

# Hicks's Neo-Austrian Theory and Böhm-Bawerk's Austrian Theory of Capital

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**Abstract.** This paper provides an assessment of Böhm-Bawerk's contribution to the theory of capital, accumulation, and growth, and of Hicks's elaboration on it. We first evaluate Böhm-Bawerk's contribution in a historical perspective, that is, we ask how it relates to the analyses of his most important predecessors, Ricardo and Marx, and what are the merits and shortcomings of Böhm-Bawerk's construction. We find that Böhm-Bawerk's analysis is conceptually very close to those of his predecessors: like them, he studied the interaction between income distribution, capital accumulation and technical change in the framework of a given state of technical knowledge, where known but hitherto unused methods of production may be adopted, but in which there is no technical progress proper. Confronted with the task of studying the evolution of a complex economic system in which both the methods of production and the set of commodities change over time Böhm-Bawerk forged some important analytical tools by means of which he sought to come to grips with such a system without reducing its complexity beyond limit in terms of simplifying assumptions. In particular, his device of the 'average period of production' turns out to be closely related to Marx's concept of the 'organic composition of capital' of the economic system as a whole, on which the maximum rate of profits depends. Finally, we briefly discuss John Hicks' elaboration of Böhm-Bawerk's theory in *Capital and Time*, and find that its focus on the transitional dynamics is not congenial to Böhm-Bawerk's enterprise.

## 1. Introduction

Like all his teachers, colleagues and major students, most notably Carl Menger, Friedrich von Wieser, Joseph Alois Schumpeter, and Friedrich August von Hayek, Eugen von Böhm-Bawerk was concerned with explaining the working of the economic system as a whole. The analyses of the Austrian economists were typically general, not partial. They tried to explain the allocation of resources to alternative ends, the exchange ratios between different commodities and services, and the distribution of the social product among different claimants in terms of given preferences of agents, given technical alternatives of production, and given endowments of agents with productive resources. One of their main concerns was the theory of capital and interest. While the Austrian economists advocated vastly different views as to the causes of interest (an 'Austrian school' does not exist in this regard), they were united in

the rejection of the socialist doctrine that interest (or profits) was due to the ‘exploitation’ of workers.

The Austrian economists were also united in another respect. Contrary to Léon Walras’s general equilibrium theory, the Austrians insisted on the importance of the element of time in all economic activity, whether it belongs to production or consumption. They were keen to elaborate a temporal theory of value and distribution and were critical of Walras’s atemporal theory. As regards production, they followed the classical economists and especially David Ricardo, who had stressed the time profile of the amounts of labour bestowed upon a commodity as a determinant of its (relative) price. It has rightly been observed that Böhm-Bawerk in his theory of capital and interest was first and foremost concerned with a genuinely Ricardian problem, namely that of seeing through the complexity of heterogeneous capital goods in terms of some analytical device that allowed the theorist to assume a standpoint from which the properties of the economic system could be discerned more easily. Reducing the complexity of the problem at hand arbitrarily in terms of some bold assumptions regarding its nature, such as, for example, the one-good assumption, was not regarded as admissible. Retaining as much as possible the complexity of the problem under consideration but looking at it from a viewpoint that revealed some otherwise hidden properties of the object of investigation was considered to be the only acceptable scientific approach. This was at least the aim, which, however, was every so often violated by economists confronted with problems that were way above their heads, that is to say, problems they could not successfully tackle with the analytical tools at their disposal. The aim was certainly laudable and the Austrian economists deserve praise for cherishing it despite all the difficulties they encountered and failures they suffered.

In this paper we deal with Eugen von Böhm-Bawerk’s theory of capital and interest and John Hicks’s attempt to overcome some of its deficiencies. Hicks admired the Austrians for their recognition of the all-important time element in economics and generalised their analyses especially in two respects. First, he tried to incorporate durable instruments of production, that is, fixed capital which in Böhm-Bawerk’s analysis had been set aside. Secondly, he sought to provide a more precise picture of the process of transition from one long-period equilibrium to another one in terms of a ‘traverse analysis’. Here we focus attention on the basic problems of the Austrian approach as it was developed by Böhm-Bawerk. In Section 2 we provide a short summary account of his theory of capital and interest. Section 3 demonstrates that in simplifying circumstances (no joint production, no fixed capital, only a single primary factor

of production) and on the crucial assumption that there is only simple interest, Böhm-Bawerk's concept of the 'average period of production' achieves indeed what it was originally designed for: to aggregate heterogeneous (capital) goods independently of relative prices and thus income distribution. Alas, the concept breaks down with compound interest which conforms to the assumption of free competition (whereas simple interest is incompatible with it). Section 4 argues that while Böhm-Bawerk's device of an average period of production both for single processes of production and for the production process of the economic system as a whole was a failure, he was not searching for a will-o'-the-wisp. Interestingly, pointers in the direction of a proper solution can be found in Karl Marx's approach to the theory of value and distribution. Marx had been grappling with similar problems as Böhm-Bawerk and had put forward a concept, that of the 'organic composition of social capital', which was meant to serve essentially the same purpose as Böhm-Bawerk's concept of the average period of social production. Yet also Marx did not fully succeed in providing a device that allowed one to see through the complexities of the actual economic system and render visible what was hidden. As Section 5 argues, this was only achieved by Piero Sraffa in terms of his concepts of the Standard system and Standard commodity. Section 6 then turns to fundamental properties of the economic system as seen by the Austrian and marginalist authors: the positivity of both price and real 'Wicksell effects'. These properties have however been called into question both within unidirectional ('Austrian') production and production conceived as a circular flow. Section 7 discusses Hicks's suggested treatment of fixed capital within an Austrian framework of the analysis. While the analysis up until then was long period, Section 8 comments on Hicks's 'traverse analysis' which deals with the problem of how an economy can pass from one long-period equilibrium to another one. Attention focuses in particular on Hicks's analysis of induced technical change and how it relates to the analyses of Ricardo, Marx, and Böhm-Bawerk. Section 9 contains some concluding remarks.

## **2. Böhm-Bawerk on capital and interest**

In volume I, *History of Interest Theories*, of his magisterial work on *Capital and Interest* ([1884, 1889] 1959) Böhm-Bawerk provided a detailed critical account of theories of capital and interest, past and contemporary. He grouped them in six (main representatives are given in brackets): 1. 'colourless theories' (Adam Smith, David Ricardo), 2. 'productivity theories' (Jean-Baptiste Say, Johann Heinrich von Thünen, Gustav Cassel), 3. 'utilization theories' (Friedrich Benedikt Wilhelm von Hermann, Carl Menger), 4. 'abstinence theories' (Nassau William Senior), 5. 'labour theories' (Albert Schäffle, Adolph Wagner), and 6. 'exploitation

theories' (Johann Carl Rodbertus, Karl Marx). Böhm-Bawerk left no doubt that in his view the 'motivated' productivity theories came closest to what he considered an appropriate explanation of interest, but that the attentive reader would even benefit from studying the other types of theories with the exception perhaps of those in groups 5 and 6. Alas, none of the earlier authors had spoken the 'redeeming word' on the matter, a task Böhm-Bawerk therefore felt he had to reserve to himself.

