the emergence of cyclical behavior. The essay then closes with a reprise of the main conclusions derived along the way.

1 The structure of the model

The economy modelled here, which is assumed to be a closed one and with no government activities, produces only one good for both investment and consumption purposes. Only two (homogeneous) factors of production are used, capital and labor, the technology of production being one of fixed-coefficients of the type

$$X = \min\ [Ku_k, L / a] \qquad (1)$$

where X is the output level, K is the capital stock, L is the employment level, u_k is the technologically-full capacity utilization, while a stands for the labor-output ratio. The fixed coefficients assumption can be justified by reference to an independence of the choice of techniques of factors prices or to technological rigidities in factor substitution. In order to fuller specify the structure of the model, we proceed by detailing each one of its building blocks, which draw mainly on Dutt (1992, 1994).

1.1 Firm behavior

Production is carried out by capitalist firms in oligopolistic markets, which allows them to be price-makers. At a point in time, prices are given, having resulted from previous dynamics. Firms will produce (and hire labor) according to demand whenever demand is insufficient to produce at full capacity at the ongoing price or at full capacity, Ku_k, otherwise. Once full-capacity output is reached, further increases in demand will generate price (as opposed to quantity) adjustments only. Besides, once the economy reaches capacity output some of the following behavioral assumptions underlying firms' accumulation plans may eventually be no longer valid. In the compass of this paper, though, we model only the case in which excess capacity prevails.[2] Labor employment is determined by production, being given by

$$L = aX \tag{2}$$

meaning that no excess labor is employed, for we abstract from long-term labor contracts. Firms make capital-accumulation plans according to the following desired accumulation function

$$g^d = \alpha + \beta u + \gamma(1 - \sigma) + \delta h \tag{3}$$

where α, β, γ, and δ are all (positive) parameters of the desired investment function, g^d, which is firms' desired capital accumulation as a ratio of the existing capital stock, $u = X / K$ is the actual rate of capacity utilization, π is the share of profits in output, and h is the rate of technological innovation whose labor-saving nature is better specified below. Since we assumed that capacity output is proportional to the capital stock, with the coefficient of proportionality being given by u_k, we can identify capacity utilization with the output-capital ratio.

(2) Steindl (1952) claims that firms plan excess capacity so as to be ready for a sudden expansion of sales. First, the existence of fluctuations in demand means that the producer wants to be in a boom first, and not to leave the sales to new competitors who will press on her market when the boom is over. Second, it is not possible for the producer to expand her capacity step by step as her market grows because of the indivisibility and durability of the plant and equipment. Finally, there is the issue of entry deterrence: if prices are sufficiently high, entry becomes feasible even where capital requirements are great; therefore, the holding of excess capacity allows olipolistic firms to confront new entrants by suddenly raising supply and driving prices down.

We follow Rowthorn (1981) and Dutt (1984, 1990), who in turn follow Steindl (1952), in assuming that desired accumulation depends positively on capacity utilization due to accelerator-type effects.[3] However, while Rowthorn (1981) and Dutt (1984, 1990) follow Kalecki (1971) and Robinson (1956, 1962) and make desired accumulation to depend on the profit rate, we make it to depend on the profit share instead.[4] Rather than following Bhaduri & Marglin (1990) in making it to depend on the profit share, though, we make it to depend non-linearly on the wage share.

Finally, firms' desired investment is made to depend positively on the rate of technological innovation, the central point being that the latter results in more investment, at any given level of capacity utilization and profit share, than would otherwise be the case. While Dutt (1994) invokes Kalecki's (1971) claim that the higher the rate of technological change, the more desirable is to install new machinery, other plausible reasons for the above specification can be called up as well. It is compatible with the Marxian contention that cost-reducing technical change, which is the one dealt with here (as detailed below), places continuous pressures on any individual firm to invest. This specification is also consistent with Schumpeter's (1912, 1942) view that the process of technological innovation itself opens up new investment opportunities for firms, and with the neo-Schumpeterian notion (e.g. Nelson & Winter 1982) that investment behavior is influenced by the dynamics of technical change (Lima, 1996).

Further, desired replacement investment is probably largely determined by the pace of technical change (Silverberg, Dosi & Orsenigo, 1988; Perelman, 1989). According to Landesmann & Goodwin (1994), the introduction of new

---

(3) As seen above, Steindl (1952) argues that firms aim at the preservation of a certain margin of excess capacity. In case, therefore, actual excess capacity falls below the desired one, firms will tend to speed up capital accumulation. Interestingly, variable capacity utilization has been recently claimed by some proponents of the real business cycle approach to be a source of propagation of (exogenous) technology shocks. Burnside & Eichenbaum (1996), for example, models variable capacity utilization by assuming that technology depends on effective capital services and effective hours of work. Depreciation is a function of capital utilization, and in equilibrium firms will choose to hoard capital, so they can increase its effective stock at once in response to shocks that raise the marginal product of capital. I would stressed, though, that the supply-side nature of this approach makes its endogenous determination of capacity utilization quite distinct from the demand-driven one pursued here. Besides, technological change is endogenously determined in this model, rather than being guided by exogenous shocks as in the real business cycle approach.

(4) Bhaduri & Marglin (1990) argues for a formulation of desired investment as a function of the profit share, rather than the profit rate, on the ground that this clearly separates the two influences at work whereas the rate of profit reflects the dual influences of profit share and capacity utilization. For instance, in the latter it is simply assumed that a given rate of profit will produce the same level of investment as results from high capacity utilization and a low profit margin or from low capacity utilization and a high profit margin.

technologies may indeed raise the propensity to invest. First, firms may not be willing to lose out vis-à-vis competitors by not having the most updated technology which could allow them to attract a larger share of demand. Second, firms may expect strong learning by using effects from introducing the new technologies and they may not want to miss out on them. Third, firms may expect additional secondary innovations complementary to the initial one, and an early introduction might bring further competitive and learning advantages over competitors.[5]

1.2 Technological innovation

At a point in time, the technological parameters u_k and a are given, having resulted from previous technological change and capital accumulation. Over time, though, technological innovation is assumed to take place, which results in the labor-output ratio falling at rate h. The potential output-capital ratio u_k, in turn, is assumed to remain constant. Hence, it is assumed labor-augmenting (Harrod neutral) technological change, which acts as a substitute for labor; output can be increased with a given labor input while the capital-output ratio – or, in the present model, the ratio of capital to capacity output – remains constant. In terms of the taxonomy proposed by Freeman (1982), distinguishing between incremental innovation, radical innovation, new technology systems and changes of techno-economic paradigm, we are dealing with the former; that is, innovations which occur more or less continuosly, although at differing rates in different industries, and are concerned only with improvements in the existing array of products and processes of production.

