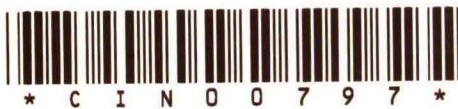


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ENDOGENOUS GROWTH AND INCOME DISTRIBUTION

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ENDOGENOUS GROWTH AND INCOME DISTRIBUTION *

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Abstract

A theory of endogenous growth is based on an investment possibility function, relating the ratio of gross investment to the growth rates of output and employment. Consumers maximise an intertemporal utility function and producers maximise the value of the firm. The long-run rate of growth depends on consumer preferences, the exogenous growth of labour supply and the degree of monopoly. The functional distribution of income is determined along with the investment ratio in the steady state. Labour market imperfections and real wage inertia induce transition processes, which are important for medium term growth. Hysteresis and union power give rise to long-run unemployment.

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1 Introduction

A dissatisfaction with neoclassical growth theory of the sixties has led to a revival of the theory of economic growth. Neoclassical theory developed by Solow (1956) and Swan (1956) builds upon diminishing returns of factors of production. If one factor can be accumulated and the other factor is exogenous economic growth in the long run depends entirely on exogenous factors, for instance the growth rate of labour supply and the growth rate in labour efficiency (technological change). The new growth theory (endogenous growth theory as it is often called) introduces different devices to overcome diminishing returns of the reproducible factor. There are now a number of useful surveys that compare the different approaches taken (e.g. Romer, 1989; Barro and Sala-i-Martin, 1990; Sala-i-Martin, 1990).

Endogenous growth theories take a more realistic view of the production process in the economy by allowing non-decreasing returns with respect to reproducible factors. Whereas in neoclassical theory physical capital is the only reproducible factor, the new growth theory takes a broader view by including human capital (explicitly or implicitly) as a reproducible factor of production (e.g. Lucas, 1988; King and Rebelo, 1990). Assuming non-decreasing returns with respect to accumulated factors of production the long-run growth rates depend on intertemporal preferences for consumption. Countries with identical structures will grow at the same rate, but there is no convergence to a unique level of output as there is in the neoclassical theory. These results of endogenous growth theory seem more in line with empirical observations, although this claim is not undisputed (see for instance Mankiw, Romer and Weil, 1990).

There are a number of interesting extensions of the new growth theory. Research and development activities may be directed at innovating new intermediate products, which may be used in turn to increase the production of final goods. Diminishing returns with respect to different types of capital goods in the final goods producing sector are then counterbalanced by adding new types to the set of inputs (e.g. Romer, 1990; Grossman and Helpman, 1989). There are other specifications of the R&D process which give similar results (e.g. Helpman and Grossman, 1989). What these models have in common is that they spell out production activities in some detail by way of examples that illustrate the endogeneity of accumulation.

Here we take a different route by emphasising change as such. Production at a point in time is a singular event, determined by past history. What matters more is that the world is in a constant flux, because people change

things by investing in many different ways. Following ideas put forward by Scott (1989) in a seminal book on economic growth we assume that gross investment always implies change and never mere reduplication of existing processes¹. Economic evolution and learning are two sides of the same coin. On a microeconomic level there may be merit in modelling specific activities like R&D, institutional learning, etc. On a macroeconomic level it may suffice to assume a relation between gross investment (consumption foregone) and the growth rates of output and employment. Such a relation, which will be introduced more formally in the next section, is reminiscent of earlier attempts like Kaldor's technical progress function (Kaldor, 1957) or the Kennedy-Samuelson-Weiszacker technological possibility frontier (Kennedy, 1964; Samuelson, 1965). However, where Kaldor failed ultimately to present a real alternative and Kennedy c.s. addressed a partial problem, the model approach by Scott fits into the new growth theory.

The approach preferred in the present paper implies that the production function in its traditional static setting is not taken into account. The elimination of the production function has nothing to do with the capital debate that dominated the Cambridge-Cambridge discussion of the seventies. Nevertheless, the problem of the functional distribution of income will be an important issue in the analysis to come. The theory of endogenous growth developed in this paper puts the distribution problem in a proper, that is to say, a dynamic perspective.

The rest of the paper is organised as follows. In Section 2 we derive a formal model of economic growth from microeconomic principles. The determinants of steady state growth are examined in Section 3 by working out the comparative statics of the model. In Section 4 it is assumed that the labour market does not clear immediately but adjusts over time according to some well-known theories. Under this assumption the model exhibits transition dynamics, which can be illustrated by numerical examples as the model proves to be saddlepoint stable. Conclusions and suggestions for further research along the lines set out in this paper are presented in Section 5.

¹For a comparison of neoclassical theory, endogenous growth theory and the work of Scott, see van de Klundert (1990).

2 A growth model based on microfoundations

At each point in time production (y), employment (l) and the real wage rate (w) are predetermined variables. Firms can change their environment by investing in new capital goods or by spending money to alter existing equipment. By doing so output and employment can be changed. Usually output will increase, but employment may go either way. If firms expect real wages to rise fast it may be profitable to invest in labour saving expansions of production capacity ("defensive investment"). In the opposite situation of a moderate wage increase firms will invest in a more offensive way or, as Lamlalussy (1961) suggested some time ago, engage in "enterprise investment". Following Scott (1989) investment is taken gross of depreciation, because the total amount matters in creative destruction to paraphrase Schumpeter (1934). Depreciation of existing equipment, as quasi-rents become zero, is of no relevance, because it is a byproduct of economic growth. Or to put it differently, economic growth is always concerned with qualitative change. New vintages of capital goods drive out old existing ones. There may be ways to add machines and equipment of different kinds, but the question is whether such a concept of capital is useful for an analysis of economic growth.