In volume II of his work, *Positive Theory of Interest* ([1889] 1921b), Böhm-Bawerk then put forward what he considered as the final word on the matter. His argument revolved around what he called the 'Three Grounds' for interest:

1. 'different circumstances of want and provision' in the present and in the future;
2. the 'under-estimation of the future', that is, a positive time preference; and
3. the 'technical superiority of present over future goods', that is, the superiority of more 'roundabout' processes of production.

Immediately after his treatise was published there were discussions about the meaning and validity of each one of the grounds and of how they related to one another. Böhm-Bawerk's most important and analytically gifted follower Knut Wicksell shared the Austrian's basic theoretical vision and was convinced that the latter's analysis contained the key to solving the two main problems of the theory of capital and interest, that is, (i) to explain the *origin and level of interest* and (ii) to explain the *origin and formation of capital* (Wicksell, [1893] 1954, pp. 21-2). Yet, in Wicksell's view Böhm-Bawerk had not fully grasped the proper status of each of the three grounds and their interaction. Already in *Value, Capital and Rent*, published originally in German in 1893, Wicksell set out his own understanding of the proper division of labour amongst the three grounds in tackling the two problems (cf. Wicksell, [1893] 1954, pp. 21-2); essentially the same view is found in the *Lectures* (cf. Wicksell, [1901] 1934, pp. 154-6). For given endowments of the factors of production, including capital, the third ground is said to allow one to determine the rate of interest,  $r$ , as the 'marginal product of waiting'. This provides a preliminary answer to the first main problem of capital theory. In an economy which according to Böhm-Bawerk and Wicksell was still far away from being saturated with capital the resulting 'natural' rate of interest may be expected to be larger than the (average) rate of time preference in society,  $\rho$ , contemplated by the second ground. With  $r > \rho$ , a sufficient condition for positive net capital formation is met. This leads immediately to the first ground, which supposes a growing income per capita, and which now turns out to be

merely a consequence of  $r$  exceeding  $\rho$ . Finally, the greater is the difference between  $r$  and  $\rho$ , the greater is *ceteris paribus* the pace at which capital accumulates and the economy grows. Setting aside technical progress and population growth, as capital accumulates its relative scarcity decreases, which will be reflected in a falling rate of interest. Other things equal, this implies a gradual deceleration in the formation of new capital (Wicksell, [1901] 1934, p. 209). This is taken to provide some elements of a preliminary answer to the second main problem.

As regards the concept of the ‘quantity of capital’ in given supply at a given moment of time, Böhm-Bawerk was aware since the beginning of his investigation that this required him to define a measure of the capital endowment of the economy, which consists of heterogeneous capital goods, that is independent of the rate of interest. If it were to depend on the rate of interest, whose level he sought to determine in terms of the relative ‘scarcity’ of capital, this would involve ‘circular reasoning’ and thus render the argument devoid of any explanatory value. It was at this point that Böhm-Bawerk was confronted with the problem of forging a tool that allowed him to simplify matters which were blurred by the multiplicity and variety of goods and especially of capital goods. Was it possible to aggregate across heterogeneous capital goods and arrive at a scalar representation of social capital without prejudicing the issue of income distribution? Böhm-Bawerk thought that this was indeed possible in terms of the concept of the ‘average period of production’. According to this concept, time could serve as the sought measure of capital.

### 3. The ‘average period of production’

Scrutiny shows that while Böhm-Bawerk was keen to provide a general solution to the problem at hand, he quickly saw that contrary to his original intentions he had to contain the complexity of the problem in terms of a set of *ad hoc* assumptions by means of which all phenomena he could not deal with are set aside. In particular, the construction of the average period of production is subject to the following assumptions:<sup>1</sup>

- (i) There is only single production; joint production is ruled out.
- (ii) There is only circulating capital; fixed capital is set aside.
- (iii) There is only a single ‘original’ factor of production, homogeneous labour; land is taken to be a free good.

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<sup>1</sup> The same assumptions underlie William Stanley Jevons’s related concept of the ‘average time of investment’ (see Steedman, 1972).

Böhm-Bawerk allowed for a positive (and, in competitive conditions, uniform) rate of interest, but in his theory of relative prices and income distribution added the crucial assumption:

(iv) There is only simple interest; compound interest is set aside.

This assumption is crucial in the sense that without it Böhm-Bawerk's concept of the average period of production cannot be sustained even if the bold assumptions (i)-(iii) are met.

We can render this fact clear by building up the concept of the average period from the price equations relating to  $n$  different goods. With wages paid at the beginning of the production period, the average period of production of commodity  $i$  can be derived as follows. Making use of the 'reduction to dated quantities of labour' (see Sraffa, 1960, chapter VI, and Kurz and Salvadori, 1995, chapter 6, section 1) and assuming wages to be paid *ante factum*, for a given system of production the system of  $n$  price equations with *compound interest* is

$$\mathbf{p} = w[(1+r)\mathbf{l} + (1+r)^2\mathbf{A}\mathbf{l} + (1+r)^3\mathbf{A}^2\mathbf{l} + (1+r)^4\mathbf{A}^3\mathbf{l} + \dots]$$

or

$$\mathbf{p} = w[(1+r)\mathbf{l}_1 + (1+r)^2\mathbf{l}_2 + (1+r)^3\mathbf{l}_3 + (1+r)^4\mathbf{l}_4 + \dots], \quad (1)$$

where  $\mathbf{A}\mathbf{l} = \mathbf{l}_{j+1}$  ( $j = 0, 1, 2, \dots$ ).

With Böhm-Bawerk's *simple interest* we have instead

$$\mathbf{p} = w[(1+r)\mathbf{l}_1 + (1+2r)\mathbf{l}_2 + (1+3r)\mathbf{l}_3 + (1+4r)\mathbf{l}_4 + \dots]. \quad (2)$$

This can be written as

$$\mathbf{p} = w\left(\sum_t \mathbf{l}_t + r \sum_t \mathbf{l}_t\right) = w(\mathbf{I} + r\mathbf{T})\mathbf{v} \quad \mathbf{p} = w \quad (3)$$

where  $\mathbf{v} = \sum_t \mathbf{l}_t$  is the vector of direct and indirect quantities of labour 'embodied' in the different commodities,  $\mathbf{T}$  is a diagonal matrix which has the average periods of production of the different industries on its main diagonal,  $t_{ii} = \tau_i$ , and

$$\tau_i = \frac{\sum_t t \frac{l_{ti}}{\sum_h l_{hi}}}{v_i} = \frac{\sum_t t l_{ti}}{v_i}.$$

The average period is the weighted average of the periods of time over which the amounts of labour  $l_{ji}$ ,  $j = 1, 2, \dots$ , remain invested until one unit of commodity  $i$  is obtained, with the

respective amounts of labour serving as weights. By means of this device Böhm-Bawerk (and, following his lead, other Austrian theorists such as Hayek) thought it possible to replace in each line of production a vector of physically heterogeneous capital goods with a scalar,  $\tau_i$ , which is independent of distribution and prices. ‘Capital’ was thus taken to be reducible to a single variable dimension: the length of time.<sup>2</sup>

However, if instead of equation (2) we would start from equation (1) we could not define the  $\tau_i$ 's independently of the rate of interest,  $r$ . This implies that we could also not define the capital endowment of the economic system as a whole relative to the amount of labour employed independently of the rate of interest. This in turn means that we cannot take the average period of social production as a determinant of the rate of interest, because the very concept of the average period presupposes knowledge of this rate.