The fixed-coefficient production technology assumed here is amply supported by a reputable literature. As several eminent contributors to the economics of technological change have documented – from David (1975) and Rosenberg (1976) to Nelson & Winter (1982) and Dosi (1984) – technological change is marked by strong cumulative effects – 'learning' in its various forms. As a result, it is typically characterized by 'localized' shifts in some production function, to use David's (1975) term, or by progress along particular 'natural trajectories', to use Nelson & Winter's (1982) concept. This implies that a more

(5) Steindl himself admitted later on that his *Maturity and stagnation* was carried out on the naive assumption that technological change does not affect investment activity (Steindl, 1981). Actually, in the introduction to the 1976 reprint of the book he had already recognized that innovations which are sufficiently advanced, and which can be exploited without too much delay and risk, are a powerful inducement to investment.

rigid, if not (at least in the short run) fixed set of production coefficients will prevail. More recently, consistent analyses such as Freeman & Soete's (1987) and Verspagen's (1990) demonstrate that localized technological change strongly diminishes the short-run possibilities for factor substitution.[6]

Rather than falling as manna from heaven, technological innovation is an endogenous process whose behavior is given by the following non-linear innovation function

$$h = \rho\sigma - \phi\sigma^2 \qquad (4)$$

where ρ and ϕ are both positive parameters. We assume that $\rho = \phi$, which will ensure that this concave-down parabola has two real roots, $h(0) = h(1) = 0$. Hence, h is positive throughout its (economically) relevant domain. The level of σ which will yield the maximum rate of innovation is given by $\sigma^* = \rho / 2\phi$, which means that a higher wage share will speed up (slow down) the rate of technological innovation for levels of σ to the left (right) of σ^*.

This simplified technological innovation function is intended to capture a plausible non-linearity in the influence of the wage share on firms' propensity to adopt labor-saving innovations, namely, that it is lower for both low and high levels of wage share, it being higher for intermediate levels of wage share. While at low (high) levels of wage (profit) share the availability of funding for innovation is high but the incentives to innovate are low, at high (low) levels of wage (profit) share the incentives to innovate are high but the availability of funding is low. As it turns out, firms' desired investment function will also be non-linear in the wage (profit) share, which implies that both the direction and the intensity of the effect of changes in the distributive shares on the rate of capital accumulation will then depend on the prevalent level of these distributive shares.

(6) Probably the most quoted formalization of localized technological change is still the one by Stiglitz & Atkinson (1969). The underlying idea is that for any industrial grouping the range of efficient techniques (in terms of relative factor intensity per unit of output) is often very small, sometimes reaching the limit of one technological system which rules at any point in time. Localized technical change strongly diminishes the short-run possibilities for substitution, and constant improvements of one single production technique usually lead to a Leontief shape similar to the one assumed here.

1.3 Classes

The economy is inhabited by two classes, capitalists and workers. Following the tradition of Marx, Kalecki (1971), Kaldor (1956), Robinson (1956, 1962) and Pasinetti (1962), we assume that these classes have different saving and consumption behavior. Workers provide labor and earn only wage income, which is all spent in consumption. They are always in excess supply, with the number of potential workers (labor supply) growing at the rate n. Capitalists receive profit income, which is the entire surplus over wages, and save a fraction s of it. Division of income is then given by

$$X = (W / P)L + rK \qquad (5)$$

where W is the money wage, P is the price level, and r is the profit rate, which is define as the flow of money profits divided by the value of capital stock valued at output price. From eqs. (2) and (5), the share of labor in income is given by

$$\sigma = Va \qquad (6)$$

where $V = (W / P)$ stands for the real wage. The profit rate is then given by

$$r = (1 - \sigma)u = \pi u_1 \qquad (7)$$

1.4 Price dynamics

The price level is given at a point in time, but over time it will rise whenever the desired markup of firms exceeds their actual markups. Formally, this assumption can be expressed as

$$\hat{P} = \tau[\sigma - \sigma_f] \qquad (8)$$

where $\hat{P}$ is the proportionate rate of change in price, $(dP / dt)(1 / P)$, and $0 < \tau \leq 1$ is the speed of adjustment. Inflation is thus determined within a framework of conflicting income claims, inflation resulting whenever the income claims of workers and capitalists exceed the available income. Price is determined à la Kalecki (1971) as a markup over prime costs

$$P = (1 + z)Wa \qquad (9)$$

where z is the markup. Given labor productivity, $(1 / a)$, the markup is thus inversely related to the wage share, so that the gap between the desired and the actual markups can be measured by the gap between the actual and the desired wage share. The desired markup by firms depends on the state of the goods market, and 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

$$\sigma_f = \varphi - \theta u \tag{10}$$

where φ and θ are both positive parameters.

Several arguments can be invoked to support procyclicity of the markups. Harcourt & Kenyon (1976) and Eichner (1976) argue 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 utilization 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 & Bowles (1984) argues 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 thus 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. Later on, though, we will briefly examine how sensitive are the long-run stability properties of the system to this assumption that the desired markup rises with capacity utilization.[7]

(7) Minsky (1975) argue that the fall in sales in a downturn forces firms to raise markups to meet outstanding financial obligations. Kalecki (1954) argues that since the markup depends partially on the ratio of overheads to prime costs, the rise in this ratio in downturns causes markups to rise. On the neoclassical side, Rotemberg & Saloner (1986) and Rotemberg & Woodford (1991, 1992) claim that it is more difficult for oligopolistic firms to sustain collusive prices during booms. Stiglitz (1984) and Bils (1989) argue that demand may become less elastic during recessions, allowing firms to increase markups. Neoclassical financial theories of countercyclical markups are based on capital-market imperfections, examples being Greenwald, Stiglitz & Weiss (1984) and Chevalier & Scharfstein (1996). The shared idea is that since capital-market imperfections constrain the ability of firms to raise external financing, liquidity-constrained firms will increase markups during recessions and lower them during booms.

1.5 Nominal wage dynamics

At a point in time the money wage is given, and with labor being always in excess supply, employment is determined by labor demand. Over time, though, the money wage will change in line with the gap between the wage share desired by workers, σ_w, and the actual wage share. This wage adjustment equation can be expressed as

$$\hat{W} = \mu[\sigma_w - \sigma] \tag{11}$$

where $\hat{W}$ is the proportionate rate of change in money wage, $(dW / dt)(1 / W)$, and $0 < \mu \leq 1$ is the speed of adjustment. We follow Keynes (1936) in assuming that wage bargain takes place over nominal wages rather than real wages.[8] The wage share desired by workers is assumed to depend on their bargaining power in the labor market. A higher employment rate will increase the bargaining power of workers, and thus stimulate them to desire a higher wage share. We formalize their desired wage share function as follows

$$\sigma_w = \lambda e \tag{12}$$

where λ is a positive parameter and e is the employment rate, L / N, which is linked to the state of the goods market in the following way

$$e = uk \tag{13}$$

where k stands for the ratio of capital stock to labor supply in productivity units, that is, $k = K / (N / a)$, with N being the supply of labor. This formal link between u and e is necessary because 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.

1.6 Capital accumulation

As seen above, firms will produce according to demand because forthcoming demand is insufficient for them to produce at full capacity at the

(8) One of the reasons why Keynes (1936) rejected the classical second postulate is that it flows from the mistaken idea that the wage bargaining determines the real wage. For Keynes, the postulate that there is a tendency for the real wage to come to equality with the marginal disutility of labor incorrectly presumes that labor is in a position to decide the real wage for which it works, even though not the quantity of employment forthcoming at this wage. Keynes' economics of employment is analyzed in detail in Lima (1992).

ongoing price. This implies that the macroeconomic equality between desired investment and saving will be brought about by changes in capacity utilization. Assuming that capital does not depreciate, g, the rate of growth of capital stock, which is the growth rate for this one-good economy, is given by

$$g = sr \tag{14}$$

which follows from the aforementioned assumptions that workers do not save and capitalists save a fraction s of their income.