To confine attention to only two dimensions we consider rates of change of output per unit ratio of investment expenditure ($\frac{g}{\sigma}$) and rates of change of employment per unit ratio of investment expenditure ($\frac{g_l}{\sigma}$), where g , g_l and σ denote respectively the growth rate of output (y), the rate of change in employment (l) and the ratio of gross investment to output ($\sigma \equiv \frac{i}{y}$). The investment possibility function (IPF) reads:

$$\frac{g}{\sigma} = q(\sigma)f \left[\frac{g_l}{\sigma} \frac{1}{q(\sigma)} \right], \quad f' > 0, \quad f'' < 0 \quad (2.1)$$

The sub-function $q(\sigma)$ is decreasing in σ , so that there are diminishing returns with respect to σ : $q'(\sigma) < 0$, $q''(\sigma) > 0$. For given values of σ it is possible to draw investment programme contours (IPC's) as shown in Figure 1. Higher values of σ correspond to lower IPC's, because of diminishing returns. Each IPC shows a concave relation between $\frac{g}{\sigma}$ and $\frac{g_l}{\sigma}$ indicating that it becomes increasingly more difficult to raise the labour intensity of per ratio unit of investment expenditure. For a given change in σ the IPC shifts iso-elastic along rays from the origin. The variable g , which may be called

the radius of the IPC, decreases with a positive change in the investment ratio.

The IPF is based on the view that investment leads to change and change is essential to learning. Invention can be seen as a form of investment determined by its profitability. There may be learning externalities, because firms may learn from investments undertaken by others. Such externalities should be taken into account if the welfare implications of the theory are considered. To simplify matters and concentrate on the essentials we do not pursue this question for the time being.

Insert: Figure 1.

Firms maximise the value of the firm over an infinite horizon for given time paths of real wages (w) and real interest rates (r). It is assumed that markets are characterised by monopolistic competition. Each firm faces a downward sloping demand curve and chooses its optimal price and quantity independent of the actions of its competitors. There may be different ways to model imperfect competition in a general equilibrium framework. A nice example is Blanchard and Kiyotaki (1987), where each firm sells its own commodity variety in an otherwise symmetric world. Cooper and John (1988) stress the role played by the number of firms in markets with an homogeneous product. Here, we employ a short-cut by simply postulating a downward sloping demand curve $p = p(y)$ for the representative firm. The relative price p is of course equal to unity because all firms are in the same position ultimately. Omitting time subscripts the cash flow in real terms is: $yp(y) - lw - i$. The firm's decision problem can therefore be formulated as

$$\text{Max}_{\{g, i, \sigma\}} V = \int_0^{\infty} \left[\{yp(y) - lw - \sigma y\} \exp\left(-\int_0^t r(s) ds\right) \right] dt \quad (2.2)$$

subject to equation (2.1) and the definitions:

$$\dot{y} = gy \quad (2.3)$$

$$\dot{i} = g_i i \quad (2.4)$$

$$\dot{w} = g_w w \quad (2.5)$$

where g_w denotes the exogenously given rate of change of real wages. The Hamiltonian for the present maximisation problem is

$$\begin{aligned} \mathcal{H} = & yp(y) - lw - \sigma y + \xi \left\{ \frac{g}{\sigma} - q(\sigma) f \left[\frac{g_l}{\sigma} \frac{1}{q(\sigma)} \right] \right\} \\ & + \varphi_1 g y + \varphi_2 (g_w + g_l) l w \end{aligned} \quad (2.6)$$

The letter ξ denotes a Lagrangean multiplier associated with the investment possibility function (2.1), while φ_1 and φ_2 are costate variables associated with the state variables output, y , and labour costs, lw .

The first order conditions are obtained by differentiating \mathcal{H} with respect to the three instrument variables σ , g and g_l .

$$\frac{\partial \mathcal{H}}{\partial \sigma} = -y - \xi \left\{ \frac{g}{\sigma^2} + \frac{g}{\sigma} \frac{q'(\sigma)}{q(\sigma)} - \left(\frac{g_l}{\sigma^2} + \frac{g_l}{\sigma} \frac{q'(\sigma)}{q(\sigma)} \right) f' \right\} = 0 \quad (2.7)$$

$$\frac{\partial \mathcal{H}}{\partial g} = \frac{\xi}{\sigma} + \varphi_1 y = 0 \quad (2.8)$$

$$\frac{\partial \mathcal{H}}{\partial g_l} = \frac{-\xi f'}{\sigma} + \varphi_2 l w = 0 \quad (2.9)$$

Eliminating the Lagrangean multiplier ξ results in the conditions

$$f' = -\frac{\varphi_2}{\varphi_1} \lambda \quad (2.10)$$

$$\left(\frac{g}{\sigma} - \frac{g_l}{\sigma} f' \right) (1 - \chi) = \frac{1}{\varphi_1} \quad (2.11)$$

where $\lambda \equiv \frac{lw}{y}$ denotes the share of labour in income and $\chi \equiv -\frac{\sigma q'(\sigma)}{q(\sigma)}$ denotes the positively defined elasticity of the radius with respect to the investment ratio. As can easily be shown $g > g_l f'$ and $\varphi_1 > 0$. The elasticity of the

radius should therefore be smaller than one ($\chi < 1$). Moreover, as $\varphi_1 > 0$ equation (2.10) implies $\varphi_2 < 0$. The rates of change of the costate variables are obtained in the usual way as

$$\dot{\varphi}_1 = (r - g)\varphi_1 - (\eta - \sigma) \quad (2.12)$$

$$\dot{\varphi}_2 = [r - (g_l + g_w)]\varphi_2 + 1 = (r - g - \frac{\dot{\lambda}}{\lambda})\varphi_2 + 1 \quad (2.13)$$

where η in equation (2.12) is the ratio of marginal revenue to price. Assuming a constant, positively defined, price elasticity of demand ($\epsilon = -\frac{p}{y} \frac{dy}{dp}$) and setting the price at unity we derive $\eta = (1 - \frac{1}{\epsilon})$ as a measure of the degree of monopoly. It is assumed that ϵ is larger than unity. If markets are perfect $\eta = 1$, otherwise we have $\eta < 1$.