Böhm-Bawerk's laudable attempt to analyse the economic system in its full generality turned out to be futile. The question is: Is any such attempt doomed to failure for systematic reasons or is there a way out of the impasse?

#### **4. Marx vs. Böhm-Bawerk**

In the above we said that Böhm-Bawerk was struggling with a problem that was genuinely Ricardian. Ricardo, as is well known, explained profits (and rents) in terms of the surplus product left after the means of production and the means of subsistence in the support of workers had been deducted from gross outputs. In physical terms the general rate of profits is the ratio of the social surplus and the social capital. Apparently a theory of value was needed in order to render commensurable two sets of heterogeneous commodities, the ratio of which is the rate of profits. Ricardo had recourse to the labour theory of value precisely in order to cut through the Gordian knot he was confronted with. The quantities of labour ‘embodied’ in the various commodities provided a device to aggregate the various commodities independently of the rate of profits and thus ascertain the latter. In much of his respective argument Ricardo assumed that capital consisted only of wages, or could be reduced to wages in a finite number of steps. That is, Ricardo assumed that the absolute length of the production

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<sup>2</sup> The Austrian authors thought that by generalising the argument also fixed capital and other complications could be subsumed under the general approach adopted, without affecting the basic validity of the results derived in the more specialised conditions. However, they never managed to show that their supposition was correct.

process of a commodity (and thus the series of dated quantities of labour as it is given by equation (1)) was finite. Obviously, this constituted a regression from the *circular flow* representation of social production entertained by the Physiocrats (and also by Ricardo in other parts of his analysis).

However, Ricardo also introduced a new analytical tool by focusing attention on income shares rather than absolute magnitudes. In his analysis of the problem of income distribution and its development over time Ricardo contemplated the case in which workers participate in the sharing out of the surplus product. In this case wages could no longer be given in commodity terms. With the traditional concept of subsistence or real wages being obsolete, Ricardo decided to put in its place a *share* concept of wages: ‘the proportion of the annual labour of the country ... devoted to the support of the labourers’ (Ricardo, 1951-73, vol. I, p. 49). In order to fully understand the ingenuity of Ricardo’s analytical device, it must be borne in mind that he sought to provide an answer to an extremely intricate problem: How to determine the development of the rate of profits in an economic system that is subject to capital accumulation, population growth, and continuous changes in the productivity of labour, arising on the one hand from the need to have recourse to less fertile plots of land in agricultural production and on the other hand from the substitution of machinery for human labour in the manufacturing sector and technical improvements in general. In such a world it is clearly not possible to specify ‘real wages’ in terms of a given set of commodities consumed by the workers. Over time the workers’ consumption basket will generally not only change in composition (including more of some and less of other commodities) but will also incorporate entirely new commodities, which had not been available before, while others will perhaps no longer be included. Conceptualising wages in terms of the surplus share received by the workers seems congenial in this case. However, it was only because of the simplifying assumption of linear or unidirectional production of finite length that Ricardo thought he could reduce all capital to wages and thus arrive at what may be called his ‘fundamental proposition on distribution’: that the *rate of profits* depends on *proportional wages*, and on nothing else.

Ricardo’s analysis provides the foil against which we can assess respectively the analyses of Böhm-Bawerk and Marx. Böhm-Bawerk, we may now say, adopted the unidirectional view of production Ricardo used in his theory of profits and at the same time retained the conventional real wage concept defined in terms of an inventory of commodities. Marx, on the other hand, adopted Ricardo’s novel concept of proportional wages in terms of the concept



of the rate of surplus value, but chastised Ricardo for having abandoned the conceptualization of social production as a circular flow. This made Ricardo (and later Böhm-Bawerk) lose sight of the fact that the price of a commodity can never be fully resolved into wages and profits, because however far one carries on the reduction to dated quantities of labour there will always remain a commodity residue. Because of the circular character of production the rate of profits will not tend towards infinity when wages hypothetically tend to zero, as the unidirectional view would have it. Rather, there is a finite maximum level of the rate of profits which corresponds to zero wages. The maximum rate of profits is however nothing but the inverse of the ‘organic composition of social capital’. Marx concluded that contrary to Ricardo’s dictum the rate of profits depends on two magnitudes instead of on only one: it depends on proportional wages *and* on the organic composition.

We may express Marx’s view in somewhat greater detail. In his conceptualization, the maximum rate of profits that obtained when wages were nil was equal to  $Y/K$ , that is, the ratio of total living labour expended during a year ( $Y = P + W$ , where  $P$  is surplus labour, alias surplus value, and  $W$  is the labour received in the form of wages, alias variable capital) and social constant capital ( $K$ ), that is, labour embodied in the means of production. It was thus equal to the inverse of the organic composition of capital of the system as a whole. Marx’s concept of constant capital, and the related concept of the organic composition, expresses the fact that commodities are produced by means of commodities. This implies that the rate of profits is bounded from above. Marx considered the maximum rate of profits,  $R$ , to be a purely technological datum of the system as a whole, independent of relative prices and the actual rate of profits. The latter is given by

$$r = \frac{P}{K + W} = \frac{\frac{P}{Y}}{\frac{K}{Y} + \frac{W}{Y}} = \frac{1 - \frac{W}{Y}}{\frac{1}{R} + \frac{W}{Y}} = \frac{R(1 - w)}{1 + Rw}, \quad (4)$$

where  $w$  is the share of wages. It follows that the rate of profits depends on two factors instead of only one: the share of wages,  $w$  (or the rate of surplus value,  $(1 - w)w^{-1}$ ), and the maximum rate of profits,  $R$ . Differentiating  $r$  partially with respect to  $R$  gives

$$\frac{\partial r}{\partial R} = \frac{1 - w}{(1 + Rw)^2} > 0 \quad (5)$$

This explains why in his discussion of the long-run tendency of the rate of profits Marx focused attention on the development of the organic composition of social capital. For, with a

given and constant share of wages the rate of profits is bound to fall with a fall in the maximum rate of profits.

