Growth

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Ever since the inception of systematic economic analysis at the time of the classical economists from William Petty to David Ricardo the problem of economic growth – its sources, forms and effects – was high on the agenda of economists. In the real world the problem and the fact of economic growth is, of course, of much longer standing. Even in the more or less stationary economies of antiquity the possibility, if not the fact, of economic expansion lingers at the back of certain considerations. Brick plates from Mesopotamia provide information about social productivity by means of a simple input-output calculation in terms of barley. The main question concerned the *surplus product* of barley the ancient society was able to generate, that is, the excess of total output in a year with a normal harvest over the amount of input of barley as seed or as means of subsistence of labourers plus any other inputs needed in the society measured in terms of barley. From the Surplus Rate, that is, the ratio of Surplus Product to Necessary Input, it is obviously only a small step intellectually, but a huge step historically, to the concept of the *rate of growth*.

Adam Smith on growth

Adam Smith viewed the growth process as strictly *endogenous* (see also Lowe [1954] 1987: 108, Eltis 1984: 69 and Rostow 1990: 34), placing special emphasis on the impact of capital accumulation on labour productivity. He began his inquiry into the *Wealth of Nations* by stating that income per capita

> must in every nation be regulated by two different circumstances; first, by the skill, dexterity, and judgment with which its labour is generally applied; and, secondly, by the proportion between the number of those who are employed in useful labour, and that of those who are not so employed (WN I.3).

According to Smith there is no upper limit to labour productivity. This is why Smith maintained that an investigation of the growth of income per capita is first and foremost an inquiry into 'The causes of this improvement, in the productive powers of labour, and the order, according to which its produce is naturally distributed among the different ranks and conditions of men in the society' (WN I.5).

Smith's attention focused accordingly on the factors determining the growth of labour productivity, that is, the factors affecting 'the state of the skill, dexterity, and judgment with which labour is applied in any nation' (WN I.6). At this point the accumulation of capital enters into the picture, because of Smith's conviction that the key to the growth of labour productivity is the division of labour which in turn depends on the extent of the market and thus upon capital accumulation. 'The greatest improvement in the productive powers of labour', we are told, 'seem to have been the effects of the division of labour' (WN I.i.1), both *within* given firms and industries and, even more significantly, *between* them. In the first three chapters of book I of *The Wealth of Nations* Smith established the idea that there are *increasing returns*, which are largely *external* to firms, that is, broadly compatible with the classical hypothesis of a uniform rate of profit. (Here we set aside the reasons put forward by Smith and Ricardo, why profit rates may permanently differ between sectors; see therefore Kurz and Salvadori 1995: chap. 11). In the first chapter he made clear how powerful a device the division of labour is in increasing labour productivity, and analysed in some detail its major features: (i) the improvement of the dexterity of workers; (ii) the saving of time which is otherwise lost in passing from one sort of work to another; and, most importantly, (iii) the invention of specific machinery (cf. WN I.i.6-8). In the second chapter he argued that there is a certain propensity in human nature 'to truck, barter and exchange one thing for another', which appears to be rooted in 'the faculties of reason and speech', that gives occasion to the division of labour (WN I.ii.1-2). In the third chapter the argument is completed by stressing that the division of labour is limited by the extent of the market (cf. WN I.iii.1): a larger market generates a larger division of labour among people and, therefore, among firms, and a larger division of labour generates a larger productivity of labour in all firms.

Despite the presence of increasing returns, Smith retained the concept of a *general* rate of profit. His argument appears to be implicitly based on the hypothesis that each single firm operates at constant returns, while total production is subject to increasing returns. Even though some examples provided by Smith relate more to the division of labour within firms than to the division of labour among firms, Smith appears to be correct in sustaining that some of the activities which were originally a part of the division of labour within the firm may eventually become a different 'trade' or 'business', so that the division of labour *within* the firm is but a step towards the division of labour *amongst* firms. In the example of pin making at the beginning of chapter I, Smith pointed out that 'in the way in which this business is now carried on, not only the whole work is a peculiar trade, but it is divided into a number of branches, of which the greater part are likewise peculiar trades' (WN I.i.3).

Smith's analysis foreshadows the concepts of *induced* and *embodied* technical progress,

learning by doing, and *learning by using*. The invention of new machines and the improvement of known ones is said to be originally due to the workers in the production process and 'those who had occasion to use the machines' (WN I.i.9). At a more advanced stage of society making machines 'became the business of a peculiar trade', engaging 'philosophers or men of speculation, whose trade it is, not to do any thing, but to observe every thing; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects'. Research and development of new industrial designs becomes 'the principal or sole trade and occupation of a particular class of citizens' (ibid.). New technical knowledge is systematically created and economically used, with the sciences becoming more and more involved in that process. More than two centuries before the invention of the term 'knowledge society' Smith insists that 'the quantity of science' available to a society decides its members' productivity and wealth (WN I.i.9). The accumulation of capital propels this process forward, opens up new markets and enlarges existing ones, increases effectual demand and is thus the main force behind economic and social development (WN V.i.e.26).

Did Smith expect the endogenous growth factors to loose momentum as capital accumulates? He considered three potential limits to growth: an insufficient supply of workers, the scantiness of nature, and an erosion of the motives of accumulation. Smith saw that the scarcity and potential degradation of renewable and the depletion of exhaustible resources may constrain human productive activity and the growth of the economy (WN I.xi.i.3; see also I.xi.d). However, at the time when he wrote the limits to growth deriving from nature were apparently still considered far away.

Smith also saw no danger that the process of accumulation might come to an end because of an insufficient supply of labour and any diminishing returns to capital. He rather advocated a view, which was to become prominent amongst the classical economists: the supply of labour is generated within the socio-economic system, that is, *endogenously*. He drew an analogy between the multiplication of animals and that of the inferior ranks of people (cf. WN I.viii.39-40). Smith envisaged the growth of the labour force as endogenous, the determinant being the rate of capital accumulation. Real wages are higher, the more rapidly capital accumulates. As to the impact of high and rising real wages on the rate of profit, it appears that we cannot say anything definite, given Smith's opinion that 'the same cause ... which raises the wages of labour, the increase of stock, tends to increase its productive powers, and to make a smaller quantity of labour produce a greater quantity of work' (WN I.viii.57).