2 The behavior of the model in the short run

The short run is defined as a time period in which the stock of capital, K, the supply of labor, N, the labor-output ratio, a, the price level, P, and the money wage rate, W, can all be taken as given. As excess capacity prevails, firms will produce according to demand, thus realizing their desired accumulation plans. The existence of excess capacity implies that capacity utilization will adjust to remove any excess demand or supply in the economy, which implies that in short-run equilibrium, $g = g^d$. Substituting from equations (3), (4), (7) and (14), we can solve for the short-run equilibrium value of u, given σ and the other parameters of the model, thus obtaining

$$u^* = \frac{(\alpha + \gamma) + (\delta\rho - \gamma)\sigma - \delta\phi\sigma^2}{[s(1-\sigma) - \beta]} \tag{15}$$

Meaningful (i.e. greater than zero) values for the wage and profit shares are required, and a positive profit share is automatically ensured by $z > 0$. A positive wage share, in turn, is ensured by $z < +\infty$, which we assume. As far as stability goes, we assume a Keynesian short-run adjustment mechanism stating that output will change in proportion to the excess demand in the goods market. This means that the short-run equilibrium value for u will be stable provided the denominator of the expression in (15) is positive, which is ensured by the familiar condition for macroeconomic stability that aggregate saving is more responsive than desired investment to changes in output (capacity utilization). We also assume that $\alpha > \delta\rho > \gamma$, which will ensure a positive value for the numerator of the expression for u^* throughout its relevant domain and, given the stability condition, for u^* itself. A natural issue to address regards the impact of changes in the wage share on capacity utilization. After some rearranging, total differentiation of the equality between g and g^d leading to the determination of u^* will yield

$$u_\sigma^* = \frac{du^*}{d\sigma} = \frac{g_\sigma^d - g_\sigma}{g_U - g_U^d} \tag{16}$$

where a subscript denotes the variable with respect to which the differentiation applies. Hence, whether $u_\sigma^* \geq 0$ depends on whether $g_\sigma^d \geq g_\sigma$. The response of desired investment to a change in the wage share is given by $(\delta\rho - \gamma) - 2\delta\phi\sigma$, while the response of aggregate savings to that change is given by $-su$. The expression for u_σ^* is then given by

$$u_\sigma^* = \frac{[(\delta\rho - \gamma) - 2\delta\phi\sigma] + su}{[s(1-\sigma) - \beta]} \tag{17}$$

For the numerator in eq. (17) to become negative, thus making for $u_\sigma^* < 0$, a rise (fall) in the wage (profit) share has not only to reduce firms' desired investment, but also to do so by more than it reduces aggregate savings. Substituting (15) into (17), the formal expression for u_σ^* becomes

$$u_\sigma^* = \frac{s\delta\phi\sigma^2 - 2\delta\phi(s-\beta)\sigma + [\delta\rho(s-\beta) + s\alpha + \beta\gamma]}{[s(1-\sigma) - \beta]^2} \tag{18}$$

The numerator of this expression for u_σ^* is a concave-up parabola, and further convenient restrictions in the parameters will ensure that it is zero at $\sigma^* = \rho / 2\phi$ and at some $\sigma > 1$, these being the levels of wage share at which the expression for u_σ^* will change sign. Given that the numerator of eq. (18) is a concave-up parabola, it follows that u_σ^* will be positive for $\sigma < \sigma^*$, and negative for $\sigma > \sigma^*$. While for low and intermediate-low levels of wage share a higher (lower) wage (profit) share will increase capacity utilization, the reverse will happen for intermediate-high and high levels of wage share. Borrowing the terminology employed by Bhaduri and Marglin (1990), a stagnationist capacity utilization regime prevails at low and intermediate-low levels of wage share, while an exhilarationist one prevails at high levels of wage share.[9]

(9) Since Bhaduri & Marglin (1990) uses an investment function which is implicitly positively linear in the profit share, the way it allows for the possibility that capacity utilization may rise or fall when the profit shares rises is basically by suggesting that investment may be less (more) responsive than savings to changes in the profit share at low (high) levels of capacity utilization. While stagnation or wage-led capacity utilization may be more likely at low levels of capacity utilization, exhilarationism or profit-led capacity utilization may be more likely at

When $\sigma < \sigma^*$, a higher wage share will unambiguosly raise capacity utilization, as in the newer Post Keynesian model developed independently by Rowthorn (1981) and Dutt (1984, 1990). While in these models the rise in u would be due to the corresponding rise in consumption demand, in this model a positive innovation effect will add to that mechanism. As in these Post Keynesian models, an increase in the wage share – by redistributing income from capitalists who do save to workers who do not – raises consumption demand, increases investment spending through the capacity utilization effect on investment and hence raises the level of activity. In addition, the rise in the wage share will increase the innovation rate, raise firms' desired accumulation and hence increase capacity utilization even more. However, for intermediate-high and high levels of the wage share, which are given by $\sigma > \sigma^*$, the positive impact of a higher wage share on consumption demand is more than compensated by the accompanying fall in the rate of technological innovation, thus leading to a fall in capacity utilization.

The short-run equilibrium values of the other variables be can solved by substituting the equilibrium value for u into the respective equations. For instance, we can solve for the rate of profit by substituting (15) into (7), and then for the rate of capital accumulation by substituting this equilibrium value for the rate of profit into (14). In order to solve for the rate of inflation, we must first substitute (15) into (10), and then substitute the resulting equilibrium value for σ_f into (8). Now, given our assumptions that workers do not save and capitalists save a fraction s of their income, the rates of profit and accumulation move in the same direction, as shown by eq. (14). As shown by eq. (7), an increase (decrease) in the wage (profit) share will unambiguously exert a downward pressure on the rates of profit and accumulation. However, the non-linear nature of the innovation function makes for the possibility that a higher (lower) wage (profit) share generates a rise in capacity utilization which may eventually more than compensate the accompanying fall in the profit share. As established above, for low and low-intermediate levels of wage share a higher (lower) wage (profit) share will increase capacity utilization, whereas the reverse will happen for intermediate-high and high levels of wage share. Using eqs. (7), (14) and (15), the response of the growth rate to a change in the wage share can be shown to be

$$g_\sigma^* = sr_\sigma^* = s[u_\sigma^*(1-\sigma) - u^*] \qquad (19)$$

high levels of capacity utilization. In the model of this essay, the desired investment function, by being explicitly non-linear in distribution, implies more naturally that whether investment or saving is more responsive to changes in profitability depends on the prevalent level of profitability.

which implies that whether $g_\sigma^* \geq 0$ depends on the prevailing distribution. For intermediate-high and high levels of wage share, a redistribution of income towards workers will unambiguously slow down the rate of growth, the reason being that the resulting profit squeeze will reduce capacity utilization through its negative impact on the rate of technological innovation. For low and intermediate-low levels of wage share, in turn, a rise in the wage share, by raising capacity utilization, may eventually speed up the growth rate, the resulting profit-squeeze not being harmful to growth. Hence, the innovation function (4), by being non-linear in the distributive shares, allows us to establish precise distributional conditions under which the relationship between distribution and growth is either positive or negative. All this ambiguity is captured by the expressions for g^* and g_σ^*, which, using equations (7), (14), (15) and (19), are

$$g^* = \frac{s[\delta\phi\sigma^3 - (2\delta\rho - \gamma)\sigma^2 - (\alpha - \delta\rho + 2\gamma)\sigma + (\alpha + \gamma)]}{[s(1-\sigma) - \beta]} \qquad (20)$$

and

$$g_\sigma^* = \frac{-s^2[2A\sigma^3 - B\sigma^2 + C\sigma - D]}{[s(1-\sigma) - \beta]^2} \qquad (19')$$

where

$A = \delta\rho$; $\quad B = A(3+\beta) - \gamma$; $\quad C = (1+\beta)(4A - 2\gamma)$ and
$D = (1+\beta)A + \beta(2\gamma - \alpha) - \gamma$