Before we proceed, two facts should be stressed. First, in a circular production framework Böhm-Bawerk's concept of the average period of production of the system as a whole is equivalent to the inverse of Marx's concept of the organic composition of social capital. Both are expressions of the ratio of the value of the net product of the economic system to the value of its means of production (or the inverse of this ratio). In both concepts the quantities of commodities corresponding to the self-reproducing system of production in use are measured in terms of labour values, which can be ascertained independently of the rate of interest (profits). Secondly, it is this labour-based measuring rod that turns out to be untenable.

### **5. The economic system seen through the lens of a 'construction'**

While Marx's argument was insightful and can be said to mark a huge step forward compared with where Ricardo had left the subject, it was not fully satisfactory. This Sraffa stressed explicitly in his hitherto unpublished papers and implicitly in his published book (Sraffa, 1960). Since we have expounded this in some depth in another paper of ours (see Gehrke and Kurz, 2006, section 4) here it must suffice to provide a summary account of Sraffa's argument. In his analysis Marx used side by side two different conceptions of wages: given real wages in terms of commodity bundles ('inventory wages') and a share concept of wages. Sraffa pointed out that as far as surplus value and the rate of surplus value were concerned, according to Marx's assumption of given inventory wages only wage-good industries come into consideration, but when the rate of profits was concerned Marx insisted against Ricardo that industries producing luxury goods, consumed only by capitalists, need not to be taken into account. Marx argued instead that all spheres of production had to be considered, for in order to obtain the general rate of profits all the different rates of profit must be averaged out over all capitals. Sraffa emphasized: 'The two points of view are incongruous, and are bound to lead to contradictions.' (Sraffa papers, D1/91: 21; quoted in Gehrke and Kurz, 2006, p. 142)

Was there a way out of the impasse? Sraffa's answer was in the positive and consisted in the construction of the Standard system and Standard commodity. An important step on the way toward this *Hilfskonstruktion* was the change from *ante* to *post factum* payment of wages. Whereas with wages given at the subsistence level it was natural to consider wages as paid out of capital, with a part of the surplus product going to workers, the traditional wage

concept was incompatible with the revenue aspect of proportional wages. Yet, as soon as wages as a whole were taken to be paid out of the social product rather than out of the social capital, the way was open to replacing the *socioeconomic* distinction of the classical authors and Marx between ‘necessaries’ or ‘wage goods’ on the one hand and ‘luxuries’ on the other with the purely *technical* distinction between ‘basics’ and ‘nonbasics’. Basics enter directly or indirectly in the production of all commodities, nonbasics don’t. In the Standard system nonbasic products are eliminated and the maximum rate of profits,  $R$ , is shown to equal the Standard ratio of the Standard system, a ratio of two vectors of commodities that are linearly dependent. The Standard commodity, which allowed Sraffa to assume a particular view of the given system and ‘render visible what was hidden’ (Sraffa, 1960, p. 23), made him establish the sought-after congruity between wages and capital in the circular flow framework in terms of a linear relation between the rate of profits,  $r$ , and proportional wages,  $w$ :

$$r = R(1 - w).$$

This linear relation applies also to the actual system, provided wages and prices are expressed in terms of the Standard commodity. As Sraffa was to emphasize in his book: ‘The same rate of profits, which in the Standard system is obtained as a ratio between quantities of commodities, will in the actual system result from the ratio of aggregate values’ (1960, p. 23).

## 6. Salient features of the economic system in dispute

Böhm-Bawerk’s failure to provide in terms of the concept of the ‘average period of production’ a measure of capital that is independent of income distribution could perhaps be regarded as merely a minor analytical deficiency that does not affect the validity of the more fundamental ideas of the Austrian theory of value and capital. We therefore turn now to what according to Böhm-Bawerk and marginalist economics at large are the two most fundamental properties of the economic system. We discuss these properties in terms of what are known as *price Wicksell* and *real Wicksell effects* (henceforth PWE and RWE) (see Kurz and Salvadori, 1995, chapter 14). A PWE relates to a change in relative prices corresponding to a change in income distribution, given the system of production in use. A RWE in addition takes into account the problem of the choice of technique. The ‘changes’ under consideration refer to comparisons of long-period equilibria. According to marginalist theory both Wicksell effects are *positive*. Let us see what is meant by this.

Knut Wicksell ([1893] 1954; [1901] 1934, pp. 147-51) discussed these effects within a Böhm-Bawerkian or Austrian framework of the analysis, which conceives of production as a one-

way avenue of finite length leading from the services of original factors of production, in particular labour, via some intermediate products to consumption goods. Before Wicksell they had been studied by the classical economists, especially David Ricardo (1951-73, vol. I, pp. 30-43). Relative prices depend on income distribution because of the ‘variety of circumstances under which commodities are actually produced’ (1951-73, vol. IV, p. 368). This in conjunction with the fact that ‘profits [are] increasing at a compound rate ... makes a great part of the difficulty’ (1951-73, vol. IX, p. 387).

The source of PWEs can be illustrated by expressing the ratio of the prices of two commodities,  $A$  and  $B$ , by means of their reduction to dated quantities of labour. Call  $p_a$  and  $p_b$  the prices per unit of two commodities,  $w$  the wage rate per unit of labour (paid *post factum*) and  $r$  the rate of interest (profits). Then we have

$$\frac{p_a}{p_b} = \frac{wl_{a0} + (1+r)wl_{a1} + (1+r)^2wl_{a2} + \dots + (1+r)^nwl_{an} + \dots}{wl_{b0} + (1+r)wl_{b1} + (1+r)^2wl_{b2} + \dots + (1+r)^nwl_{bn} + \dots}$$

On the right hand side of the equation  $w$  could be eliminated. Obviously,  $l_{a0}$  ( $l_{b0}$ ) gives the amount of labour expended directly on the last stage of producing one unit of commodity  $a$  ( $b$ );  $l_{a1}$  ( $l_{b1}$ ) the amount expended directly on the last but one stage; etc. Whilst with the Austrian concept each series is finite, with the classical circular flow concept it is infinite. Since for a given system of production the rate of interest and wages are inversely related, a change in distribution typically affects the prices of the two commodities differently: It all depends on how the total amounts of labour expended are distributed over time – whether or not relatively much labour is expended in early periods of time and little in later ones. Since with a rise of  $w$  and the corresponding fall of  $r$  the size of each term in each of the reduction equations (except the first term) is pulled in different directions, the overall effect of a change in distribution on relative prices depends on how the time patterns of the labour inputs compare with one another, with compound interest as a magnifier.

With a choice of technique a change in the real wage rate may prompt cost-minimizing producers to change the methods of production to produce the various commodities. This brings us to the concept of RWE. In order to be able to compare the new situation with the original one, it has to be assumed that in both situations the same net output is produced; typically the economy is taken to be in a stationary state both before and after the change. The questions to be answered are: Which technique will be chosen in the new situation? What will then be the level of the other distributive variable and the set of normal prices? And most

importantly: Is it possible to say anything definite about how the two situations compare with one another?

To illustrate RWEs, we may refer back to the equation above. However, now  $A$  and  $B$  stand for two different processes of production of a *given* commodity available to producers. In competitive conditions that method will be chosen which allows one to produce the commodity at lower unit costs and thus a lower price.