Adam Smith explained economic growth thoroughly as an *endogenous* phenomenon. The growth rate depends on the decisions and actions of agents, especially their saving and

investment behaviour, and the creativity and innovativeness they come up with in given social and historical conditions and institutional settings. Special emphasis is placed on the endogenous creation of new knowledge that can be used economically. New technical knowledge is treated as a good, which is or in the long run tends to become a public good. There are no clear and obvious limits to growth. The additional work force needed in the process of accumulation is generated in that process itself: labour power is a commodity the quantity of which is regulated by the effectual demand for it. Diminishing returns due to scarce natural resources are set aside or seen to be of little significance vis-à-vis increases in productivity due to the division of labour.

While Smith saw 'improvements' to take place in all major sectors of the economy – agriculture, manufacturing, commerce and trade (see WN I.x.b.43), he was convinced that manufacturing was most susceptible to an ever deeper division of labour and thus a rapid growth of labour productivity. Alas, he vastly underrated the importance of the manufacturing sector as an engine of growth by assuming that it produces only amenities and luxuries. The idea that necessities, raw materials, tools and machines are produced by means of necessities, raw materials, tools and machines is not yet to be found in Smith. Mentally he was still rooted in the age of corn and had only glimpsed the dawn of the upcoming age of coal and iron. Others coming after him had seen more of the new age triggered by the Industrial Revolution and began to understand better the crucial role of machinery and industry. These included authors such as David Ricardo, Charles Babbage and Karl Marx.

David Ricardo on diminishing returns

Ricardo in much of his reasoning set aside what may be called *statically and dynamically increasing returns*. The beneficial effects of capital accumulation on productivity mediated through the extension of the division of labour, which assumed centre stage in Smith's analysis, play hardly any role in Ricardo's. In modern parlance, the problems of externalities are given only sparse attention. This does not mean that Ricardo was of the opinion that they are of negligible importance, certainly not. One has to recall that Ricardo explicitly subscribed to much of Smith's analysis and set himself the moderate task of correcting views of the Scotsman he deemed wrong. These concerned especially Smith's view of the long-term trend of profitability as capital accumulates and the role of scarce natural resources in it. Ricardo was keen to show that, given the real wage rate, the rate of profits cannot fall as a consequence of the 'competition of capital', as Smith had argued, but only because of diminishing returns due the scarcity of land(s). Much of Ricardo's argument therefore was

developed in terms of the explicit and often implicit assumption that the set of (constant returns to scale) methods of production from which cost-minimizing producers can choose, is given and constant. In such a framework the question then is how scarce natural resources affect profitability as capital accumulates. The resulting vision is reflected in what Ricardo called the 'natural course' of things.

As capital accumulates and population grows, and assuming the real wage rate of workers given and constant, the rate of profit is bound to fall; due to extensive and intensive diminishing returns on land, 'with every increased portion of capital employed on it, there will be a decreased rate of production' (Ricardo, *Works* I: 98). Since profits are a residual income, based on the surplus product left after the used up means of production and the wage goods in the support of workers have been deducted from the social product (net of rents), the 'decreased rate of production' involves a decrease in profitability. On the assumption that there are only negligible savings out of wages and rents, a falling rate of profit involves a falling rate of capital accumulation. Hence, Ricardo's 'natural course' of things will necessarily end up in a stationary state.

This path must not be identified, however, with the *actual* path the economy takes because technical progress, which is set aside in the argument under consideration, will repeatedly offset the impact of the 'niggardliness of nature' on the rate of profit (see Ricardo, *Works* I: 120). Ricardo is frequently presented as a technological pessimist, who believed in the overwhelming importance of diminishing returns in agriculture in combination with the Malthusian law of population and who saw the stationary state around the corner; see, for example Blaug (2009) and Solow (2010). This interpretation does not do justice to him. As early as in *The Essay on Profits* of 1815 he expressed the view that there are no signs pointing in the direction of a falling rate of profits in the foreseeable future: ‘we are yet at a great distance from the end of our resources, and … we may contemplate an increase of prosperity and wealth, far exceeding that of any country which has preceded us’ (see Ricardo, *Works* IV: 34). This view is confirmed in a letter to Hutches Trower of 5 February 1816, in which he concluded from the fall in grain prices since 1812 that ‘we are happily yet in the progressive state, and may look forward with confidence to a long course of prosperity’ (Ricardo, *Works*: VII: 17).

So let us see more clearly the way in which Ricardo approached the difficult problem of capital accumulation and growth. The assumptions of a given real wage rate and the absence of technical progress represent a first *logical step* in an approach to the problem of capital accumulation and income distribution, which proceeds in terms of distinct analytical stages (see Garegnani 1990). The attention focuses first on abstract and general principles, which are

then gradually attuned to the concrete case or specific historical circumstances under consideration. Economic theory is combined with historical analysis. Here we focus only on the first stage and set aside its historical part. The reader will therefore not be misled thinking that in our view classical political economy is co-extensive with or can be reduced to this first stage. It reaches far beyond it.

Like Smith, Ricardo thought that savings and investment, that is, accumulation, would largely come from profits, whereas wages and rents played a negligible role. Hence, as regards the dynamism of the economy attention should focus on profitability. Assuming that the marginal propensity to accumulate out of profits, s, is given and constant, a 'classical' accumulation function can be formulated

$$g = \begin{cases} s(r - r_{min}) & \text{if } r \geq r_{min} \\ 0 & \text{if } r \leq r_{min} \end{cases}$$

where $r_{min} \geq 0$ is the minimum level of profitability which, if reached, will arrest accumulation (see Works I: 120).