The interpretation of the costate variables is somewhat difficult, although the expressions for φ_1 and φ_2 are intuitively appealing. The costate variable φ_1 shows the present attractiveness of investment in terms of marginal revenue versus consumption foregone, whereas φ_2 signals the development of labour cost over time. Taking account of these interpretations it may be said that condition (2.10) determines the investment strategy of the firm. Relatively high labour costs in the future induce firms to select investment programmes with a relatively high proportional marginal product of labour (f'). Firms then opt for a defensive investment strategy. The extent of the investment programme is governed by condition (2.11). A high value of φ_1 makes investment of given type (f' fixed) more attractive. But a high value of φ_1 ceteris paribus induces firms also to accept relatively more offensive investment projects as appears from equation (2.10).

The representative household maximizes an additive separable intertemporal utility function. Instantaneous utility depends on the level of consumption (c_t). Labour supply is dealt with as an exogenous variable. Assuming a constant elasticity of intertemporal substitution $\frac{1}{\beta}$ the household's decision problem can be written as

$$Max_{\{c_t\}} U = \int_0^{\infty} \left[\frac{c_t^{1-\beta}}{1-\beta} \right] \exp(-\alpha t) dt, \quad \beta \neq 1 \quad (2.14)$$

subject to an intertemporal budget constraint, which can be formulated in general terms

$$\dot{a}_i = r a_i - c_i \quad (2.15)$$

where a_i denotes household's total wealth and all labour income is fully diversifiable. Human and non-human wealth are aggregated for convenience. The first-order conditions for this maximization problem boil down to

$$\frac{\dot{c}_i}{c_i} = \frac{r - \alpha}{\beta} \quad (2.16)$$

The rate of growth of aggregate consumption (c) equals the sum of the rate of growth of per capita consumption and the exogenous rate of growth of the number of households: $\frac{\dot{c}}{c} = \frac{\dot{c}_i}{c_i} + g_n$. Substitution of this relation in (2.16) yields:

$$\frac{\dot{c}}{c} = \frac{r - \alpha}{\beta} + g_n \quad (2.17)$$

Ignoring the public sector the equilibrium condition in the output market is $c = (1 - \sigma)y$. Taking account of this relation equation (2.17) can be rewritten as

$$\frac{\dot{\sigma}}{1 - \sigma} = \frac{\alpha - r}{\beta} + (g - g_n) \quad (2.18)$$

To close the model we assume for the time being that the labour market clears without delay:

$$g_l = g_n \quad (2.19)$$

It may be useful to count equations and endogenous variables. The complete model comprises the equations: (2.1), (2.10), (2.11), (2.12), (2.13), (2.18) and (2.19) and solves for the variables $g, g_l, \sigma, \lambda, \varphi_1, \varphi_2$ and r . The state variables φ_1 and φ_2 are non-predetermined. The economy has no transitional dynamics and always jumps to a steady state in case of a disturbance. The levels of output and employment follow from the definition equations (2.3) and (2.4) and predetermined values at an arbitrary starting point.

3 Determinants of economic growth

A steady state solution is obtained for $\dot{\varphi}_1 = \dot{\varphi}_2 = \dot{\sigma} = \dot{\lambda} = 0$. Substitution of these conditions in equations (2.12), (2.13) and (2.18) yields after some manipulation the following results for a situation of balanced growth:

$$g = \sigma q(\sigma) f \left[\frac{g_n}{\sigma} \frac{1}{q(\sigma)} \right] \quad (3.1)$$

$$r = \alpha + \beta(g - g_n) \quad (3.2)$$

$$\sigma r = (\eta - \sigma)(1 - \chi)(g - f'g_n) + \sigma g \quad (3.3)$$

$$\lambda = (\eta - \sigma)f' \quad (3.4)$$

Equations (3.1)-(3.4) can be used to solve for the steady-state (balanced growth) values of g, σ, λ and r . A closed-form solution is intractable. Instead, the comparative statics of the system are studied by linearising the model in the neighbourhood of a steady-state solution.

Substitution of equation (3.2) in equation (3.3) and combining the result with equation (3.1) gives two equations in two endogenous variables, viz. g and σ . Differentiation of the subsystem and applying matrix notation results in

$$\begin{bmatrix} \Phi + (1 - \beta)\sigma & (1 - \chi)f'g_n(1 - \Phi \frac{\epsilon_f}{\sigma}) + \chi g - r + \Sigma \\ \sigma & -(1 - \chi)(g - f'g_n) \end{bmatrix} \cdot \begin{bmatrix} dg \\ d\sigma \end{bmatrix} = \begin{bmatrix} \Phi f'(1 - \epsilon_f) - \beta\sigma & \sigma & -(1 - \chi)(g - f'g_n) \\ \sigma f' & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} dg_n \\ d\alpha \\ d\eta \end{bmatrix} \quad (3.5)$$

where by way of short-hand notation we have $\Phi \equiv (1 - \chi)(\eta - \sigma)$, $\Sigma \equiv (\sigma - \eta)(g - f'g_n)(1 + \chi - \epsilon_q) \frac{\chi}{\sigma}$, $\epsilon_f = -\frac{f''g_n}{f'\sigma q}$ and $\epsilon_q = -\frac{q''\sigma}{q'\sigma}$. The ϵ 's are positively defined elasticities, which are a measure of the curvature of respectively the IPC and the function $q = q(\sigma)$. Empirical work shows that the IPC is rather flat, so that ϵ_f is very small (Scott, 1989, chapters 10 and