The numerator of this expression for g_σ^* is a cubic equation in the wage share which can be made to have three real roots via further suitable restrictions in the parameters. As seen above, for intermediate-high and high levels of wage share a rise in the wage share will unambiguously slow down the growth rate. For low and low-intermediate levels of wage share, in turn, the non-linear nature of the technological innovation function makes for the possibility that a higher wage share generates a rise in capacity utilization which may eventually more than compensate the fall in the profit share, thus speeding up the growth rate. Further convenient restrictions in the parameters thus ensure that the cubic expression in the numerator of eq. (19') is zero at some $\sigma < 0$, at some $0 < \sigma^+ < \sigma^*$, and at some $\sigma > \rho / \phi = 1$. This way the relevant domain of the expression for g^* can then be divided into two regions according to the impact of changes in the wage (profit) share on the accumulation rate. For intermediate-low, intermediate-high and high levels of wage share ($\sigma > \sigma^{+}$) profit-led accumulation will prevail, whereas for low (high) levels of the wage (profit) share ($\sigma < \sigma^{+}$), it is wage-led accumulation which will obtain.

Hence, the meaningful subset of the domain can be divided into three regions. In the first one, comprised by low levels of wage share ($\sigma < \sigma^{+}$), the rates of technological innovation, capacity utilization and accumulation are directly related to the wage share. We refer to this region as LW region in the analysis that follows. In the second, which comprises intermediate-low levels of wage share ($\sigma^{+} < \sigma < \sigma^{*}$), while the rates of innovation and capacity utilization are directly related to the wage share, the rate of accumulation is inversely related to it. We refer to this region as IL region in the ensuing analysis. In the third region, which includes intermediate-high and high levels of wage share ($\sigma > \sigma^{*}$), the rates of technological innovation, capacity utilization and accumulation are all inversely related to the wage share. In the subsequent analysis, we refer to this region as HW region.

3 The behaviour of the model in the long run

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 capital, K, the supply of labor, N, the labor-output ratio, a, the price level, P, and the money wage, 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 capital stock to labor supply in productivity units, and this is the alternative pursued here. From the definition of these state variables, and denoting time-rates of change by overhats, we have the following state transition functions:

$$\hat{\sigma} = \hat{W} - \hat{P} + \hat{a} \tag{21}$$

and

$$\hat{k} = \hat{K} - \hat{N} + \hat{a} \tag{22}$$

Substitution from (4) into (21), from (12) and (13) into (11), and then from the resulting expression into (21), along with substitution from (10) into (8), and then from the ensuing expression into (21), will yield

$$\hat{\sigma} = \mu(\lambda uk - \sigma) - \tau(\sigma - \varphi + \theta u) - (\rho\sigma - \phi\sigma^2) \quad (23)$$

where u is given by eq. (15). Substituting from (7) into (14) and then the resulting expression into (21), and from (4) into (21), we obtain

$$\hat{k} = s(1-\sigma)u - (\rho\sigma - \phi\sigma^2) - n \quad (24)$$

where u is again given by eq. (15), while n is the growth rate of labor supply, assumed to be exogenously given. A constant unemployment rate as a long-run characteristic, required to make for a stationary wage share, implies growth of employment equal to growth of the labor force plus growth of labor productivity. Hence, the rate of capital accumulation must be equal to the rate at which the reserve army is replenished through growth of the labor supply and labor productivity. Since we are dealing with endogenous technological innovation and exogenous labor supply growth, long-run equilibrium is determined by the interaction between the warranted rate (capital accumulation) and the natural rate (labor supply growth plus growth of productivity), with the course of both of them depending on the prevalent level of distribution.

Eqs. (23) and (24), after using (15), constitute a planar autonomous two-dimensional non-linear 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 level of parameters of the system. The matrix M of partial derivatives for this dynamic system is given by

$$M_{11} = \partial\hat{\sigma} / \partial\sigma = \mu(\lambda k u_\sigma^* - 1) - \tau(1 + \theta u_\sigma^*) - (\rho - 2\phi\sigma) \quad (25)$$

$$M_{12} = \partial\hat{\sigma} / \partial k = \mu\lambda u^* > 0 \quad (26)$$

$$M_{21} = \partial\hat{k} / \partial\sigma = g_\sigma^* - (\rho - 2\phi\sigma) \quad (27)$$

$$M_{22} = \partial\hat{k} / \partial k = 0 \quad (28)$$

Not all of these partial derivatives can be unambiguously signed. Eq. (26) shows that an increase in the ratio of capital to labor supply in productivity units, by raising the employment rate, will raise the wage share desired by workers, σ_w. This will raise the rate of increase in money wages, as shown by eq. (10), with the strength of such an increase given by $\mu\lambda$. Eq. (28) shows that since an increase in k does not affect either σ or u, there is no effect either on the rate of accumulation or in the rate of innovation, and hence no effect on the rate of growth of k.

Let us now turn to those partial derivatives whose signs are ambiguous, an ambiguity mainly associated with the non-linearity of the desired investment function. Eq. (25) shows that the impact of a change in the wage share on its rate of growth is mediated directly and indirectly by its impact on capacity utilization. The reason is that both the wage share desired by workers and the wage share implied by firms' desired markup depend on capacity utilization. While σ_f depends directly on the state of the goods market, σ_w depends directly on the state of the labor market. Now, given the fixed-coefficient nature of the technology, an increase in capacity utilization in the short run will necessarily be accompanied by an increase in employment. Whether, in turn, a change in the wage share will raise or lower the rate of innovation depends on the prevailing distributive profile. In case an increase in the wage share raises the innovation rate, then desired investment and (eventually) capacity utilization will raise as well, which will then trigger a new round of effects via conflict inflation along the lines just described. The sign of this partial derivative will depend, therefore, on the relative strength of all these effects. As for the sign of $\partial\hat{k} / \partial\sigma$, it is given by the relative impact of changes in the wage share on the rate of growth and on the rate of technological innovation.

We now have all the elements for a qualitative phase-diagrammatic analysis of the (local) stability properties of this dynamic system. The way we proceed is by analyzing the (local) stability of an equilibrium position in each one of the three regions into which we divided the meaningful subset of the domain. Now, eq. (20) shows that the numerator of $g = s(1 - \sigma)u$ is cubic in the wage share, while h, the technological innovation function, is quadratic in the wage share. With n being exogenously given, the equation describing the $\hat{k} = 0$ isocline is, therefore, cubic in the wage share, which means that there may be up to three real values for the wage share in the $(k - \sigma)$-space at which a respective vertical $\hat{k} = 0$ isocline will be located – recall that $\hat{k}$ does not depend on k. Given this geometry, the way we proceed is by analyzing the (local) stability properties of the equilibrium solution in each one of those regions were one of the $\hat{k} = 0$ isoclines to be located there.