Ricardo saw the rate of accumulation as endogenous. The demand for labour is seen to depend on the pace at which capital accumulates. As regards the long-term supply of labour Ricardo in some of his analysis adopted some form of the 'Malthusian Law of Population'. However, since contrary to Malthus Ricardo was no technological pessimist he did not share the latter's pessimism as regards the development of real wages. Real wages, he insisted, may rise, that is, the 'market price of labour' may rise above the 'natural' wage rate. This is the case in a situation in which capital accumulates rapidly, leading to an excess demand for labour. As Ricardo put it, 'notwithstanding the tendency of wages to conform to their natural rate, their market rate may, in an improving society, for an indefinite period, be constantly above it' (ibid: 94-5). If such a constellation prevails for some time a ratchet effect may make itself felt: it is possible, Ricardo observed, that 'custom renders absolute necessaries' what in the past had been comforts or luxuries. Hence, the natural wage is driven upward by persistently high levels of the actual wage rate. Accordingly, the concept of 'natural wage' in Ricardo is a flexible one and must not be mistaken for a physiological minimum of subsistence.

Assuming for simplicity a given and constant real wage rate, Ricardo's view of the long-run relationship between profitability and accumulation and thus growth (in the absence of technical progress) can be illustrated in terms of Figure 1, which is a diagram used by Kaldor (1956). The curve *CEGH* is the marginal productivity of labour-cum-capital; it is decreasing since land is scarce: when labour-cum-capital increases, either less fertile qualities of land must be cultivated or the same qualities of land must be cultivated with processes which

require less land per unit of product, but are more costly in terms of labour-cum-capital. Let the real wage rate equal *OW*. Then, if the amount of labour-cum-capital applied is L_1, the area $OCEL_1$ gives the product, $OWDL_1$ gives total capital employed, and *BCE* total rent. Profit is determined as a residual and corresponds to the rectangular *WBED*. As a consequence, the *rate* of profit can be determined as the ratio of the areas of two rectangulars which have the same basis and, therefore, it equals the ratio WB/OW. Let us now consider the case in which the amount of labour-cum-capital is larger, that is, L_2. Then $OCGL_2$ gives the product, $OWFL_2$ the capital, *ACG* the rent, and *WAGF* profits. The rate of profit has fallen to WA/OW. Obviously, if a positive profit rate implies a positive growth rate (i.e., $r_{min} = 0$), the economy will expand until labour-cum-capital has reached the level $\bar{L}$. At that point the profit rate is equal to zero and so is the growth rate. The system has arrived at a stationary state. Growth has come to an end because profitability has.

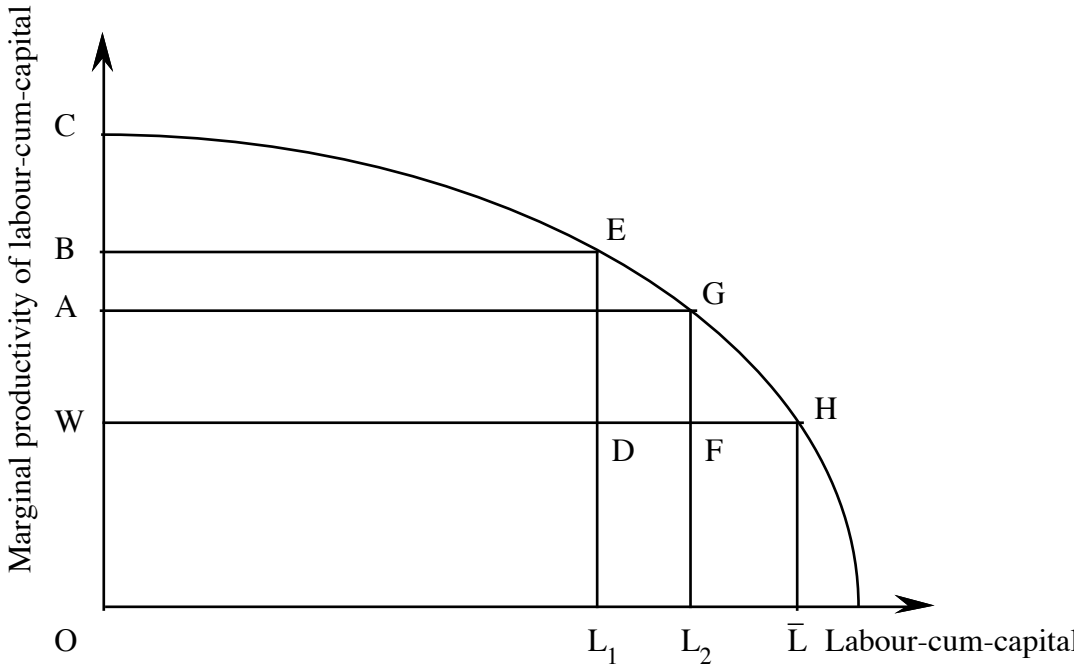

Figure 1: Land as an indispensable resource

For both Smith and Ricardo the required size of the work force is essentially generated by the accumulation process itself. In other words, labour power is treated as a kind of producible commodity. It differs from other commodities in that it is not produced in a capitalistic way in a special industry on a par with other industries, but is the result of the interplay between the generative behaviour of people and socioeconomic conditions. In the most simple and abstract conceptualization possible, labour power is seen to be in elastic supply at a given and constant real wage basket. Increasing the number of baskets available in the support of workers involves a proportional increase of the work force. In this view the rate of growth of labour supply adjusts to any given rate of growth of labour demand without necessitating a variation

in the real wage rate. In a more sophisticated conceptualization, higher rates of growth of labour supply presuppose higher levels of the real wage rate. But the basic logic remains the same: in normal conditions the pace at which capital accumulates regulates the pace at which labour, a *non-accumulable* factor of production, grows. (For a more detailed presentation, see Kurz and Salvadori 2006.)

Thus labour cannot put a limit to growth because it is generated within the growth process. The only limit to growth can come from other non-accumulable factors of production. In other words, there is only endogenous growth in Ricardo. This growth is bound to lose momentum as the system hits its natural barriers, especially as soon as extensive and intensive diminishing returns make themselves felt and are not counteracted by a sufficient technical progress.