11). Notice that we did not differentiate with respect to β to simplify the analysis. The solution of (3.5) can be written as

$$\begin{bmatrix} dg \\ d\sigma \end{bmatrix} = \frac{1}{\Delta} \begin{bmatrix} T_{11} & T_{12} & T_{13} \\ T_{21} & T_{22} & T_{23} \end{bmatrix} \cdot \begin{bmatrix} dg_n \\ d\alpha \\ d\eta \end{bmatrix} \quad (3.6)$$

where

$$\begin{aligned} \Delta &\equiv (1-\chi)\{\beta\sigma(g-f'g_n) + \Phi f'g_n\epsilon_f\} + \{1+\chi-\epsilon_q\}\frac{\chi}{1-\chi}\Phi(g-f'g_n) > 0 \\ T_{11} &\equiv (1-\chi)\Phi f'g\epsilon_f + (g-f'g_n)\{(1-\chi)\beta\sigma + (\chi\Phi + \sigma)f'\} \\ &\quad + \Phi f'\frac{\chi}{1-\chi}(1+\chi-\epsilon_q)\} + \chi\sigma g_n(f')^2 > 0 \\ T_{12} &\equiv -(1-\chi)(g-f'g_n)\sigma < 0 \\ T_{13} &\equiv (1-\chi)^2(g-f'g_n)^2 > 0 \\ T_{21} &\equiv \sigma f'\Phi\epsilon_f + \beta(1-f')\sigma^2 + f'\sigma^2 > 0 \\ T_{22} &\equiv -\sigma^2 < 0 \\ T_{23} &= \sigma(1-\chi)(g-f'g_n) > 0 \end{aligned}$$

The signs of the expressions above are derived by assuming $\chi < 1$ and $f' < 1$. The latter assumption is discussed in Scott (1989, p. 164). It implies that the proportionate marginal product (for a given σ) is always smaller than one. Pure labour saving activities lead to a decline in output that is less than proportionate, which seems a reasonable assumption. In addition, ϵ_q should be small as may be assumed. A sufficient but overly strong condition is $\epsilon_q < 1 + \chi$. Putting things together the system of equations in (3.6) yields:

$$\begin{aligned} \frac{dg}{dg_n} > 0, \quad \frac{dg}{d\alpha} < 0, \quad \frac{dg}{d\eta} > 0 \\ \frac{d\sigma}{dg_n} > 0, \quad \frac{d\sigma}{d\alpha} < 0, \quad \frac{d\sigma}{d\eta} > 0 \end{aligned} \quad (3.7)$$

An increase in the rate of growth of labour supply raises the growth rate of

output and the investment ratio ². If diminishing returns are not too severe labour productivity rises also: $\frac{dg}{dg_n} > 1$ ³. A higher rate of time preference corresponds with a lower rate of growth of output and a lower savings ratio. Finally, more intensive competition between firms (a rise in η) induces a higher rate of growth along with a higher rate of investment.

It remains to be seen what effects these determinants of economic growth have on the distribution of income. Total differentiation of equation (3.4) leads to

$$d\lambda = f' d\eta - (\eta - \sigma) \frac{\epsilon_f f'}{g_n} dg_n + f' \left\{ \frac{1-\chi}{\sigma} (\eta - \sigma) \epsilon_f - 1 \right\} d\sigma \quad (3.8)$$

Assuming relatively flat sloping IPC's, so that $\epsilon_f < \frac{\sigma}{(1-\chi)(\eta-\sigma)}$ holds, equation (3.8) gives in combination with the inequalities in (3.7):

$$\frac{d\lambda}{dg_n} < 0, \quad \frac{d\lambda}{d\alpha} > 0 \quad (3.9)$$

Notice, that the main effect comes through σ . A higher investment ratio goes along with a lower share of labour in national income. Firms fix the share of investment in national product, because in an economy where the long-run growth rate depends on σ this is the right instrument. However, a higher σ requires a lower λ to be profitable, which brings the Kaldor-Pasinetti theory of income distribution back to mind (Kaldor, 1956; Pasinetti, 1962). There is nevertheless an important difference between these theories because causation is the other way around. In the Kaldor-Pasinetti view differential saving rates out of wages and capital income along with the required investment ratio determine the distribution of income. In the present theory savings follow the Ramsey rule, but the required investment ratio lays a claim on the cash flow of firms, which must be matched by the share going

²In models with non-decreasing returns to capital and labour population growth leads to an ever-increasing growth rate of the economy (e.g. Romer, 1989). This rather unappealing result is not obtained in the Scott model as it is formulated in rates of changes instead of technological relations between levels of variables.

³In the absence of diminishing returns to investment ($\chi = 0$) labour productivity increases as $\frac{dg}{dg_n} = \frac{\sigma(g-f'g_n)(\beta+f')+(\eta-\sigma)f'g\epsilon_f}{\sigma(g-f'g_n)\beta+(\eta-\sigma)f'g_n\epsilon_f} > 1$.

to labour. Otherwise, the rate of return would be too low, so that savings are insufficient compared with intended investments.