Marginalist theory, of which Austrian theory is but a variant, maintains that both effects are invariably positive. A *positive PWE* means that with a rise (fall) in the rate of interest (and the corresponding fall (rise) in the wage rate) consumption goods will become relatively more (less) expensive compared with capital goods. The reason given is that consumption goods are said to be produced more capital-intensively than capital goods: consumption goods emerge at the end of the production process, whereas capital goods are intermediate products that gradually ‘mature’ towards the final product. The higher (lower) is the rate of interest the less (more) expensive are the intermediate products in terms of a standard consisting of a (basket of) consumption good(s). At the macro level of a stationary economy (in which the net product contains only consumption goods) this implies: With a rise in the rate of interest the value of the net social product rises relatively to the value of the aggregate of capital goods employed. Clearly, seen from the marginalist perspective, a positive PWE with regard to the relative price of the two aggregates under consideration involves a negative relationship between the aggregate capital-to-net output ratio on the one hand and the interest rate on the other. Let  $K/Y = \mathbf{x}\mathbf{p}(r)/\mathbf{y}\mathbf{p}(r)$  ( $\mathbf{x}$  is the row vector of capital goods,  $\mathbf{y}$  the row vector of net outputs, and  $\mathbf{p}(r)$  the column vector of prices (in terms of the consumption vector) which depends on  $r$ ) designate the capital-output ratio, then the marginalist message is:

$$\frac{\partial(K/Y)}{\partial r} \leq 0 \quad (\text{I})$$

Since for a given system of production the amount of labour is constant irrespective of the level of the rate of interest, also the ratio of the value of the capital goods and the amount of labour employed, or capital-labour ratio,  $K/L$ , would tend to fall (rise) with a rise (fall) in the rate of interest,

$$\frac{\partial(K/L)}{\partial r} \leq 0 \quad (\text{II})$$

This is the first claim marginalist authors put forward. The second is that RWEs are also positive. A *positive RWE* means that with a rise (fall) in the rate of interest cost-minimizing producers switch to methods of production that generally exhibit higher (lower) labour intensities, ‘substituting’ for the ‘factor of production’ that has become more expensive – ‘capital’ (labour) – the one that has become less expensive – labour (‘capital’). Hence (II) is said to apply also in this case. The assumed positivity of the RWE underlies the marginalist concept of a demand function for labour (capital) that is inversely related to the real wage rate (rate of interest).

Careful scrutiny of the marginalist argument has shown that it cannot generally be sustained: there is no presumption that PWEs and RWEs are invariably positive. In fact there is no presumption that techniques can be ordered monotonically with the rate of interest (Sraffa, 1960). As Mas-Colell (1989) stressed, the relationship between  $K/L$  and  $r$  can have almost any shape whatsoever.

The finding that PWEs and RWEs need not be positive challenges the received doctrine of the working of the economic system as it is portrayed by conventional economic theory with its reference to the ‘forces’ of demand and supply.

## **7. Hicks’s treatment of fixed capital in the neo-Austrian model**

A serious shortcoming of Böhm-Bawerk’s theory of capital was the limitation to circulating capital only. Not surprisingly, several attempts were made by economists working in the Austrian tradition to overcome this limitation and to extend the analysis to fixed capital (see, in particular, Åkerman, 1923-24; Wicksell, 1923; and Hayek, 1941). Studying the problem of fixed capital within an Austrian framework of the analysis was also a major concern of John Hicks in *Capital and Time* (1973).

According to Hicks, fixed capital goods ‘are “durable-use goods”; their essential characteristic is that they contribute, not just to one unit of output, at one date, but to a sequence of units of output, at a sequence of dates’ (1973, p. 8). Because fixed capital gives rise to intertemporal joint production, the ‘flow input-point output’ conception underlying Böhm-Bawerk’s approach to capital theory has to be replaced by that of ‘flow input-flow output’ processes. As Hicks put it: ‘While the old Austrian theory was “point output” (its elementary process having a single dated output), we shall use an elementary process that

converts a sequence (or stream) of inputs into a sequence of outputs. Our conception of capital-using production is thereby made much more general' (1973, p. 8).

However, Hicks's conception of capital-using production was more general than Böhm-Bawerk's only in some respects but not others. In *Capital and Time* the available technology was depicted in terms of elementary processes in which, for analytical convenience, 'all "original inputs" are taken to be homogeneous, and all final outputs homogeneous' (1973, p. 37).<sup>3</sup> Hicks provided no justification for the homogeneity assumption with regard to the original inputs but simply pointed out that 'it is natural, having made this simplification, to call the homogeneous input Labour' (1973, p. 37). With regard to the outputs, the problem of commodity heterogeneity was boldly set aside with the simple remark that the homogeneous final output 'is to be thought of as standing for "consumption goods in general"' (1973, p. 37). The problem of the (continuously changing) variety of consumer goods, that had prompted Ricardo and Marx to advocate a share concept of wages in their analyses of the accumulation process, was thus simply circumnavigated by Hicks by means of a bold assumption. Hicks followed Ricardo however in another regard: He assumed the elementary processes to be of finite length and thus failed to take into account the existence of circular production relationships and, consequently, of a finite maximum rate of profits, in his neo-Austrian conceptualisation of production.

As Hicks pointed out, taking into account fixed capital implied that some characteristic features of traditional Austrian capital theory had to be abandoned. For example, the notion of the 'degree of roundaboutness' of a production process, which under the assumption of point input-point output processes could be used as a measure of capital intensity, must be dispensed with: with flow input-flow output processes 'the whole notion collapses' (1973, p. 9). With a process going on forever, the notion cannot even be given a clear meaning, whereas in other cases there is no presumption that the degree of roundaboutness and the rate of interest are inversely related. Hicks thus dispensed with those Austrian concepts that he considered obsolete and tried to revive those that he thought could be given a logically consistent formulation. He was particularly concerned with establishing, in terms of his 'Fundamental Theorem' (1973, pp. 19-26), which is about the optimal truncation of

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<sup>3</sup> Moreover, for most of the analysis in *Capital and Time* Hicks assumed the elementary processes to exhibit a particular profile (the so-called 'Simple Profile'; see Hicks 1973, pp. 41 and 84). The involved technological restrictions were critically discussed by Burmeister (1974) and by Hagemann and Kurz (1976).

production processes, the uniqueness of the rate of interest, given the wage rate and the technical alternatives of production. He was of the opinion that uniqueness implies an economic lifetime of a fixed capital good which is inversely related to the rate of interest, that is, a result which, if it were true, could be seen as reflecting an old Austrian idea in a somewhat 'diluted' form. However, as has been shown by Hagemann and Kurz (1976), this opinion is unfounded: the possibility of the return of the same truncation period cannot be ruled out even within the Neo-Austrian scheme of production. This finding seems to be sufficient to dispel the idea that a general economic theory can be constructed in neo-Austrian terms.