Ricardo contemplated the implications for income distribution and the rate of expansion of the economic system in the hypothetical case in which land of the best quality is available in abundance. In one place he wrote:

> Profits do not necessarily fall with the increase of the quantity of capital because the demand for capital is infinite and is governed by the same law as population itself. They are both checked by the rise in the price of food, and the consequent increase in the price of labour. If there were no such rise, what could prevent population and capital from increasing without limit? (Ricardo, *Works* VI: 301)

If land of the best quality was available in abundance it would be a free good and no rent would be paid for its use. In this case the curve of the graph showing the marginal productivity of labour-cum-capital would be a horizontal line and the rate of profit would be constant whatever the amount of labour-cum-capital employed. As a consequence, other things equal, the growth rate would also be constant: the system could grow for ever at a rate that equals the given rate of profit times the propensity to accumulate. There are other possible interpretation of a horizontal marginal productivity of labour-cum-capital: either workers consume only non-agricultural commodities, which are produced without using land either directly or indirectly (D'Alessandro and Salvadori 2008) or the economy is small and open and the economy is so large that any increase in the pace of the accumulation process is obtained through an increase in the production of the industrial commodities (Salvadori and Signorino 2014).

To conclude, two observations are apposite. First, vis-à-vis a widespread misconception it

deserves to be emphasized once again that Ricardo was no technological pessimist. In the above we cited some passages from his work in support of this. Here is another one. In his entry on the 'Funding System' for volume IV of the *Supplements to the Encyclopædia Britannica*, published in September 1820, he stressed that 'the richest country in Europe is yet far distant from that degree of improvement', that is, the stationary state, and that 'it is difficult to say where the limit is at which you would cease to accumulate wealth and to derive profit from its employment' (Ricardo, *Works* IV: 179). Secondly, in the new chapter 21 'On Machinery' added to the third edition of the *Principles* (1823) Ricardo responded to the movement of the Luddites and a pamphlet by John Barton, in which the introduction of machinery was taken to be responsible for unemployment and workers' distress. Ricardo admitted that a particular form of improved machinery, the one that decreases the gross produce, is harmful to workers and that there is no presumption of an automatic compensation of the displacement of workers. Ricardo's chapter inspired Marx to his concept of an 'industrial reserve army of the unemployed' and is the starting point of an extended debate on 'technological unemployment'. The chapter contains also a clear statement of the fact that the use of machinery is not limited to the production of luxury goods, as in Smith, but plays an increasingly important role also in the production of 'necessaries' and of machinery itself. Interestingly, Ricardo even contemplated the extreme case of a fully automated production and pointed out: 'If machinery could do all the work that labour now does, there would be no demand for labour. Nobody would be entitled to consume any thing who was not a capitalist, and who could not buy or hire a machine' (Ricardo, *Works* VIII: 399-400).

Linear Classical models of production

Central elements of classical analysis are the concept of production as a circular flow and the related concept of *surplus* product left after the wage goods and what is necessary for the replacement of the used up means of production have been deducted from the annual output. This surplus can be consumed or accumulated. With constant returns to scale and setting aside the problem of scarce natural resources, the notion of an economy expanding at a constant rate of growth was close at hand. In this section we shall mention some contributions to what may be called linear growth theory with a classical flavour.

Robert Torrens in his *Essay on the External Corn Trade* (1815) clarified that the concept of surplus provides the key to an explanation of the *rate* of profit. Growth in the model by Torrens is both linear and endogenous; the rate of growth depends on the general rate of profit and the propensity to accumulate. The same can be said of Marx's theory of expanded

reproduction in chapter 21 of volume II of *Capital* (Marx [1885] 1956). In it Marx studied the conditions under which the system is capable of reproducing itself on an upward spiralling level: the economy expands at an endogenously determined rate of growth. This rate depends on the proportion of the surplus value ploughed back into the productive system to increase the scale of operation. Marx stressed that the accumulation of capital is 'an element *immanent* in the capitalist process of production' (ibid: 497; emphasis added). For, 'the aim and compelling motive of capitalist production' is 'the snatching of surplus-value and its capitalisation, i.e., accumulation' (ibid: 507). In Marx's analysis, this theory is only a first logical step toward a proper theory of accumulation. Here we cannot deal with the latter and Marx's 'law' of a falling tendency of the rate of profits in Volume III of *Capital*. There Marx argues that a tendency of the real wage rate toward a socially and historically defined subsistence level is not due to a population mechanism, but due to the presence of an 'industrial reserve army of the unemployed', which is continually filled and re-filled by labour saving technical progress. This form of technical progress Marx takes to involve an increase in the 'organic composition of capital', that is, the ratio of 'dead labour' incorporated in the capital goods employed, or 'constant capital' C, and of 'living labour' L hired by capitalists with the 'variable capital' V. The inverse of the organic composition for the economy as a whole is seen to be equal to the maximum rate of profit, which obtains in the case in which wages (variable capital) vanish. The form of technical progress, which according to Marx dominates capitalism, thus translates into a falling maximum rate of profit.

The Russian mathematician Georg von Charasoff elaborated on Marx's analysis and was possibly the first to provide a clear statement of the fundamental duality relationship between the system of prices and the rate of profit on the one hand, and the system of quantities and the rate of growth on the other (see Charasoff, 1910). He developed his main argument within the framework of an interdependent model of (single) production exhibiting all the properties of the later input-output model, and which is fully specified in terms of use values (rather than labour values as in the case of Marx) and labour needed per unit of output (see Kurz and Salvadori 1995: chap. 13).

John von Neumann (1945) in a paper first published in German in 1937 and then translated into English in 1945 elaborated the by far most sophisticated linear model of endogenous growth. In it von Neumann assumed that there are n goods produced by m constant returns–to–scale production processes. There is a problem of the choice of technique which consists of establishing which processes will actually be used and which not, being 'unprofitable'. Von Neumann (1945: 1-2) took the real wage rate, consisting of the 'necessities of life', to be given and paid at the beginning of the uniform period of production, that is, he considered wages as

a part of the capital advanced and thus as a part of the *physical real costs of production*. In addition, he assumed 'that all income in excess of necessities of life will be reinvested'. In von Neumann's model the rate of growth is determined *endogenously*. He set aside the problem of scarcity of all non-accumulable factors of production: while all primary factors other than labour (that is, all natural resources) were taken to be available at whichever amount was needed at zero price, labour was assumed to be available at the required amount at a given real wage rate.