Things are different in case η changes. A decline in the degree of monopoly (a rise in η) has a direct positive effect on the share of labour as appears from equation (3.8). There is also a positive effect on the investment ratio as shown in (3.7). The latter effect gives rise to a negative effect on λ for the same reason as given above. Which effect dominates remains to be seen. Substitution of the expression for $\frac{d\lambda}{d\eta}$ from (3.6) in equation (3.8) and rearranging results in

$$\begin{aligned} \frac{d\lambda}{d\eta} = \frac{f'}{\Delta} \left[(g - f'g_n) \{ \sigma(1 - \chi)(\beta - 1) + (1 + \chi - \epsilon_g) \frac{\chi}{1 - \chi} + (1 - \chi)^2(\eta - \sigma)\epsilon_f \} \right. \\ \left. + (1 - \chi)^2(\eta - \sigma)f'g_n\epsilon_f \right] > 0 \end{aligned} \quad (3.10)$$

A sufficient condition for the inequality sign in (3.10) is $\beta \geq 1$, which is reasonable from an empirical point of view (e.g. Scott, 1989). With a positive relation between λ and η the redistribution effect dominates the growth effect, provided that the elasticity of intertemporal substitution ($1/\beta$) is not too high.

4 Labour market imperfections and growth dynamics

The assumption that the labour market clears without delay will be dropped in this section. Our analysis differs in this respect from the usual setting in growth theory, where prices (including the wage rate) are fully flexible and markets clear by adjustment in relative prices. In our view labour market imperfections and real wage inertia matter as the economy is hit by shocks of a diverse nature. It may then take substantial time to attain a new steady state. Growth theory should consider these medium term movements as well as the long-run consequences of shocks and shifts in parameters (see e.g. Stern, 1991). Moreover, under certain conditions, which will be spelled out later, the labour market itself may be a determinant of the long-run rate of growth. Taking account of recent theoretical developments, different

forms of labour market inertia will be considered which are summarised in the following dynamic equation for the share of labour in output.

$$\dot{\lambda} = \theta_1 \lambda (g_l - g_n) - \theta_2 u + \theta_3 \zeta \quad (4.1)$$

where $u \equiv \frac{l^* - l}{l^*}$ denotes unemployment as a percentage of labour supply (l^*) and $\zeta \equiv \frac{\lambda^* - \lambda}{\lambda}$ is a measure of union's desired share of labour in national income relative to the actual share of labour. The dynamics of the model are now governed by the differential equations (2.3), (2.4), (2.12) and (2.13). With this system correspond five state variables, two of which are non-predetermined (viz. φ_1 and φ_2) and the other three are predetermined (viz. λ , y and l or u). Equation (4.1) gives rise to the following taxonomy:

1. $\theta_1 = \theta_3 = 0; \theta_2 > 0$. The labour market adjusts fully in time according to a standard Phillips curve mechanism, except that there is no nominal wage rigidity as there is no money in the model. If there is unemployment real wage growth falls behind the rise in labour productivity and firms will invest in relatively more labour-using projects. Besides the two positive roots associated with the costate variable φ_1 and φ_2 the model should now have two negative roots, so that it is saddlepoint stable. The negative roots are associated with the predetermined state variables λ and l (or u). In the long run the labour market clears ($\dot{\lambda} = 0$ implies $u = 0$). Notice that there is an additional root which is equal to zero reflecting that the level of output is path-dependent. Whether hysteresis is quantitatively important in this case remains to be seen.
2. $\theta_1 > 0; \theta_2 = \theta_3 = 0$. This is a pure insiders-outsiders model variant. Real wages deviate from the path set by the rise in labour productivity under impact of changes in unemployment. Insiders opt for a wage increase that warrants the existing level of employment, but may fail to do so exactly because expectational errors must be taken into account (e.g. Blanchard and Summers, 1986). Saddlepoint stability is now ensured by two positive and one negative root, associated with the predetermined variable λ . In addition there are two zero roots, associated with y and l (or u). As is well-known hysteresis phenomena are relevant in insider-outsider models of the type considered here.

3. $\theta_1 = 0, \theta_2 > 0, \theta_3 > 0$. This case corresponds to a labour union model with (implicit) cost of adjustment with respect to wage changes. In a monopoly union model wages are set in such a way that the welfare of union members is maximised. As a consequence there will be a trade-off between employment and labour income (e.g. Oswald, 1985; Layard and Nickell, 1985, 1986). Cost of adjustment may prevent an immediate response on impact of shocks. This idea is captured by introducing an error correction mechanism à la Sargan (1964). The long-run trade-off between income and employment can be found by setting $\dot{\lambda} = 0$ in equation (4.1):

$$u = \frac{\theta_3 \lambda^* - \lambda}{\theta_2 \lambda} \quad (4.2)$$

The share of labour in the steady state is determined by the factors discussed in Section 3. If unions opt for a higher share than the market share ($\lambda^* > \lambda$) there will be equilibrium unemployment as follows from equation (4.2). However, this may not be the complete story. As argued by Kalecki (1971, chapter 5) trade unions may influence the degree of monopoly. Powerful unions may tend to reduce profit margins by wage claims, which reinforce competition. This view is of course disputable, but the basic idea may be given some consideration. After all, the degree of monopoly may respond to different socio-economic pressures. Kalecki's idea can be modelled by assuming a positive relation between degree of monopoly (η) and the strength of union power (ζ):

$$\eta = \eta(\zeta), \quad \eta' > 0, \quad \eta'' < 0 \quad (4.3)$$

Finally, it should be observed that saddlepoint stability in the union models requires two negative roots (associated with λ and u) and two positive roots (associated with φ_1 and φ_2). Moreover, there will again be a zero root (associated with y).

