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THE IMPORTANCE OF BÖHM-BAWERK'S THEORY OF CAPITAL AND INTEREST FROM A HISTORICAL PERSPECTIVE*

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This article argues that Böhm-Bawerk's approach has allowed the development of a powerful theory of capital and interest which has demonstrated under which conditions are valid the reasons for a positive interest rate. It has also led to general intertemporal equilibrium analysis and to a better analysis of the characteristics of balanced growth and of infinite horizon models than neoclassical theory; it has furthered the integration of the problems raised by innovation, limited resources and pollution; and it has inspired the construction of real business cycle models. Finally, the issue of whether Böhm-Bawerk belittled the merits of his precursors is discussed. The works of Turgot, Senior and Rae are analyzed with the result that since they lacked an adequate theory of utility and/or demand, much of Böhm-Bawerk's criticism is warranted.

1. Introduction

Eugen von Böhm-Bawerk's *Geschichte und Kritik der Kapitalzins-Theorien* was first published in German in 1884, his *Positive Theorie des Kapitales* five years later. Especially the latter, in which he expressed his own *Positive Theory of Capital*, was at the center of controversy from the very beginning, a controversy which was revived in the 1920s and 1930s, and again in the 1970s. Knut Wicksell expressed his positive evaluation as follows: "It may therefore justly be said that the work contains, albeit in a somewhat imperfect form, the real and definitive theory of capital ..." (Wicksell 1934, 171). Irving Fisher, though perhaps more critical than Wicksell, also appreciated Böhm-Bawerk's accomplish-

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ments: "Böhm-Bawerk presented the agio theory, or what is here called the impatience or time preference theory, clearly and forcibly, and disentangled it from the crude and incorrect notions with which it had previously been associated. It was only when he attempted to explain the emergence of this agio by means of his special feature of 'technical superiority of present over future goods' that ... he erred greatly" (Fisher 1930, 473-474). On the other hand, Gustav Cassel disagreed very much with Wicksell's positive opinion (Cassel 1903).

Recently Jürg Niehans also gave a somewhat critical evaluation of Böhm-Bawerk's merits. He mentions that Böhm-Bawerk's three reasons for the existence of interest (see below) became famous. But "There was not much originality in this list. All three factors had been mentioned by Menger, and all had a long history, which Böhm-Bawerk knew well (though he did not then know John Rae)" (Niehans 1990, 227). "The first part [of *Capital and Interest*] is a critical history of interest theories. It is a mine of information, but Böhm was much better at picking other contributions apart than in entering into their spirit" (Niehans 1990, 226). "In the ensuing controversy, Böhm-Bawerk revealed himself as clearly inferior to theorists like Wicksell, Alfred Marshall, and Irving Fisher" (228). But "At the same time, through his general equilibrium theory of interest, Böhm-Bawerk laid the basis for most of the important work in this field until far into the 1930s (...) theorists like Irving Fisher and Wicksell, though analytically his superiors, gratefully acknowledged their debt to him" (231).

Murray Rothbard (1987) follows Frank A. Fetter's (1902) critique of Böhm-Bawerk's third reason for the existence of a positive rate of interest, the greater productivity of more roundabout production processes, as resting on faulty arguments (645-646). But even more emphatically he states: "One of the notable injustices in the historiography of economic thought was Böhm-Bawerk's brusque dismissal in 1884 of Turgot's anticipation of his own time-preference theory of interest as merely a 'land fructification theory'" (645).

From these citations the reader gets a first impression of Böhm-Bawerk's accomplishments and shortcomings in his effort to build a theory of capital and interest. This paper shows how his integration of diverse ideas – which was at least partly present already in the earlier literature – into one coherent theory, proved to be the beginning of a fruitful development up to the present days. To the present author such a fecundity is the high mark of a successful scientific innovation. But the problems involved in this general approach were so complex that Böhm-Bawerk's analytical capabilities and inadequate knowledge of mathematics not only hindered him in completing his task but also led him to commit several mistakes (for a very careful and comprehensive evaluation see Hennings 1972). But even people with much greater analytical and mathematical powers like Wicksell, Irving Fisher and Stackelberg who developed further Böhm-Bawerk's work were not able to complete it. In several respects it has not even been completed today. Thus the Austrian Theory of Capital still remains controversial, though much of the resistance probably stems from the fact that many economists find it difficult to step out of the neoclassical paradigm.

In the following sections we will first state and discuss the validity of the three reasons given by Böhm-Bawerk for the existence of a positive real rate of interest (Section 2). Afterwards we shall take up some shortcomings of Böhm-Bawerk's approach and sketch the further development and generalization of his theory at the hand of his successors up to the present day (Sections 3 and 4). Finally we will ask whether Böhm-Bawerk gave sufficient credit to some of his most important predecessors (Section 5).