3.1 LW region ($\sigma < \sigma^*$)

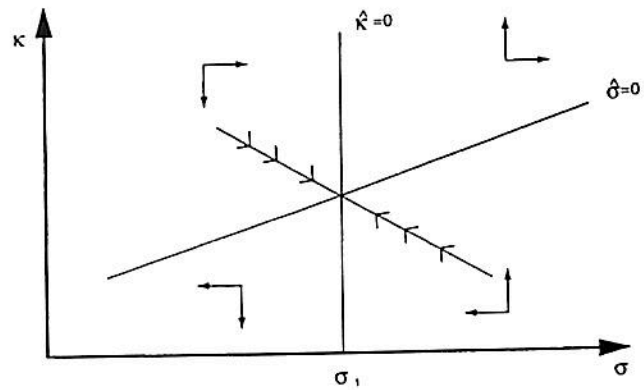
Recall that in this region the rate of technological innovation, capacity utilization and growth are directly related to the wage share. Hence, a higher wage share will exert an upward pressure on its rate of change by raising capacity utilization and thus employment, which will then raise the wage share desired by workers. However, this same rise in capacity utilization will also raise the markup desired by firms, which will then exert a downward pressure on the rate of change of the wage share by lowering firms' desired wage share. Besides, a higher wage share will also raise the innovation rate, which will increase firms' desired investment even more. The sign of M_{11} will then depend on the relative strength of all these effects, with closer inspection of eq. (25) revealing that it will be negative unless the impact via workers' desired wage share is very strong.

Regarding the sign of M_{21}, its ambiguity can be explained in the following way. In this region, a higher wage share will raise capacity utilization by more than it lowers the profit share, so that the growth rate will rise with the wage share. Now, one reason why capacity utilization will rise in this region is that a higher wage share will speed up technological innovation and thus, other things being equal, desired accumulation, which might suggest that the ultimate effect of a higher wage share on the growth rate is likely to be stronger than that immediate impact on the innovation rate.

However, the accompanying fall in the profit share will, other things being equal, affect capacity utilization in two other ways. Firstly, it will have a negative influence on desired investment and hence a negative one on capacity utilization. Secondly, it will have a negative influence on aggregate savings and therefore a positive one on capacity utilization. Now, having been assumed that a higher wage share will raise capacity utilization by more than it lowers the profit share, the question that remains is whether the ultimate rise in the growth rate is greater than the immediate rise in the rate of innovation.

In case $M_{11} < 0$ and $M_{21} > 0$, the resulting steady-state solution will be a saddle-point, given that Det(M) < 0. The dynamics for this instability situation is shown in Figure 1. Given that $M_{12} > 0$, the slope of the $\hat{\sigma} = 0$ isocline, which is given by $-(M_{11} / M_{12})$, is positive. Since $\partial \hat{k} / \partial \sigma$ is positive, $\hat{\sigma}$ undergoes a steady rise as k increases, so that the sign of $\hat{\sigma}$ is negative (positive) to the right (left) of the $\hat{\sigma} = 0$ locus, which explains the direction of the horizontal arrows. The slope of the $\hat{k} = 0$ isocline, given by $-(M_{21} / M_{22})$, is equal to zero. Given that $\partial \hat{k} / \partial \sigma > 0$, $\hat{k}$ undergoes a steady rise as σ increases, thus implying that the sign of $\hat{k}$ is negative (positive) to the left (right) of the $\hat{k} = 0$ isocline, which explains the direction of the vertical arrows.

Figure 1



In case $M_{11} > 0$ and $M_{21} > 0$, which means that the rate of change in nominal wages is very responsive to changes in capacity utilization and employment, the resulting equilibrium will still be a saddle-point, the reason being that the sign of Det(M) is given by the sign of M_{21}, with them having opposite signs. Hence, an equilibrium will be potentially stable only in case $\partial \hat{k} / \partial \sigma < 0$: the extent to which capacity utilization rises by more than the profit share falls in response to a rise in the wage share is smaller than the initial impact of this rise in the wage share on the rate of innovation. In this case, whether equilibrium will be stable or not will depend on the sign of Tr(M), which happens to have the same sign as M_{11}. Equilibrium will be stable (unstable) in case a change in the wage share puts a weaker (stronger) pressure on the rate of change of nominal wages than on the rate of price change and on the rate of innovation together. The dynamics for the stable situation is shown in Figure 2, whereas the dynamics for the unstable one is shown in Figure 3.

3.2 IL region ($\sigma^{+} < \sigma < \sigma^{*}$)

Recall that in this subset of the domain both the innovation rate and capacity utilization are still directly related to the wage share, so that the sign of

$\partial\hat{\sigma} / \partial\sigma$ is as ambiguous as in the previous region. The sign of $\partial\hat{k} / \partial\sigma$, though, is unambiguously negative now, the reason being that a higher wage share will both lower the growth rate and raise the rate of innovation. This ensures that Det(M) is positive, which rules out the possibility of saddle-point instability, with whether equilibrium is stable or unstable depending, as in the preceding region, on the sign of Tr(M), which will be negative unless the nominal wage growth effect is strong. While a negative sign for M_{11} will make for a stable equilibrium solution similar to the one shown in Figure 2, a positive one will make for an unstable equilibrium solution similar to the one shown in Figure 3.

Figure 2

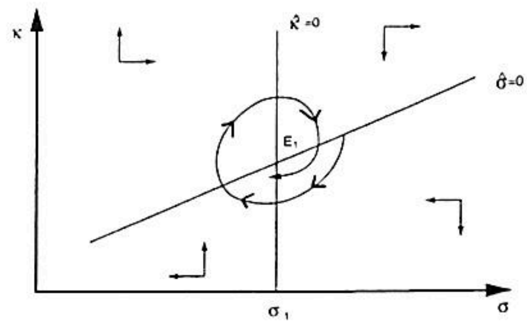
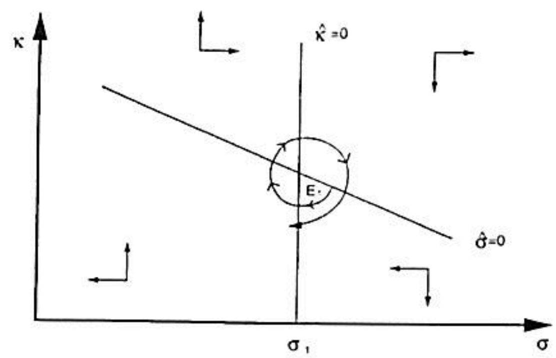


Figure 3



3.3 HW region ($\sigma > \sigma^*$)

Recall that in this region the technological innovation rate, capacity utilization and growth are inversely related to the wage share. The sign of $\partial \hat{k} / \partial \sigma$, whose inverse will give the sign of Det(M), is therefore negative, the reason being the following. In this subset of the domain, a higher wage share will lower desired accumulation by reducing both the profit share and the technological innovation rate. Even though a higher wage share will also imply a lower aggregate saving, capacity utilization will fall, which will add to a falling profit share to make for an even greater fall in the growth rate. Hence, the ultimate fall in the growth rate is greater than the immediate fall in the technological innovation rate, which makes for a negative sign for $\partial \hat{k} / \partial \sigma$ and, accordingly, makes for a positive sign for Det(M). With the possibility of a saddle-point instability thus ruled out, whether an equilibrium solution located in this region is stable or unstable will depend on the sign of Tr(M), which in turn shares the sign of $\partial \hat{\sigma} / \partial \sigma$, which is ambiguous again. A higher wage share will put a downward pressure on its own rate of change by lowering capacity utilization and thus employment, which will lower the wage share desired by workers. However, this same fall in capacity utilization will lower firms' desired markup as well, which will then put a upward pressure on the rate of change of the wage share by lowering the rate of change in prices. Besides, a higher wage share will put an upward pressure on its rate of change by lowering the innovation rate, with the strength of this effect rising with the wage share, so that the sign of $\partial \hat{\sigma} / \partial \sigma$ will depend on the relative strength of all these effects.