A closed-form solution of the time paths of the endogenous variables is intractable. The dynamic implications for the different forms of labour inertia will therefore be illustrated by numerical simulations. The specifications

of the functions applied, the values of the parameters chosen and the initial steady-state solutions are presented in the Appendix. In Section 4.1 we discuss the implications of a wage shock in the Phillips curve model and in the insiders-outsiders model. A change in factors generating wage pressure in the union model (e.g. Nickell, 1990) is dealt with in Section 4.2. In addition to a discussion of the usual trade-off between employment and income we pay attention to the Kalecki model by taking equation (4.3) into account.

4.1 A positive wage shock

The effects of a wage push in the Phillips curve model (case 1) are presented in Figure 2. All figures refer to deviations from the initial steady state value of the variables expressed in percentage points. There is no unemployment initially ($u = 0$). An additional increase in the real wage rate of 10 percentage points induces a rise in the share of labour of about 7 percentage points on impact. Firms switch towards relatively more labour-saving investment projects. This implies a shift along the relevant IPC's to the left. The rate of growth of employment declines and the resulting unemployment puts a pressure on subsequent rises in the real wage rate. The gross rate of investment declines after a small upward jump on impact, because the profitability of firms is affected by the rise in λ . The growth rate of output declines along with the fall in the growth rate of employment.

The system adjusts cyclical towards the initial steady state in which there is no unemployment and the other variables shown attain their values as given in the Appendix. There is one exception to this rule. The level of output is path-dependent, implying that y falls by 0.12 per cent in the long run. This result shows that hysteresis, although not absent, plays a minor role in the presented model. Cyclical adjustment seems inevitable as the relevant instrument variable of the firm is the rate of growth of employment (g_l) and not the level of employment (l). For the unemployment rate to decline, g_l must exceed its steady-state level, which occurs for the first time at $t = 9$ as can be seen from Figure 3. From then on u declines until employment growth falls again below its steady-state value at $t = 37$, etc.

Insert: Figure 2.

The results of a similar wage push in case of the insiders-outsiders model (case 2) are illustrated in Figure 3. There are a number of interesting dif-

ferences with the Phillips curve model. First, the savings and investment ratio rises on impact and lies above its initial steady-state value during the whole transition period. Households react to a decline in future income by smoothing consumption over time, so that the rate of savings rises in the short run. Moreover, it pays to realise more labour-saving projects and to extend this strategy over a longer time horizon. The reason is that in the present model real wages only adjust as long as the growth rate of employment lags behind the growth rate in labour supply. Second, in the new steady state the rate of unemployment is about 6 per cent, while the level of output declines by 5,5 per cent. This illustrates the relevance of hysteresis in insiders-outsiders models of the labour market. Third, in contrast with the Phillips curve model adjustment towards the steady state is monotone. Fourth, the growth rate of output deviates from its steady-state value over a prolonged period of time. Adverse supply shocks may therefore have a substantial impact on economic growth in the medium run if insiders-outsiders effects are dominant in the labour market.

Insert: Figure 3.

4.2 A rise in union pressure

In a monopoly union model (case 3 discussed above) there is a number of factors generating wage pressure such as bargaining power, benefits, mismatch and the wedge between the product wage and the consumption wage. In our model real wage pressure relates to the desired share of labour income (λ^*) in comparison with the market outcome (λ). The effects of a change in λ^* are shown in Figure 4 ⁴. Increased wage pressure leads to a rise in the growth rate of real wages (g_w). Firms change their investment strategy towards relatively more labour-saving projects, so that employment decreases. The shift towards labour-saving projects is marked by an increase in the savings rate. Here again we have an example of a dynamic substitution process. It pays to invest an extra amount to reduce the growth rate of employment. As a result the growth rate of output is somewhat less affected, as can be

⁴It is assumed that λ^* increases by about 3.5 percentage points compared with the initial steady state. The initial steady state with $\lambda = \lambda^*$ differs from the one in Section 4.1, because we now assume imperfect competition. For details see the Appendix.

seen in Figure 4. The share of labour increases first, but the movement is reversed as wage increases are moderated under the influence of rising unemployment. The turning point is attained at $t = 6$.

Insert: Figure 4.

However, unemployment rises gradually towards its equilibrium value $u = 6.33\%$. In the long run the other variables return to their initial steady-state values. The long-run result of the model resembles the outcome in the Layard-Nickell model with mark-up pricing on the side of firms (see Layard and Nickell, 1985, 1986). With mark-up pricing real wages are fixed by firms, so that competing claims between employers and unions can only be reconciled by allowing unemployment as an equilibrium phenomenon⁵. In our model competing claims lead to a similar result, because the activities of firms determine the distribution of income in the long run.

The situation is different in the Kalecki model as it is assumed that unions can foster competition between firms by increasing wage pressure. The effects of a change in λ^* of the same magnitude as in the monopoly union model are presented in Figure 5. At first the development is positive (σ , g_l and g lie above their initial values) as competition is intensified. But the share of labour rises in the course of time and firms shift towards labour-saving investments. This causes some unemployment, which induces real wage moderation. Finally, the economy settles at a new steady state, which differs from the initial solution in a number of respects. First, the rate of growth is slightly higher. Second, the share of labour in national income is also higher. Third, there is still equilibrium unemployment, but the rate is substantially lower than in the monopoly union model, $u = 1.68\%$. It remains to be seen whether labour unions can activate the economy in such a way and gain by realising a higher labour share in output. But the example illustrates the role institutions may play in the process of economic growth. As observed by Stern (1991) growth theory is in need of extensions in this direction.