Models of exogenous growth

The marginalist or 'neoclassical' school of economic thought seeks to explain income distribution in a symmetrical way via the relative scarcities of the factors of production, labour, 'capital,' and land. Interestingly, the idea of *exogenous* growth which classical theory did *not* entertain is the starting point of important early works in the marginalist tradition.

The idea of an economic system growing exclusively because some exogenous factors make it grow has variously been put forward in the history of economic thought as a standard of comparison. For example, in chapter V of book V of his *Principles*, first published in 1890, Alfred Marshall ([1890] 1977: 305) introduced the 'famous fiction of the "Stationary state" ... to contrast the results which would be found there with those in the modern world'. By relaxing one after another of the rigid assumptions defining the stationary state, Marshall sought to get gradually closer to the 'actual conditions of life'. The first relaxation concerned the premise of a constant (working) population:

> The Stationary state has just been taken to be one in which population is stationary. But nearly all its distinctive features may be exhibited in a place where population and wealth are both growing, provided they are growing at about the same rate, and there is no scarcity of land: and provided also the methods of production and the conditions of trade change but little; and above all, where the character of man himself is a constant quantity. For in such a state by far the most important conditions of production and consumption, of exchange and distribution will remain of the same quality, and in the same general relations to one another, though they are all increasing in volume. (ibid: 306)

The resulting economic system grows at a constant rate which equals the exogenous rate of growth of population. Income distribution and relative prices are the same as in the stationary

economy. In modern parlance: the system expands along a steady-state growth path.

We encounter essentially the same idea in Gustav Cassel's ([1918] 1932) *Theory of Social Economy*. The model of exogenous growth delineated by Cassel can be considered the proximate starting point of the development of neoclassical growth theory. In chapter IV of book I of the treatise Cassel presented two models, one of a stationary economy, the other one of an economy growing along a steady-state path.

In his first model Cassel assumed that there are z (primary) factors of production. The quantities of these resources and thus the amounts of services provided by them are taken to be in given supply. General equilibrium is characterized by the equality of supply and demand for each factor service and for each good produced and the equality of the price of a good and its cost of production. The resulting sets of equations constitute what is known as the 'Walras-Cassel model' (Dorfman, Samuelson and Solow 1958: 346). It satisfies the then going criterion of completeness: there are as many equations as there are unknowns to be ascertained.

Cassel (1932: 152-3) then turned to the model of a uniformly progressing economy. Although described only verbally, he introduced the model in the following way:

> We must now take into consideration the society which is progressing at a uniform rate. In it, the quantities of the factors of production which are available in each period ... are subject to a uniform increase. We shall represent by [g] the fixed rate of this increase, and of the uniform progress of the society generally.

In Cassel's view this generalization to the case of an economy growing at an exogenously given and constant rate does not cause substantial problems. The previously developed set of equations can easily be adapted appropriately, 'so that the whole pricing problem is solved'. Cassel thus arrived at basically the same result as Marshall.

The neoclassical growth models of the 1950s and early 1960s differ from the growth version of the Walras-Cassel model in six important respects:

(1) They are macro-models with a single produced good only which could be used both as a consumption good and as a capital good.
(2) The number of primary factors of production is reduced to one, homogeneous labour (as in Solow 1956 and 1970; Swan 1956), or two, homogeneous labour and homogeneous land (as in Swan 1956; Meade 1961).

(3) The all-purpose good is produced by means of labour, capital, that is, the good itself, and possibly land.
(4) There is a choice of technique, where technical alternatives are given by a macroeconomic production function, which is homogenous of degree one with positive and decreasing marginal productivities with respect to each factor of production.
(5) Savings are proportional to net income, that is, a 'Keynesian' saving function is assumed.
(6) Say's law holds, that is planned savings are taken to be equal to planned investment at all times. There is no separate investment function.

Focusing attention on the models with a single primary factor (labour), in steady-state equilibrium

$$sf(k) = gk,$$

where s is the (marginal and average) propensity to save, $f(k)$ is the per unit of labour or *per capita* production function, k is the capital-labour ratio (where labour is measured in terms of efficiency units), and g is the steady-state growth rate of capital (and labour, and income etc.). In steady-state equilibrium output expands exactly as the exogenous factors make it grow. Note that assuming $s > 0$ presupposes that the exogenous factors are growing at some positive rate. In these models the steady-state rate of growth is exogenous. Outside steady-state equilibrium the rate of growth can be shown to depend also on the behavioural parameter of the system, that is, the propensity to save (and invest), but that parameter plays no role in determining the long-term rate of growth.

While these models are aptly described as models of *exogenous* growth, they can also be described as models of *endogenous* profitability. Since in the one-good framework adopted by the authors under consideration the rate of profit r equals the marginal productivity of capital,

$$r = f'(k),$$

the two equations are able to determine a relationship between the rate of profit and the steady-state rate of growth.