Interestingly, therefore, a strong nominal wage growth effect is now necessary to ensure that Tr(M) becomes negative, which in turn ensures the stability of an equilibrium located in this subset of the domain. While in the LW region, where wage-led growth obtains, a too strong nominal wage growth effect will make for an unstable equilibrium solution, in the HW region, where profit-led growth obtains, it will rather make for an stable one. Again, a negative sign for M_{11} will make for a stable equilibrium solution similar to the one shown in Figure 2, whereas a positive one will make for an unstable equilibrium solution similar to the one shown in Figure 3.

Now, to measure how sensitive are all these stability requirements to the assumption that firms' desired markup is directly related to capacity utilization, let us briefly examine the general implications of assuming an inverse relationship instead. In the LW region, where wage-led capital accumulation obtains, recall that saddle-point equilibrium will obtain unless $\partial\hat{k} / \partial\sigma$, with a negative (positive) M_{11} then making for a stable (unstable) equilibrium. Hence, firms' desired markup being inversely related to capacity utilization will not remove the source of saddle-point instability. In the IL region, where the possibility of saddle-point instability had been ruled out, the chances of Tr(M) being negative are lower than before. The reason is that a higher wage share leading to a higher capacity utilization will now put an upward pressure on $\hat{\sigma}$ not only by raising σ_w, but by raising σ_f as well. In the HW region, though, the chances of Tr(M) being negative are higher than before. The reason is that now a higher wage share, by lowering capacity utilization – and thus employment – will both lower the rate of change in nominal wages and raise the rate of change in prices, which means that $\partial\hat{\sigma} / \partial\sigma$ becomes negative unless the technological innovation effect is strong enough to more than compensate that combined downward pressure.

4 Multiple equilibria analysis

The non-linearity embodied in the desired investment function makes for the possibility of multiple equilibria within the relevant domain given by $0 < \sigma < 1$. As shown above, there may be up to three real values for the share of wages at which a corresponding vertical $\hat{k} = 0$ isocline would be located in the (k - σ)-space. For illustrative purposes, we will assume that only two of these levels of wage share are located in the relevant domain. Let us call σ_1 and σ_2 two levels of wage share located in the LW and IL, respectively, and call $\hat{k}_1 = 0$ and $\hat{k}_2 = 0$ the corresponding $\hat{k} = 0$ isoclines.

Amongst the possible configurations leading to multiple equilibria, one worthy of a more detailed phase-diagrammatic analysis contains a saddle-point in the LW region and an unstable solution in the IL region. Recall that the sign of M_{11} depends on the relative bargaining power of capitalists and workers and on the strength of the innovation effect, while the sign of M_{21} depends on the relative response of the accumulation rate and of the innovation function to a change in the wage share. Let us hypothesize that the parameters which govern the relative strength of the nominal wage change, price change and innovation effects can be such that the former dominates the latter two in the IL region, it being dominated by them in the LW one. Hence, M_{11} is negative in the LW region and positive in related to it. In the situation hypothesized in Figure 4, a rise in the wage share will raise the rate of change of nominal wage by more than it rises the rate of change in prices and the rate of innovation combined, so that the level and the rate of change of the wage share move in the same direction. On the other hand, the wage share and the rate of change of the capital to efficiency labour supply ratio move in the opposite direction. A rise in the wage share, for instance, will both lower the rate of accumulation and raise the labour supply in productivity units. Also, recall that the fixed-proportion nature of the technology implies that capacity utilization and the rate of employment move in the same direction, with the strength of the connection being given precisely by the capital to efficiency labor supply ratio. More precisely, the higher k, the higher the change in the employment rate brought about by a change in capacity utilization. Since the price-setting power of capitalists and workers is endogenous to capital accumulation through a conflict theory of inflation, a fall in k, for instance, leads to a fall in the extent to which the nominal wage change effect is greater than the price change and innovation effects combined. Therefore, in the upper (lower) part of the zone of instability the level and the rate of change of the wage share move in the same (opposite) direction throughout the domain precisely because k does not fall (rise) enough to make for a cyclical reversal. In the zone of stability, on the other hand, the system will move cyclically precisely because k can rise or fall to the extent that it is necessary to make for a cyclical reversal.

Starting from a point in the upper part of the $\hat{\sigma} = 0$ isocline in the IL region, for instance, a rise in the wage share will raise the rates of innovation and capacity utilization, but will lower the accumulation rate. At such levels of σ and k, though, k will keep rising until the $\hat{k}_2 = 0$ isocline is reached, after which further rises in the wage share will raise σ and lower k, higher levels of wage share carrying the seeds of their own reversal. Once the lower part of the $\hat{\sigma} = 0$ isocline is reached, σ will have risen, and k fallen, by enough for the upward motion of the wage share to cease. A lower wage share will, by lowering (raising) the rates of innovation and capacity utilization (accumulation), reduce σ and k even more, until the lower part of the $\hat{k}_2 = 0$ isocline is reached. At that point, σ and k will have fallen by enough for the reversal of the downward motion of σ to occur. Once σ has fallen, and k risen, by enough, the upper part of the $\hat{\sigma} = 0$ isocline will then be reached back.

Therefore, this model shares with the classic contribution by Goodwin (1967) a cyclical growth dynamics governed by the interaction between capital accumulation, employment and distribution.[10] Unlike the Goodwin model, though, this one allows effective demand to play a role through a variable degree of capacity utilization, incorporates price and nominal wage dynamics by means of a conflict theory of inflation, and is based on an endogenous mechanism of technological change. If left undisturbed, the Goodwin model will produce conservative cyclical fluctuations in the wage share and in the rate of employment. However, the trajectories will no longer be closed orbits if direct feedbacks from the wage share to its rate of change – or from the level of the employment rate to its rate of change – are introduced. As the partial derivatives (25)-(28) show, this model introduces a complex non-linear feedback from the wage share to its rate of change through variable capacity utilization, conflict inflation and endogenous technological change. These general features of this model are shared with Dutt (1994), from which this model draws the most. Unlike the latter, though, this model does not rely on full capacity utilization being reached for profit-led capital accumulation and multiple equilibria to obtain in the domain. Given the non-linear investment function used here, the system may experience self-sustaining fluctuations – eventually alternating phases of wage-led accumulation with phases of profit-led accumulation – below full capacity utilization. Besides, technological change is endogeneized in Dutt (1994) by being made to depend linearly on the rate of accumulation, whereas in this model it is endogeneized by being made to depend non-linearly on distributive shares. Indeed, the non-linear nature of the technological innovation function used in this model allows it to specify precise ranges of distributive shares within which wage-led and profit-led capacity utilization and accumulation obtain.