Insert: Figure 5.

⁵The competing claims model with mark-up pricing is analysed extensively in Carlin and Soskice (1990).

5 Conclusions

In a modern theory of economic growth there is no need for a production function in the traditional sense. If every act of investment changes the world in a qualitative way the distinction between movements along the production function and shifts of the function is blurred. This idea, which goes back to Kaldor (1957) has recently been worked out in a seminal book by Scott (1989). Existing production facilities are an inheritance from the past. They are what they are and to change things one has to invest. But things can be changed in different directions. In case of defensive investment emphasis is put on labour-savings. Output may grow, while at the same time employment may be reduced. In a more offensive investment strategy employment increases, so that output can grow relatively fast. A theory based on an investment possibility function (IPF), which relates the share of output invested (input) to the growth rates of commodities and employment (output) is complete in the sense that it not only explains economic growth but also the functional distribution of income.

The results obtained by a theory based on the IPF correspond globally with those of the new growth theory or endogenous growth theory as it is also called. The long-run growth rate in the economy depends on intertemporal preferences of households and the growth rate of labour supply. Distortionary taxation, although not explicitly taken into account here, will have a negative impact on growth in the long run. Moreover, it has been shown that the degree of competition in product markets has an impact on the steady-state solution of the model.

Assuming that the labour market clears immediately the economy has no transitional dynamics. Moreover, the model exhibits some form of hysteresis as the rate of output and the level of employment depend upon initial values. The process of economic growth can be enriched by considering different forms of labour market imperfection and real wage inertia, which may give rise to transitional dynamics. Economic growth in the medium run can deviate substantially from its long-run course if the economy is hit by shocks and the labour market clears with a delay (as in the Phillips curve model) or works imperfectly (as in the case of the insiders-outsiders model or the monopoly union model). In the paper we consider shocks which emanate from the labour market itself, but the story holds for other shocks and institutional changes as well.

The model is very flexible and can easily be extended in several directions. There are two topics on the research agenda, which have high priority.

First, the role of the government should be taken into account not only by introducing taxes but also by analysing the significance of productive government spending (see e.g. Scott, 1989; Barro, 1990). Second, after suitable adaptations the model may be used to study the problems of developing countries in a world where divergence rather than convergence seems the ruling situation.

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Appendix

Numerical simulation requires specification of functional forms, which determine the investment possibilities and a choice of parameter values for the functions applied. To put things in a proper perspective we draw on the empirical work of Scott (1989).

Equation (2.1) is specified as:

$$g = a\sigma q + bg_l - c \frac{g_l^2}{\sigma q}, \quad \text{with}$$

$$q = q_0 \left[\frac{1 - e^{-\gamma\sigma}}{\gamma\sigma} \right], \quad \text{so that}$$

$$\chi = \frac{-\sigma q'}{q} = 1 - \frac{\gamma\sigma}{e^{\gamma\sigma} - 1}$$

Equation (4.3), which applies to the Kalecki model is specified as

$$\eta = 1 - \frac{\omega_1(\zeta + \omega_2)}{e^{\omega_1(\zeta + \omega_2)} - 1}$$

The parameter values applied are

Firms:	$a = 0.1085,$	$b = 0.955,$	$c = 0.4,$	$\gamma = 6.0,$	$q_0 = 2.0$
Households:	$\alpha = 0.03,$	$\beta = 1.5$			
Labour market:	$g_n = 0.01,$	$\theta_1 = 0, 1.5,$	$\theta_2 = 0, 0.25,$	$\theta_3 = 0, 0.25$	
Product market:	$\eta = 1, 0.84281$				
Kalecki equation:	$\omega_1 = 20,$	$\omega_2 = 0.15$			

Numerical results for the endogenous variables are obtained by solving a two-point boundary-value problem. The algorithm used is a multiple-shooting routine described in Ascher et al. (1988).

Steady state solution with perfect competition ($\eta = 1$)

$$g = 0.03795, \quad g_l = 0.01, \quad \sigma = 0.25978$$

$$\lambda = 0.68441, \quad g_w = 0.02795, \quad r = 0.07193$$

$$\varphi_1 = 21.78556, \quad \varphi_2 = -29.43130, \quad \chi = 0.58464$$

$$\epsilon_f = 0.03287, \quad \epsilon_q = 0.89261, \quad f' = 0.9246$$

Real parts non-zero eigenvalues

1. Phillips curve model ($\theta_2 = 0.25, \theta_1 = \theta_3 = 0$)
0.1553, 0.044495, -0.05837, -0.05837

2. Insiders-outsiders model ($\theta_1 = 1.5, \theta_2 = \theta_3 = 0$)
0.15113, 0.042277, -0.11036

Steady-state solution with imperfect competition ($\eta = 0.84281, \lambda^* = 0.60$)

$$\begin{array}{lll} g = 0.03654, & g_l = 0.01, & \sigma = 0.2315 \\ \lambda = 0.56426, & g_w = 0.02654, & r = 0.06981 \\ \varphi_1 = 18.37456, & \varphi_2 = -30.05738, & \chi = 0.53866 \\ \epsilon_f = 0.03464, & \epsilon_q = 0.81040, & f' = 0.92303 \end{array}$$

Real parts non-zero eigenvalues

1. Monopoly union model
0.11127, 0.039743, -0.2279, -0.10443

2. Kalecki model
0.17711, 0.038367, -0.19276, -0.19276

Figure 1. The Investment Programme Contours (IPC)