Keynes and Keynesians

It is remarkable that whereas growth was at the centre of the concerns of the Classical political economists, and then of Karl Marx, it moved to the periphery in the aftermath of the

so-called 'marginal revolution'. Léon Walras ([1874] 1954) still tackled the problem in terms of his theory of 'capitalisation', that is, of credit and capital accumulation (see Morishima 1977), and Knut Wicksell ([1893] 1954) in terms of his theory of capital formation. Thereafter it moved largely to the background of economic theory. The field was re-vitalised when attempts were made to extend Keynes's 1936 short-run analysis to the long run by taking into account not only the income effect of investment in terms of the multiplier, but also the capacity effect of investment. Evsey Domar (1946) showed that productive capacity and effective demand grow in step with one another, if and only if investment grows at a rate that is equal to the ratio of society's propensity to save, s, and the capital-to-output ratio (which is taken to be constant), v, that is: $g = s/v$. Roy F. Harrod (1939, 1948?) sought to carry Keynes's principle of effective demand over to the long run by studying the interplay of a proportional savings function and an investment function relying on the 'acceleration principle', which takes investment to react on changes in effective demand in the past and thus on changes in the degree of utilisation of capital equipment. Within such a framework Harrod was able to show that the accumulation path is unstable: deviations of the actual growth rate of investment from the 'warranted rate' (which is essentially the one Domar had shown to guarantee the continuous full utilization of productive capacity) leads either into a boom or a recession. This has become known as Harrod's 'knife-edge problem' in the literature. The instability results because if the actual rate of growth of investment exceeds (falls short of) the warranted rate, the income effect of investment exceeds (falls short of) the capacity effect, which is reflected in a growing (falling) rate of capital utilization. This can in turn be expected to lead to an acceleration (deceleration) of investment growth, which increases the upwards (downwards) deviation of the actual from the warranted rate and acerbates the disequilibrium: the economy is bound to run into a boom (a depression), because market signals are read by single firms which leads to a collective behaviour that destabilises the economy. Harrod saw the 'Instability Principle' as an integral part of a theory of the business cycle, which had to explain first and foremost, if and why there are upper and lower turning points giving rise to cyclical behaviour of output and employment.

The papers by Solow (1956) and Swan (1956) mentioned in the previous section sought to answer not only Harrod's (short-run) knife-edge problem, but also to do away with the possibility Harrod had contemplated of economic growth in the presence of cyclically fluctuating, but persistent unemployment. This was effectuated in terms of (i) the introduction of ample possibilities of substitution among factors of production etched in a macroeconomic production function and (ii) the invocation of Say's law by abandoning an independent investment function and assuming that each and every act of saving will always and instantaneously lead to an act of investment of the same magnitude. By this token both kinds

of problems Harrod had analysed were made to disappear and the attention could focus on full employment-full capacity growth. Solow justified this approach in terms of the assumption that Keynesian stabilisation policy would accomplish the job, in case the market economy would not. It deserves to be stressed that while Solow was perfectly aware that his model reflected an idealised world in which the problem of effective demand was deliberately shunted aside, many of his followers tended to mistake the model for a description of the real world.

However, there was not only a neoclassical response to the challenges Keynes and then Harrod had put to the profession. Another response came from Nicholas Kaldor (1956) and Joan Robinson (1956), who worked in the Keynesian tradition. Kaldor's contribution became known as the Neo-Keynesian model of growth and distribution.

Kaldor distinguished between wage-earners and profit-earners, noticing that the propensity to save of the first group can be assumed to be smaller than that of the second group simply as a consequence of the fact that the bulk of profits accrues in the form of company profits and a high proportion of these profits are retained by firms in order to finance investment (see Kaldor, 1956: 95 fn.). In a later contribution Kaldor (1966: 310-311) confirmed his intention to model the role of a large share of undistributed profits to favour self-finance. Kaldor assumed the following saving function:

$$S = s_\omega W + s_\pi P,$$

where S is total savings of a given economy, and W and P are total wages and total profits. Since, in equilibrium, planned saving equals planned investment and since wages plus profits equal the national income, we have

$$I = (s_\pi - s_\omega)P + s_\omega Y,$$

where I is net investment and Y is net national income. Finally, because of 'the "Keynesian" hypothesis that investment, or rather, the ratio of investment to output, can be treated as an independent variable' (Kaldor 1956: 95),

$$\frac{P}{Y} = \frac{1}{s_\pi - s_\omega}\frac{I}{Y} - \frac{s_\omega}{s_\pi - s_\omega}. \qquad (1)$$

The rate of profits, r, is then obtained by multiplying equation (1) by the output-capital ratio, Y/K, which Kaldor (1956) assumed to be constant with respect to changes in distribution:

$$r = \frac{P}{K} = \frac{1}{s_\pi - s_\omega}\frac{I}{K} - \frac{s_\omega}{s_\pi - s_\omega}\frac{Y}{K}, \qquad (2)$$

where I/K is the rate of capital accumulation. Since he considered a fairly constant capital-to-output ratio, K/Y, as a 'stylized fact' of economic history, the rate of growth of output equals the rate of capital accumulation.

In contradistinction to Kaldor, Luigi L. Pasinetti (1962) dealt with *classes* (capitalists and workers) rather than with *income groups*, suggesting the use of the following saving functions which assume that the propensity to save out of the profits earned by the capitalist class differs from the propensity to save out of the profits earned by the working class:

$$S_w = s_w(W + P_w),$$

$$S_c = s_c P_c.$$

Further, Pasinetti explicitly introduced the dynamic equilibrium conditions, according to which capitalists' and workers' capitals, like all variables changing through time, must, in the steady state, grow at the same rate as the economy as a whole. In addition, he pointed out that, since those who save out of wages must receive a part of the profit as interest for what they lend to capitalists, to determine the rate of profits it is necessary to specify the relationship between the money rate of interest and the rate of profits in steady growth. He maintained that 'in a long-run equilibrium model, the obvious hypothesis to make is that of a rate of interest equal to the rate of profit' (Pasinetti 1962: 271-2). Then workers' and capitalists' capitals grow at the same rate g. That is, the following constraints hold:

$$s_w(W + P_w) = gK_w \tag{3}$$

$$s_c P_c = gK_c, \tag{4}$$

where K_w is workers' capital loaned to capitalists, and K_c is capitalists' own capital ($K_w + K_c = K$).

If it is assumed that interest and profit rate coincide, then $P_c = rK_c$ and $P_w = rK_w$. If, moreover, $K_c > 0$, then the rate of profits is immediately obtained from equation (4):

$$r = \frac{g}{s_c}. \tag{5}$$

This is the 'Pasinetti theorem', which gave rise to a huge debate on the limits of Pasinetti's result and involved, among others, Franco Modigliani and Paul A. Samuelson. For a detailed account, see Kurz and Salvadori (2010). For a more complete discussion of Keynesian contributions to the study of economic growth, see Commendatore et al. (2003) and Setterfield (2010).