### **8. Hicks's analysis of traverse processes and of induced technical change**

Hicks's main focus of attention in *Capital and Time* (1973) was on the analysis of traverse paths, that is, on tracing out the development of the economy after a major change in data, such as the availability of a new production method or a sudden change in the availability of labour, has disturbed the tranquil conditions of the steady state growth path. According to Hicks, the neo-Austrian model is particularly well suited for studies of this kind, because it emphasises the specificity of capital goods and thus the existence of *intertemporal complementarities* in the production structure. In *Capital and Time*, the transition processes triggered by the introduction of a new technique were analysed by considering two different 'scenarios'. In the first scenario the real wage rate was assumed to adjust instantaneously in the course of the traverse to keep the available labour force continuously fully employed ('Full Employment Path'), while in the second the wage rate was supposed to be rigidly fixed, so that the non-steady flow of consumption output along the traverse path results in variations in the level of employment ('Fixwage Path'). The two alternative hypotheses with regard to wage flexibility were then combined with the so-called '*full performance*' hypothesis, according to which the activity levels for the start of new processes are determined so as to absorb the remaining part of the full-capacity output (that is, after deducting from total output the consumption requirements of the labour force employed on the existing processes plus the so-called 'Take out' for capitalists' consumption).

A general criticism of Hicks's traverse analysis concerns the fact that the possibility to determine uniquely traverse paths in the neo-Austrian framework is inextricably bound up with the full performance hypothesis, according to which the level of aggregate investment is



determined by the level of full-capacity aggregate savings.<sup>4</sup> In these circumstances there is no room for an independent investment function, and hence also no room for variability in the degree of capacity utilisation. However, as soon as more general production structures (e.g. non-vertically integrated neo-Austrian production models) are taken into consideration the full performance hypothesis becomes difficult to sustain. Unless one is prepared to introduce some ad hoc restrictions with regard to the starting phase of the elementary processes, multiple transition paths with over- and underutilisation of productive capacities cannot be avoided (see Gehrke, 1998).

### **8.1 The analysis of induced technical change**

In the following we focus attention on a particular aspect of Hicks's traverse analysis. We scrutinise Hicks's analysis of induced technical change in chapter 10 of *Capital and Time* (1973, pp. 110-24) and investigate how it relates to the analyses of Ricardo, Marx, Böhm-Bawerk, and Wicksell. The main purpose is to identify major elements of continuity and change with regard to the concepts and analytical methods adopted by Hicks and the other authors mentioned.

#### **(a) Induced technical change in Ricardo and Marx**

Ricardo's explanation of a falling tendency of the general rate of profits was based on a 'natural course' scenario of the economic system, in which capital is accumulated and the population grows, but in which there is no technical progress proper. As is well-known, Ricardo had maintained that with a growing stock of capital and population money wages and proportional wages tend to rise, and the rate of profits tends to fall, because of increasing costs of production in agriculture. With the rise in nominal wages and the associated fall in the rate of profits, known but hitherto unused methods of production ('machinery') are eventually adopted in the manufacturing sector, because it now becomes profitable to do so. In Ricardo's words: 'Machinery and labour are in constant competition and the former can frequently not be employed until labour [i.e. the money wage] rises' (1951-73, vol. I, p. 395). Ricardo illustrated his machinery substitution argument by means of a numerical example in

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<sup>4</sup> Since in Hicks's neo-Austrian model the start of elementary processes is assumed to require no capital goods, 'investment' takes the form of provisioning workers engaged in the starting phase of new processes with consumption goods.

Section V of Chapter 1 of the *Principles* (1951-73, vol. I, pp. 40-42).<sup>5</sup> The increase in labour productivity associated with the introduction of machinery in the manufacturing sector can temporarily retard the fall in the rate of profits and the rise in money wages, because the workers' consumption basket consists partly of manufacturing products.<sup>6</sup> However, as capital continues to be accumulated money wages and proportional wages will sooner or later start rising again because of the overriding importance of decreasing returns in agricultural production. Analytically, Ricardo's argument revolved around the inverse relationship between the general rate of profits and the share of wages.

As we saw above, Marx had detected an important error in Ricardo's line of reasoning, which consisted in his neglect of the circularity of production in his analysis of the wage-profit relationship. As Marx stressed over and over again, this had serious implications; in particular, it had misled Ricardo into emphasising the wrong causes in his explanation of the tendency of the general rate of profits to fall (Marx, [1861-3] 1975, p. 73). Marx had found out that Ricardo's proposition, according to which the general rate of profits falls if, and only if, proportional wages rise, is not correct: it only holds good if one disregards the non-wage capital and argues *as if* capital advances consist only of the wages bill. However, if one takes into account the existence of non-wage capital the rate of profits can also fall with constant (or even moderately decreasing) proportional wages if the maximum rate of profits,  $R$ , falls. According to Marx, there is indeed a tendency of the maximum rate of profits to fall, which is consequent upon another element of Ricardo's doctrine which Marx had incorporated into his own analysis: the *machinery substitution argument*. According to it, an increase in money wages eventually may render it profitable to introduce machinery which hitherto could not be used profitably. Marx explicitly approved of Ricardo's substitution argument,<sup>7</sup> and pointed out that it entails an increase in the organic composition of capital (and a fall in the maximum rate of profits,  $R$ ). While his insistence on circular production relations thus led Marx to an important correction of Ricardo's views on accumulation, the analytical framework he adopted was rather similar to Ricardo's: according to Sraffa, it allowed for induced technical changes only, setting aside technical progress proper (see Gehrke and Kurz 2006).

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<sup>5</sup> See Gehrke (2003) for a discussion of Ricardo's argument.

<sup>6</sup> Ricardo typically referred to 'food and cloth' as a catch-all for the agricultural and the manufacturing components in the workers' consumption basket.

<sup>7</sup> See Marx ([1867] 1954, pp. 392-3 and [1861-3] 1975, pp. 177-8).

### **(b) Induced technical change in Böhm-Bawerk and Wicksell**

In his *Positive Theory of Capital*, Böhm-Bawerk also adopted the Ricardian analytical framework of capital accumulation in a given state of technical knowledge, which allows for induced changes in production methods, consequent upon changes in income distribution, but excludes technical progress proper. This is particularly evident in Böhm-Bawerk's "Critical excurses" in volume III of *Capital and Interest*, in which he replied to his critics (see Böhm-Bawerk [1889] 1921c; in particular the replies to Taussig, pp. 13-5, and Fisher, pp. 75-8). In his reply to Taussig, Böhm-Bawerk made it clear that the assumption of 'conditions in which the arts are stationary' by no means excludes the adoption of new production methods. According to Böhm-Bawerk, Taussig's criticism was misdirected, because the latter 'wrongly assumes that in a stationary state of productive knowledge only an exact copying of the existing instruments is admissible. This is not so. For there always exists knowledge of much else which could not be utilised before, because it would not have been economic to do so' ([1889] 1921c, p. 14). According to Böhm-Bawerk, at any moment in time the number of available inventions that are associated with a lengthening of the period of production will generally be larger than the number of those associated with a shortening. This is because the latter are in general not "stored up" for later use but used immediately upon their arrival, while the former can often only be adopted after a sufficient amount of capital has been accumulated, and the rate of interest accordingly fallen ([1889] 1921c, pp. 6-10). The accumulation process is therefore generally accompanied by a changing technique that exhibits a particular bias. According to Böhm-Bawerk, the dominant form of the change under consideration in capitalist economies consists in the substitution of 'natural powers' ("Naturkräfte"), which are said to be abundantly available, for labour power, which is becoming ever more scarce.<sup>8</sup>