The model of this essay has also some overlap with the one developed in You (1994), which also discusses the interaction between endogenous technological change and capital accumulation in the long run. Central to its multiple-equilibria dynamics is a non-linear Kaldorian endogenous technical progress function according to which the rate of capital deepening is an increasing convex function of the rate of accumulation. While in the model of this essay technological change is non-linear in distribution, in the You model it is non-linear in accumulation. This convexity comes from the assumption that the capital-deepening effect of real wage increases is similarly convex, that is, the higher the accumulation rate, the greater the capital-deepening effect of real wage growth. Basically, this convexity comes from a mutually reinforcing interaction between

(10) In the Goodwin model, capital accumulation taking place increases employment. Once the employment rate has crossed a thresold level in the neighborhood of full employment, the real wage begins to rise. This lowers the rate of profit and therefore the possible rate of accumulation. When the accumulation rate declines sufficiently, the employment rate falls low enough to cause the real wage to decline. This re-establishes the rate of profit, so that the rate of accumulation can then increase once again.

the expected rate of increase of the real wage and a labour-saving bias triggered by the recent past rate of growth of the real wage.

Hence, while in the model of this essay the focus is more on the possibility and stability of distinct capacity utilization and accumulation regimes for several distributive levels, in the You model the focus is more on the possibility and stability of different rates of growth for different accumulation regimes. While a central result of the former is that wage-led (profit-led) accumulation will obtain only for low (high) levels of wage (profit) share, a central result of the latter is that high (low) growth is stable only in a wage-led (profit-led) accumulation regime. In any case, in both models the relative price-setting power of capitalists and workers is endogenous to the accumulation process – the power of capitalists (workers) to drive up prices (nominal wages) rising with the level of capacity utilization (employment rate) – and plays a leading role on the stability properties of the system.

Reprise

This essay has developed a non-linear model of capital accumulation, distribution and conflict inflation in which endogenous technological innovation plays a significant role. With the rate of technological innovation being non-linear in distributive shares, both the direction and the intensity of the effect of changes in distribution on capacity utilization, capital accumulation and distribution will depend on the prevailing distribution. While wage-led accumulation will obtain for low levels of wage share, profit-led accumulation will be the case for intermediate-low and high ones. An equilibrium solution located in the region where wage-led capital accumulation obtains will be saddle-point unstable unless the technological innovation effect is strong enough, this being so no matter the relative bargaining power of workers and capitalists. For intermediate-low and high levels of wage share, saddle-point instability is ruled out, with stability depending on the relative bargaining power of workers and capitalists and on the strength of the innovation effect. The essay closed with a qualitative phase-diagrammatic analysis of a possible configuration for the system leading to multiple equilibria and cyclical behavior.

References

ARROWSMITH, D., PLACE, C. *Dynamical systems;* differential equations, maps and chaotic behaviour. London: Chapman & Hall, 1992.

BHADURI, A., MARGLIN, S. Unemployment and the real wage; the economic basis for contesting political ideologies. *Cambridge Journal of Economics*, v. 14, n. 4, 1990.

BILS, M. The cyclical behavior of marginal cost and price. *American Economic Review*, v. 77, n. 5, 1987.

BURNSIDE, C., EICHENBAUM, M. Factor-hoarding and the propagation of business-cycle shocks. *American Economic Review*, v. 86, n. 5, 1996.

CHEVALIER, J., SCHARFSTEIN, D. Capital-market imperfections and countercyclical markups: theory and evidence. *American Economic Review*, v. 86, n. 4, 1996.

DAVID, P. *Technical choice, innovation and economic growth.* Cambridge: Cambridge University Press, 1975.

DOSI, G. *Technical change and industrial transformation.* New York: St. Martin's Press, 1984.

DUTT, A. K. Stagnation, income distribution and monopoly power. *Cambridge Journal of Economics*, v. 8, 1984.

________. *Growth, distribution and uneven development.* Cambridge: Cambridge University Press, 1990.

________. Conflict inflation, distribution, cyclical accumulation and crises. *European Journal of Political Economy*, v. 8, 1992.

DUTT, A. K. On the long-run stability of capitalist economies; implications of a model of growth and distribution. In: ________ (Ed.). *New directions in analytical political economy.* Aldershot: Edward Elgar, 1994.

EICHNER, A. *The megacorp and oligopoly.* Cambridge: Cambridge University Press, 1976.

FREEMAN, C. *The economics of industrial innovation.* London: Pinter, 1982.

________, SOETE, L. *Technical change and full employment.* New York: Basil Blackwell, 1987.

GOODWIN, R. A growth cycle. In: FEINSTEIN, C. H. (Ed.). *Socialism, capitalism and economic growth.* Cambridge: Cambridge University Press, 1967.

GORDON, D., WEISSKOPF, T., BOWLES, S. Long-term growth and the cyclical restoration of profitability. In: GOODWIN, R., KRUGER, M., VERCELLI, A. (Ed.). *Nonlinear models of fluctuating growth.* Berlin: Springer-Verlag. 1984.

GREENWALD, B., STIGLITZ, J., WEISS, A. Informational imperfections in the capital market and macroeconomic fluctuations. *American Economic Review*, v. 74, n. 1, May 1984.

HARCOURT, G. C., KENYON, P. Pricing and the investment decision. *Kyklos*, v. 29, n. 3, 1976.

KALDOR, N. Alternative theories of distribution. *Review of Economic Studies*, v. 23, n. 2, 1956.

KALECKI, M. *Theory of economic dynamics.* London: Allen and Unwin, 1954.

________. *Selected essays on the dynamics of the capitalist economy.* Cambridge: Cambridge University Press, 1971.

KEYNES, J. M. (1936) *The general theory of employment, interest and money.* New York: Harcourt Brace, 1953.

LANDESMANN, M., GOODWIN, R. Productivity growth, structural change and macroeconomic stability. In: PASINETTI, L., SOLOWS, R. (Ed.). *Economic growth and long-term development.* New York: St. Martin's Press, 1994.

LIMA, G. T. *Em busca do tempo perdido:* a recuperação pós-keynesiana da economia do emprego de Keynes. Rio de Janeiro: BNDES, 1992.

________. Development, technological change and innovation; Schumpeter and the new-schumpeterians. *Revista Brasileira de Economia*, v. 50, n. 2, 1996.

MINSKY, H. *John Maynard Keynes.* New York: Columbia University Press, 1975.

NELSON, R., WINTER, S. *An evolutionary theory of economic change.* Cambridge: Harvard University Press, 1982.

PASINETTI, L. The rate of profit and income distribution in relation to the rate of economic growth. *Review of Economic Studies*, v. 29, 1962.

PERELMAN, M. *Keynes, investment theory and the economic slowdown.* New York: St. Martin's Press, 1989.

ROBINSON, J. *The accumulation of capital.* London: Macmillan, 1956.

________. *Essays in the theory of economic growth.* London: Macmillan, 1962.

ROSENBERG, N. *Perspectives on technology.* Cambridge: Cambridge University Press, 1976.

ROTEMBERG, J., SALONER, G. A supergame theoretic model of business cycle and price wars during booms. *American Economic Review*, v. 76, n. 3, 1986.

________, WOODFORD, M. Markups and business cycle. In: BLANCHARD, O., FISCHER, S. (Ed.). *NBER Macroeconomics Annual 1991.* Cambridge: MIT Press, 1991.