Endogenous Growth Theory

The debate in the 1960s and 1970s between neoclassical and Keynesian economists and the criticism of the neoclassical concept of capital as a quantity that could be ascertained independently of, and prior to, the determination of relative prices and the rate of profits (see in particular Kurz and Salvadori 1995: chap. 14) sent growth economics into a slumber. It was only in the second half of the 1980s that it was awakened again. The proponents of the revival of growth economics dubbed their theories 'new' or 'endogenous', henceforth NGTs, drawing attention to the fact that long-run growth was not taken to be given from the outside, as in Solow, but was explained from within the economic system, that is, endogenously.

One of the key properties of the NGTs is intensive growth, that is, an increase in income per capita, another is the elimination or at least the limitation of any tendency of the returns to capital and the rate of profits to diminish. The first generation of models of NGT defined the confines within which subsequent contributions to NGT were carried out. The attention focuses on the mechanism that prevents the returns to capital from falling (below a certain level). For a more detailed treatment of these models, see Acemoglu (2009), Aghion and Howitt (1998), Barro and Sala-i-Martin (2003), Jones (1998), and Kurz and Salvadori (1998, 1999).

The first class of NGTs (in terms of simplicity, not in chronological terms) set aside all non-accumulable factors of production, such as labour and land, and assume that all inputs in production are themselves producible and accumulable, that is, 'capital' of some kind. The simplest version of this class is the so-called 'AK model', which assumes that there is a linear relationship between total output, Y, and a single factor capital, K, both consisting of the *same* commodity:

$$Y = AK, \tag{6}$$

where $1/A$ is the amount of that commodity required to produce one unit of itself. K is said to be able to comprise both physical and human capital and it is assumed that the two can be aggregated without further ado. The rate of return on capital r is given by

$$r + \delta = \frac{Y}{K} = A,$$

where δ is the exogenously given rate of depreciation. There is a large variety of models of this type in the literature. In the two-sector version in Rebelo (1991) it is assumed that the capital good sector produces the capital good by means of itself and nothing else. It is also

assumed that there is only one method of production to produce the capital good. Therefore, *the rate of profit is determined by technology alone*. Then the saving-investment mechanism jointly with the assumption of a uniform rate of growth, that is, a steady-state equilibrium, determines a relationship between the growth rate, g, and the rate of profit, r. Rebelo (1991: 504 and 506) obtains either

$$g = \frac{A - \delta - \rho}{\sigma} = \frac{r - \rho}{\sigma} \tag{7}$$

or

$$g = (A - \delta)s = sr. \tag{8}$$

Equation (7) is obtained when savings are determined on the assumption that there is an immortal representative agent maximizing the following intertemporal utility function

$$U = \int_0^{\infty} e^{-\rho t} \frac{c(t)^{1-\sigma} - 1}{\sigma} dt ,$$

subject to constraint (6), where ρ is the discount rate, or rate of time preference, and $1/\sigma$ is the elasticity of substitution between present and future consumption ($1 \neq \sigma > 0$), and where $Y = c(t) + \dot{K}$. Equation (8) is obtained when the average propensity to save s is given. Hence, in this model the rate of profit is determined by technology alone and the saving-investment mechanism determines the growth rate.

King and Rebelo (1990) essentially followed the same avenue. Instead of one kind of 'capital' they assumed that there are two kinds, real capital and human capital, both of which are accumulable. There are two lines of production, one for the social product and the real capital, which consist of quantities of the same commodity, and one for human capital. The production functions relating to the two kinds of capital are assumed to be homogeneous of degree one and strictly concave. As in Rebelo's model the rate of profit is uniquely determined by the technology (and the maximization of profits which, because of the Non-substitution Theorem, implies that only one technique can be used in the long run); the growth rate of the system is then endogenously determined by the saving-investment equation. The larger is the propensities to accumulate human and physical capital, the larger is the growth rate.

The second class of models preserve the dualism of accumulable and non-accumulable factors but restrict the impact of an accumulation of the former on their returns by a modification of

the aggregate production function. Jones and Manuelli (1990), for example, allow for both labour and capital and even assume a convex technology, as the Solow model does. However, a convex technology requires only that the marginal product of capital is a decreasing function of its stock, not that it vanishes as the amount of capital per worker tends towards infinity. Jones and Manuelli assume that

$$h(k) \geq bk, \quad \text{each } k \geq 0,$$

where $h(k)$ is the per capita production function and b is a positive constant. The special case contemplated by them is

$$h(k) = f(k) + bk,$$

where $f(k)$ is the conventional per capita production function. As capital accumulates and the capital-labour ratio rises, the marginal product of capital will fall, approaching asymptotically b, its lower boundary. With a given propensity to save, s, and assuming that capital never wears out, the steady-state growth rate g is endogenously determined: $g = sb$. Assuming, on the contrary, intertemporal utility maximization, the rate of growth is positive provided the technical parameter b is larger than the rate of time preference ρ. In the case in which it is larger, the steady-state rate of growth is given by equation (7) with $r = b$.

Finally, there is a large class of models contemplating various factors counteracting any diminishing tendency of returns to capital. Here we shall be concerned only with the following two sub-classes: human capital formation and knowledge accumulation. In both kinds of models *positive external effects* play an important part; they offset any fall in the marginal product of capital.

Models of the first sub-class attempt to formalize the role of human capital formation in the process of growth. Elaborating on some ideas of Uzawa (1965), Lucas (1988) assumed that agents have a choice between two ways of spending their (non-leisure) time: to contribute to current production or to accumulate human capital. With the accumulation of human capital there is said to be associated an externality: the more human capital society as a whole has accumulated, the more productive each single member will be. This is reflected in the following macroeconomic production function

$$Y = AK^{\beta}(uhN)^{1-\beta}h^{*\gamma}, \tag{9}$$

where the labour input consists of the number of workers, N, times the fraction of time spent working, u, times h which gives the labour input in efficiency units. Finally, there is the term

h^*. This is designed to represent the externality. The single agent takes h^* as a parameter in his or her optimizing by choice of c and u. However, for society as a whole the accumulation of human capital increases output both directly and indirectly, that is, through the externality represented by $h^{*\gamma}$, where $\gamma > 0$.