Each introduction of a roundabout means recruitment of an assisting power that is more powerful and more skilful than the human hand; each lengthening of the roundabout process of production means an increase of the assisting powers that work for mankind, and a transfer of part of the production burden away from scarce and expensive human labour towards the abundantly available powers of nature. (Böhm-Bawerk [1889] 1921c, p. 28; cp. also [1889] 1921b, p. 15)

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<sup>8</sup> As we saw above, Marx described the same process in rather different terms. To him, the accumulation process is bound up with a rising organic composition of capital, that is, with a substitution of 'previously expended labour' for 'living labour'.

While there is no indication that Böhm-Bawerk saw any connection between his own and Ricardo's machinery substitution argument, Wicksell strongly emphasized the close relationship between the two. In *Value, Capital, and Rent* he observed, commenting on the numerical example in Section V of Chapter 1 of Ricardo's *Principles*:

Here, too, Ricardo has correctly understood the sequence of cause and effect; if money wages rise (which in his view could only happen over longer periods as a result of the greater difficulty in producing the means of maintenance of workers, although in general such a rise can be understood as the consequence of every increase of capital), then the introduction of machines which before proved unproductive will now become more profitable, as he has shown in an ingenious example. The price of machinery, that is to say, includes profit as well as wages. As this profit, like all the others, must fall when wages rise, the price of machines can consequently never rise in the same proportion as wages. (Wicksell [1893] 1954, p. 37)

Wicksell then goes on to suggest that, 'according to the more modern terminology, this means that every increase of wages encourages a lengthening of the period of production' (Wicksell [1893] 1954, pp. 37-8). The same interpretation of Ricardo's machinery substitution effect was also put forward in *Finanztheoretische Untersuchungen* (1896, p. 27) and in Volume I of Wicksell's *Lectures* ([1901] 1934, p. 167), where it was maintained that Ricardo's substitution argument 'contains, in a somewhat different form, one of the corner stones of Böhm-Bawerk's own theory' ([1901] 1934, p. 167). According to Wicksell, the argument put forward by Ricardo is 'fundamentally the same reasoning as that with which Böhm-Bawerk proves ... that a rise in wages must lead to a lengthening of the period of production or of capital investment' ([1901] 1934, p. 168).

In his own analysis, Wicksell also adopted the 'induced technical change' scenario of Ricardo, Marx, and Böhm-Bawerk:

The technical possibility of all kinds of 'improvements' is very often already present, but the economic possibility is still lacking: the new 'labour-saving' machines or processes were invented long ago, but their application is not yet profitable. It is only when an increase in wages or a decrease of capital-interest has taken place, or because of other reasons, that this application becomes just profitable enough. (Wicksell [1893] 1954, p. 117)

The doctrinal roots of Wicksell's argument in Ricardo's reasoning also become visible from his remark that a lengthening of the period of production need not necessarily be associated with an increase in the *share* of wages:

In the case of a relative increase of the national capital the wage increases and the level of interest decreases. This circumstance is generally explained by the fact that, with increasingly capitalistic production, the workers' *share* in the result of the production

becomes greater and greater, whilst that of the capital becomes smaller and smaller. This, however, is not unconditionally true. It might very well happen that the workers, although they now have higher wages, nevertheless obtain a *smaller* share in the production, since its productiveness has in the meantime increased; or – which is the same thing – the share of the capitalists might be greater, although this share amounts to a smaller interest on the capital, which in the meantime has increased. (Wicksell [1893] 1954, pp. 138-9)

While he was thus clearly aware of Ricardo's concern with income *shares*, Wicksell failed to perceive the analytical role of Ricardo's new conceptualisation of wages and, like Böhm-Bawerk, did not adopt it in his own analysis of capital accumulation and growth. As we shall see below, things are similar with Hicks.

### (c) Hicks's analysis of induced technical change in the *Theory of Wages*

Before we discuss Hicks's treatment of induced technical change in chapter 10 of *Capital and Time* (1973), it is instructive to summarise briefly his earlier analysis of this phenomenon. The problem of induced technical change was addressed by Hicks as early as Chapter VI of his *Theory of Wages* ([1932] 1963), where he discussed the effects of 'economic progress' on *income shares*.<sup>9</sup> Hicks ([1932] 1963, p. 114) distinguished between four types of 'economic progress':

1. Increase in population
2. Increase in the ability or willingness to work of a constant population
3. Increase in capital
4. Inventions and improvements.

For Hicks, types 1, 2 and 3 can be treated symmetrically: The effects of an increase in the supply of a factor of production, i.e. of labour or of capital, on income shares can invariably be studied by means of the newly introduced concept of the 'elasticity of substitution', and the general rule is that<sup>10</sup>

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<sup>9</sup> Interestingly, Hicks motivated his concern with the effects of 'economic progress' on *relative shares* by making reference to Edwin Cannan (see Hicks [1932] 1963, p. 113). However, Cannan's focus on *relative shares* was clearly inspired by Ricardo's concern with the proportional distribution of income, as is immediately evident from his *History of Production and Distribution Theories* ([1893] 1967). In his early analysis of induced technical change in the *Theory of Wages* Hicks therefore adopted a conceptual framework – unknowingly, it seems – which was directly inspired by Ricardo's conceptualisation.

<sup>10</sup> On the origin and early development of the concept of the 'elasticity of substitution' see Garcia Molina (2005).

An increase in the supply of any factor will increase its relative share (i.e., its proportion of the National Dividend) if its ‘elasticity of substitution’ is greater than unity. (Hicks [1932] 1963, p. 117)

In his analysis of the effects of capital accumulation on relative shares Hicks allowed for the possibility of factor-price-change-induced substitution in both production *and* consumption.<sup>11</sup> Moreover, in Hicks’s understanding, ‘substitution’ can mean not only that ‘methods of production already known, but which did not pay previously, may come into use’, but also that ‘the changed relative prices will stimulate the search for new methods of production which will use more of the now cheaper factor and less of the expensive one’ ([1932] 1963, p. 120). Therefore, substitution ‘partly ... takes place by affording a stimulus to the invention of new types. We cannot really separate, in consequence, our analysis of the effects of changes in the supply of capital and labour from our analysis of the effects of invention’ ([1932] 1963, p. 120). Hence inventions, and in particular ‘induced inventions’ (see below), are seen as an inseparable element of the process of capital accumulation. It should also be noted that if we disregard ‘induced inventions’, then technical change in Hicks’s analysis of capital accumulation in the *Theory of Wages* need not necessarily exhibit a labour-saving bias.