________, ________. Oligopolistic pricing and the effects of aggregate demand on economic activity. *Journal of Political Economy*, v. 100, n. 6, 1992.

ROWTHORN, B. Conflict, inflation and money. *Cambridge Journal of Economics*, v. 1, 1977.

________. Demand, real wages and economic growth. *Thames Papers in Political Economy*, Autumn 1981.

SCHUMPETER, J. (1912). *The theory of economic development.* 2nd ed. New York: Harper & Brothers, 1934.

________. *Capitalism, socialism and democracy.* New York: Harper & Brothers, 1942.

SILVERBERG, G., DOSI, G., ORSENIGO, L. Innovation, diversity and diffusion; a self-organization model. *Economic Journal*, v. 98, 1988.

STEINDL, J. *Maturity and stagnation in American capitalism.* New York: Monthly Review Press, 1952.

________. Ideas and concepts of long run growth. *Banca Nazionale del Lavoro, Quarterly Review*, v. 136, March 1981.

STIGLITZ, J. Price rigidities and market structure. *American Economic Review*, v. 74, n. 2, 1984.

________, ATKINSON, A. A new view of technological change. *Economic Journal*, v. 79, 1969.

VERSPAGEN, B. Localized technological change, factor substitution and the productivity slowdown. In: FREEMAN, C., SOETE, L. (Ed.). *New explorations in the economics of technical change.* London: Pinter Publishers, 1990.

YOU, J-I. Macroeconomic structure, endogenous technical change and growth. *Cambridge Journal of Economics*, v. 18, 1994.

TEXTO PARA DISCUSSÃO. IE/UNICAMP

Fazem parte desta Série:

n. 1 – 10; 12 – 19; 21 – 24; 27; 29; 32; 38; 54 – Esgotados.

n. 11 COSTA, Fernando Nogueira da. **(Im)Propriedades da moeda.** out./92.

n. 20 LEAL, João Paulo Garcia. **Evolução do comércio exterior sul-coreano de manufaturas segundo suas vantagens comparativas reveladas: 1981-1988.** maio/93.

n. 25 DEQUECH FILHO, David. **Salários e absorção de mão-de-obra no Brasil: um exame a partir das regiões metropolitanas.** jul./93.

n. 26 LOPREATO, Francisco Luiz Cazeiro. **Crise de financiamento dos governos estaduais (1980/1988).** ago./93.

n. 28 SANTOS FILHO, Otaviano Canuto dos. **Technological change and late industrialization: lessons from a post keynesian evolutionary approach.** set./93.

n. 30 LIMA, Gilberto Tadeu. **Taxonomy of production economies and monetary determination of effective demand: a puzzle in Keynes'economics.** out./93.

n. 31 BIASOTO JUNIOR, Geraldo. **Tributação: princípios, evolução e tendências recentes.** nov./93.

n. 33 SUZIGAN, Wilson & SZMRECSÁNYI, Tamás. **Os investimentos estrangeiros no início da industrialização do Brasil.** jan./94.

n. 34 REYDON, Bastiaan Philip. **A especulação com terras agrícolas: uma interpretação a partir de um referencial teórico pós-keynesiano.** jan./94.

n. 35 BELIK, Walter. **Um estudo sobre o financiamento da política agroindustrial no Brasil (1965-87).** abr./94.

n. 36 HIGACHI, Hermes Yukio. **Estratégias das empresas líderes na indústria brasileira do papel.** maio/94.

n. 37 COUTINHO, Mauricio Chalfin. **Marx e a economia política clássica: trabalho e propriedade.** maio/94.

n. 39 CINTRA, Marcos Antonio Macedo. **Uma visão crítica da teoria da repressão financeira.** jul./94.

n. 40 MATIJASCIC, Milko. **Fundos de pensão e rearticulação da economia brasileira.** jul./94.

n. 41 CORSI, Francisco Luiz. **As discussões em torno dos rumos da economia brasileira ao final do Estado Novo.** jul/94

n. 42 GRAZIANO DA SILVA, José. **A formação de preços dos produtos agrícolas: notas para discussão de uma abordagem alternativa.** nov./94

n. 43 LOPREATO, Francisco Luiz. **Dificuldades e perspectivas dos bancos estaduais.** nov./94.

n. 44 BRANDÃO,Sandra Márcia Chagas. **Políticas salarial e negociações coletivas: a experiência das categorias profissionais metalúrgicas e têxtil do município de São Paulo no período 1978-89.** dez/94.

n. 45 CANUTO, Otaviano. **Um modelo de crescimento endógeno com microfundamentos evolucionistas.** jan./95.

n. 46 LEONE, Eugênia Troncoso. **Manifestações da pobreza agrícola no Brasil em 1990.** jun./95.

n. 47 BELIK, Walter. **Auto-regulação e políticas públicas para o setor agroalimentar no Brasil.** jun./95.

n. 48 SUZIGAN, Wilson. **Experiência histórica de política industrial no Brasil.** ago./1995.

n. 49 ALMEIDA, Marcio W.; BAPTISTA, Margarida. **A flexibilização do monopólio das telecomunicações: desafios e mitos.** ago./1995.

n. 50 SILVA, Antonio Carlos Macedo. **Lei de Say, equilíbrio e demanda efetiva.** set./1995.

n. 51 BRAGA, José Carlos de Souza. **Economia política da dinâmica capitalista (Observações para uma proposta de organização teórica).** set./1995.

n. 52 POSSAS, Silvia Maria. **Notas acerca da lógica da decisão e de expansão da firma capitalista.** out./1995.

n. 53 ARCANGELI Fabio; CANUTO, Otaviano. **Growth models with Schumpeterian micro-foundations.** dez./1995.

n. 55 COSTA, Fernando Nogueira da. **Relação micro-macroeconomia monetária: o status teórico da preferência pela liquidez.** set./1996.

n. 56 HIGACHI, Hermes; CANUTO, Otaviano; PORCILE, Gabriel. **Modelos evolucionistas de crescimento endógeno.** dez./1996.

n. 57 KAGEYAMA, Angela. **O subemprego agrícola nos anos 90.** mar./1997.

n. 58 CANUTO, Otaviano. **Padrões de especialização, hiatos tecnológicos e crescimento com restrições de divisas.** mar./1997.

n. 59 HOLLAND, Marcio; CANUTO, Otaviano; XAVIER, Clésio. **Taxas de câmbio, elasticidades-renda e saldo comercial na economia brasileira.** mar./1997.

n. 60 FIGUEIREDO, Ferdinando de Oliveira. **Hilferding e "O capital financeiro".** set./1997.

n. 61 CANUTO, Otaviano; RABELO, Flávio Marcílio; SILVEIRA, José Maria. **Economic openness and business groups in Brazil; an evolutionary approach.** dez./1997. 20p.

n. 62 COUTINHO, Maurício. **Fundo previdenciário e impacto orçamentário no serviço público.** fev./1998. 30p.

n. 63 ALMEIDA, Júlio Sérgio Gomes de, FREITAS, Maria Cristina Penido de. **A regulamentação do sistema financeiro.** mar./1998. 64p.

n. 64 LIMA, Gilberto Tadeu. Capital controversy in the origin of macroeconomics: the Keynes-Hayek exchange. Maio/1998. 36p.