Lucas's conceptualization of the process by means of which human capital is built up is the following:

$$\dot{h} = \upsilon h(1-u) \qquad (10)$$

where υ is a positive constant. (Note that equation (10) can be interpreted as a 'production function' of human capital.)

Interestingly, it can be shown that if the above mentioned externality is *not* present, that is, if γ in equation (9) equals zero, and therefore returns to scale are constant and, as a consequence, the Non-substitution Theorem holds, endogenous growth in Lucas's model is obtained in essentially the same way as in the models of Rebelo (1991) and King and Rebelo (1990): the rate of profit is determined by technology and profit maximization alone; and for the predetermined level of the rate of profit the saving-investment mechanism determines the rate of growth. Yet, as Lucas himself pointed out, the endogenous growth is positive *independently* of the fact that there is the above mentioned externality, that is, independently of the fact that γ is positive. *Therefore, while complicating the picture increasing returns do not add substantially to it: growth is endogenous even if returns to scale are constant*. If returns to scale are not constant then the Non-substitution Theorem does not apply, implying that neither the competitive technique nor the associated rate of profit are determined by technical alternatives and profit maximization alone. Nevertheless, these two factors still determine, in steady states, a relationship between the rate of profit and the rate of growth. This relationship together with the relationship between the same rates obtained from the saving-investment mechanism determines both variables.

Models of the second sub-class attempt to portray technological change as generated endogenously. The proximate starting point of this kind of models was Arrow's (1962) paper on 'learning by doing'. Romer (1986) focuses on the role of a single state variable called 'knowledge' or 'information' and assumes that the information contained in inventions and discoveries has the property of being available to anybody to make use of it at the same time. In other words, information is considered essentially a non-rival good. Yet, it need not be totally non-excludable, that is, it can be monopolized at least for some time. It is around the two different aspects of publicness – non-rivalry and non-excludability – that the argument

revolves. Discoveries are made in research and development departments of firms. This requires that resources be withheld from producing current output. The basic idea of Romer's (1986: 1015) model is 'that there is a trade-off between consumption today and knowledge that can be used to produce more consumption tomorrow'. He formalizes this idea in terms of a 'research technology' that produces 'knowledge' from forgone consumption. Knowledge is assumed to be cardinally measurable and not to depreciate: it is like perennial capital.

Romer stipulates a research technology that is concave and homogeneous of degree one,

$$\dot{k}_i = G(I_i, k_i) \tag{11}$$

where I_i is an amount of foregone consumption in research by firm i and k_i is the firm's current stock of knowledge. (Note that the forgone consumption good is a capital good utilized in the production of 'knowledge'.) The production function of the consumption good relative to firm i is

$$Y_i = F(k_i, K, \mathbf{x}_i), \tag{12}$$

where K is the accumulated stock of knowledge in the economy as a whole and $\mathbf{x}_i$ are all inputs different from knowledge. The function is taken to be homogeneous of degree one in k_i and $\mathbf{x}_i$ and homogeneous of a degree greater than one in k_i and K. Romer (1986: 1019) assumes that 'factors other than knowledge are in fixed supply'. This implies that 'knowledge' is the only *capital good* utilized in the production of the consumption good. Spillovers from private research and development activities increase the public stock of knowledge K.

Assuming, contrary to Romer, that the above production function (12) is homogeneous of degree one in k_i and K involves a constant marginal product of capital: the diminishing returns to k_i are exactly offset by the external improvements in technology associated with capital accumulation. In this case it can be shown that, similar to the models of NGT previously dealt with, the rate of profit is determined by technology and profit maximization alone, provided, as is assumed by Romer, that the ratio K/k_i equals the (given) number of firms. The saving-investment relation then determines endogenously the growth rate. Once again endogenous growth does not depend on an assumption about increasing returns with regard to accumulable factors. Growth would be no more endogenous if increasing returns were to be assumed (but the analysis would be a good deal more complicated).

Since the publication of the papers mentioned a huge literature has built up in which the

several aspects dealt with have been studied more thoroughly and new aspects have been brought into the picture. Here we can draw the attention only to some of the contributions to this literature; for a more comprehensive account see the summary accounts referred to in the above. Romer (1990) tried to enrich the model by introducing a 'product-diversity' specification of physical capital: in a research sector 'new designs' for intermediate products are being invented, which are then used in another sector by monopolistic firms to produce these intermediate products. The sector producing the final product then employs the latter and is taken to be the more productive the greater is the product diversity of its capital inputs. Aghion and Howitt (1992) and Grossman and Helpman (1991) incorporate imperfect markets and R&D in the growth model in seek to formalize what Joseph A. Schumpeter called 'creative destruction'. Martin L. Weitzman (1998) followed a different route by taking his inspiration from agricultural research stations, in which new 'hybrid ideas' are generated by cross-breeding known ideas. Oded Galor (2005) put forward a 'unified growth theory' designed to boldly interpret the entire history of mankind in terms of NGT. David de la Croix (2013) explored the role of fertility and education in generating growth. The economic historian Joel Mokyr (1990) used arguments forged in the recent growth literature to reconsider economic history and especially the origins and consequences of the Industrial Revolution for the growth performance of industrialising countries.

The interesting thing to note by way of conclusion is that the NGTs occasionally great complexity notwithstanding, in the steady state they all replicate in one form or another a characteristic feature of the AK model: its linearity. As Romer (1990: S84) put it: 'Linearity in [the number of intermediate products] is what makes unbounded growth possible, and in this sense, unbounded growth is more like an assumption than a result of the model.' And Weitzman (1998: 345) concludes that in his model 'everything comes full circle to steady-state growth rates being linearly proportional to aggregate savings', just as in the models of Harrod and Domar and, we may add, in the AK model.

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