In Section 3 of chapter VI of his *Theory of Wages*, Hicks introduced his famous tripartite classification of inventions, ‘according as their initial effects are to increase, leave unchanged, or diminish the ratio of the marginal product of capital to that of labour. We may call these inventions “labour-saving”, “neutral”, and “capital-saving” respectively’ ([1932] 1963, p. 121). Noting the differences between his own and Pigou’s classification, Hicks observed that ‘there is no reason to question his view that inventions have a decided bias in the labour-saving direction’ ([1932] 1963, p. 123). According to Hicks, the existence of this ‘decided bias’ can be explained as follows:

The real reason for the predominance of labour-saving inventions is surely that which was hinted at in our discussion of substitution. A change in the relative prices of the factors of production is itself a spur to invention, and to invention of a particular kind – directed to economising the use of a factor which has become relatively expensive. The general tendency to a more rapid increase of capital than labour which has marked European history during the last few centuries has naturally provided a stimulus to labour-saving invention. If, therefore, we are properly to appreciate the place of invention in economic progress, we need to distinguish two sorts of inventions. We must put on one side those inventions which are the result of a change in the relative

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<sup>11</sup> It was only in the revised version of Chapter VI in edition 2 that Hicks introduced the distinction between ‘substitution in consumption’ (‘Commodity substitution’) and ‘substitution in production’ (‘Technical substitution’); see Hicks (1963, pp. 298ff).

prices of the factors; let us call these “induced” inventions. The rest we may call “autonomous” inventions. We shall expect, in practice, all or nearly all induced inventions to be labour-saving. (Hicks [1932] 1963, pp. 124-5)

With regard to the combined effect of capital accumulation and (both induced and autonomous) inventions, Hicks noted that *rising real wages* can be associated with a *falling wage share*:

Increasing capital, accompanied by stagnant invention, may very well raise labour’s relative share in the Dividend; but increasing capital, with active invention, is very likely to do the contrary. And since the activity of invention is definitely favourable to the growth of the Dividend – and with few exceptions also favourable to growth in the real income of labour – it is highly probable that periods of most rapidly rising real wages will also be periods of a falling relative share to labour. (Hicks [1932] 1963, p. 130)

In his *Theory of Wages*, Hicks followed Ricardo in adopting a share concept of wages. However, the analytical purpose which the latter had served in Ricardo’s analysis of the accumulation process seems to have escaped Hicks’s attention. Moreover, the clear-cut distinction between induced technical changes in a given technical environment and technical progress proper was blurred with the introduction of the concept of ‘induced inventions’.

#### **(d) Hicks’s analysis of induced technical change in *Capital and Time***

In chapter 10 of *Capital and Time*, Hicks tackled the problem of induced technical change in the neo-Austrian framework. He contented himself with providing a rough sketch based on a graphical representation, without providing a full model. Since the analysis was conducted in terms of movements along the wage-profit frontier (see Hicks 1973, p. 112, figure 14), one might be inclined to suppose that attention focuses on a succession of long-period positions of the economic system under consideration. However, what Hicks sought to illustrate with the help of this diagram is what he called ‘substitution en route’, that is, the introduction of a different technique triggered by an increase in the wage rate that occurs in the course of the adjustment to a new technique, that is, along a (full employment) traverse path. Hicks’s conceptualisation can be briefly described as follows: The starting point is a situation in which an old technique is dominant. There is then introduced, at time 0, a new range of techniques, one of which is adopted, being the most profitable at the going wage rate. In the course of the transition from the old to the new technique, however, the wage rate changes, and as a consequence another technique becomes the most profitable. ‘Thus between time 0 and time  $T_1$ , newly started processes use the first technique, while there are (of course) old

processes that are still unfinished; while after  $T_1$  newly started processes use the second technique, while old processes and first new technique processes are still unfinished. At time  $T_2$  there is (or may be) a second such switch, and so on' (1973, p. 111). Hicks's analysis of induced technical changes in the context of traverse paths led to a rather paradoxical result, at least from a neoclassical point of view:

The function of substitution, in an expanding economy, is to slow up the rises in wages that come from technical improvement; but the effect of the retardation is to stretch out the rise, making it a longer rise, so that a larger rise, than would otherwise have occurred, is ultimately achieved. That is the Principal Proposition I am advancing in this chapter. It is surely an important proposition, perhaps the most important in all this book. (Hicks 1973, p. 115)

While there seems to be a close resemblance between Hicks's analysis and Marx's, there are some important differences. First, as we noted above, Hicks's argument is not developed in a proper long-period framework. Secondly, it needs to be stressed that in figure 14 the efficiency curves are drawn as straight lines, in spite of Hicks's earlier acknowledgement that this is not permissible even if 'Simple profile' techniques with the same duration are assumed (see Hicks, 1973, p. 41). Since in Hicks's neo-Austrian model the rate of profits tends to infinity as the wage approaches zero, the efficiency curves should have been drawn so as to approach asymptotically the ordinate. It would then have been apparent that Hicks was prevented from ordering the different techniques according to the maximum rates of profit associated with them. Finally, Hicks in *Capital and Time* employed the notion of a commodity wage rate (in contradistinction to his analysis in the *Theory of Wages*, where he had used a share concept of wages). But the concept of a commodity wage rate only makes sense in the analysis of technical change if one excludes the possibility that the available set of goods which enter into the workers' consumption basket can vary over time. Hicks does this in terms of his simplifying assumption of a single, homogeneous final output good that does not change over time.

## 9. Concluding remarks

In this paper we have tried to assess the *analytical* contributions of Ricardo, Marx, Böhm-Bawerk and Hicks to the theory of capital, accumulation, and growth. Confronted with the task of studying the evolution of a complex economic system, in which both the methods of production and the set of commodities change over time, Ricardo, Marx, and Böhm-Bawerk each forged some analytical devices by means of which they sought to come to grips with



such a system without assuming away its complexity. One such device was Ricardo's concept of 'proportional wages', which was adopted by Marx (and, more recently, by Sraffa), while Böhm-Bawerk and his followers failed to note its importance for the theory of capital, accumulation, and growth. On the other hand, Böhm-Bawerk's concept of the 'average period of production' was seen to be closely related to Marx's notion of the 'organic composition of capital' of the system as a whole, on which the maximum rate of profits depends.

In his neo-Austrian theory Hicks abandoned the concept of the average period of production and the associated notion of a maximum rate of profits of the economic system as a whole. In *Capital and Time* Hicks also no longer made use of the share concept of wages, which he had earlier adopted in his *Theory of Wages* (without showing any awareness of its analytical significance). He was able to operate instead with a commodity wage rate because the problem of output heterogeneity was set aside by means of his simplifying assumption of a single, homogeneous output.

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