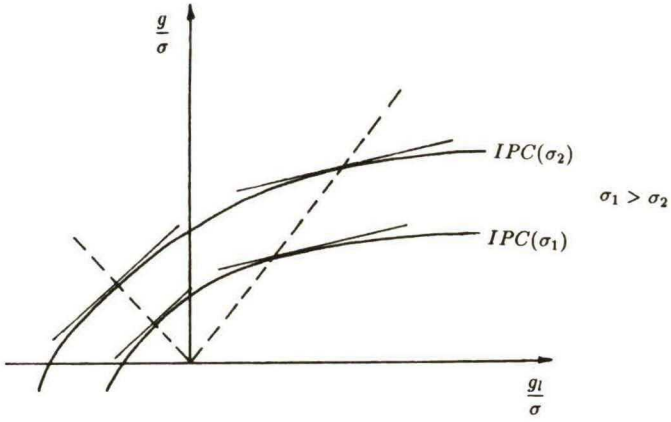


Figure 2. A positive wage shock in the Phillips curve model

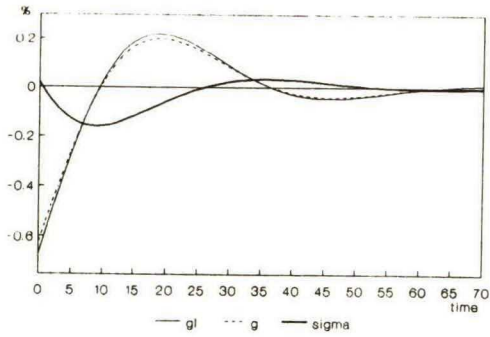
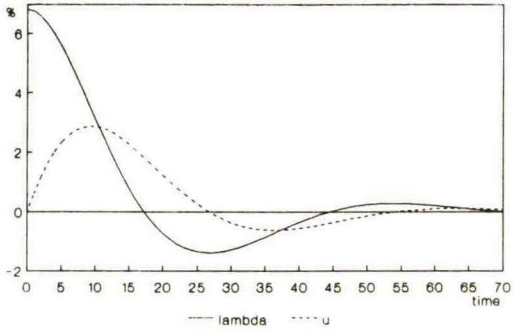


Figure 3. A Positive wage shock in the insiders/outside model

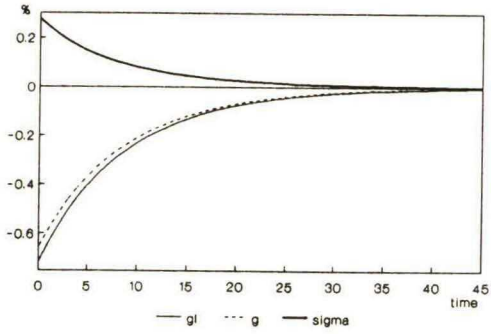
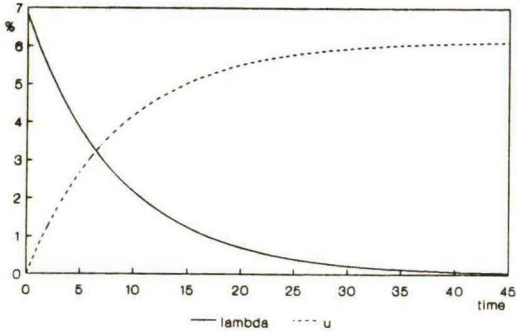


Figure 4. A rise in union power in the monopoly union model

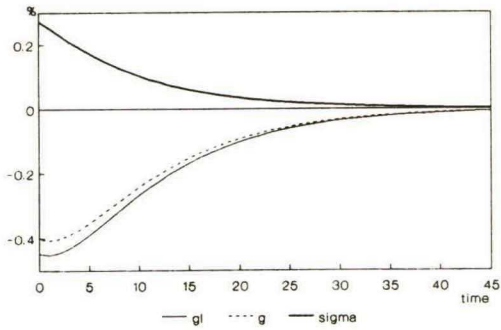
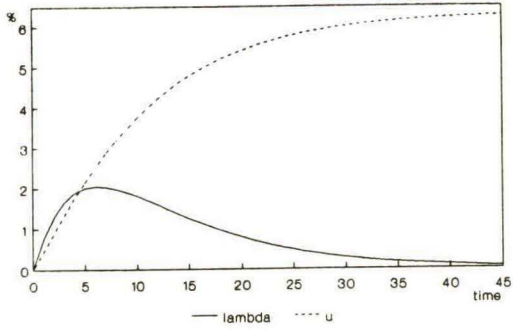
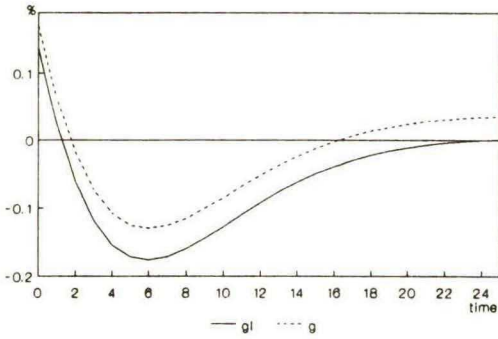
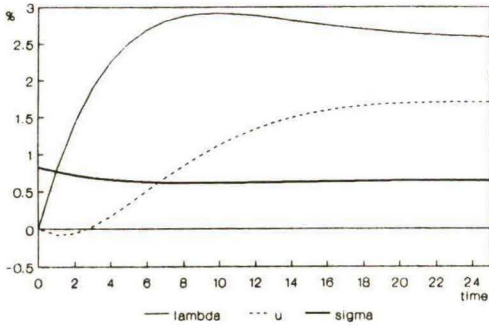


Figure 5. A rise in union power in the Kalecki model



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