2. The Validity of the Three Reasons as an Explanation for a Positive Real Interest Rate

Böhm-Bawerk gave three causes for the existence of a positive real rate of interest:

1) It is expected that more goods are available in the future than in the present (Böhm-Bawerk 1959, vol. 2, 265-268).

2) "We systematically undervalue our future wants and also the means which serve to satisfy them" (268, 268-273).

3) The superiority of more roundabout methods of production (273-289).

Let us ask whether the first cause is sufficient to bring about a positive rate of interest. For the proof we assume an economy with only two individuals, both with an economic horizon of two periods, and both together expecting a greater supply of the only consumption good in the second compared to the first period, $C^0_{11}+C^0_{21}<C^0_{12}+C^0_{22}$. We also assume that no undervaluation of future wants is present, i.e., neutral time preference. In Figure 2.1, these assumptions are represented with the help of the so-called

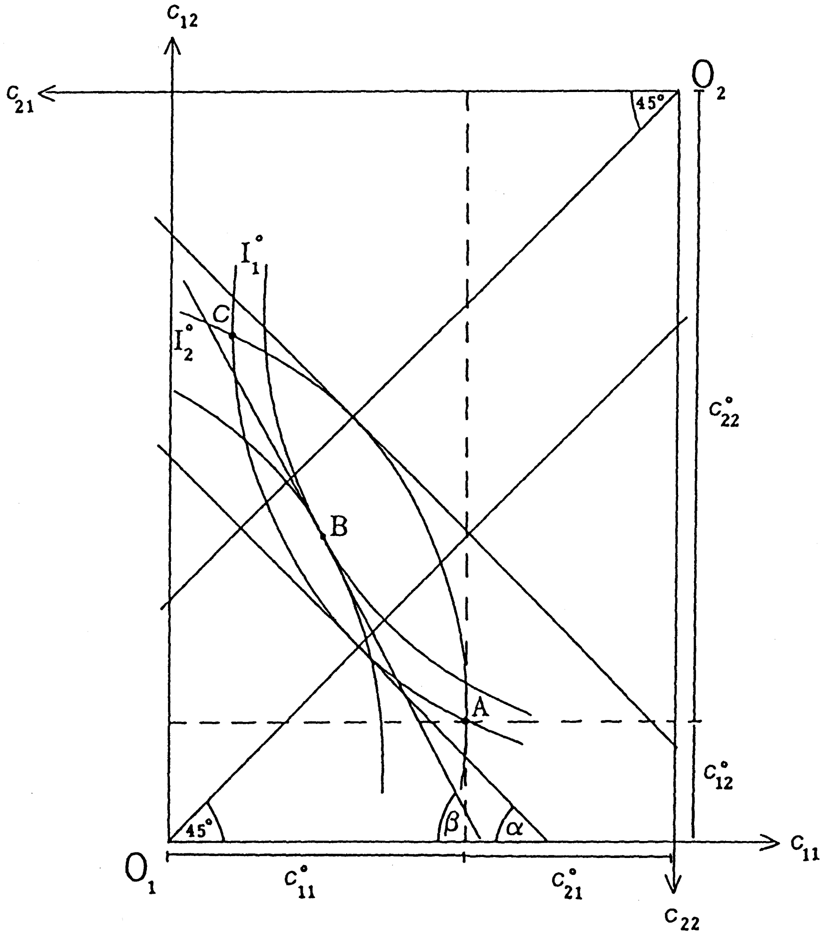

Figure 2.1

Edgeworth box. The amounts of the one (physically identical) consumption good, e.g., wheat, expected with certainty at the beginning of period 1 to be available before any exchange to consumer 1 (2) in periods 1 and 2, C^0_{11} and C^0_{12} (C^0_{21} and C^0_{22}) are measured from O_1 (O_2) to the right(left) and upward(downward). Their sums $C^0_{11}+C^0_{21}$ and $C^0_{12}+C^0_{22}$ are represented by the length and the height of the box, and thus the horizontal and vertical distances between O_1 and O_2. They give the total supplies of the consumption good in the economy in periods 1 and 2. The fact that the box has a greater height than length implies that more of the good is expected to be available in the future (period 2) than in the present (period 1), $C^0_{11}+C^0_{21}<C^0_{12}+C^0_{22}$. Point A shows the initial endowment of the two individuals before any (intertemporal) exchange.

Neutral time preference in Fig. 2.1 is reflected by the fact that the individual indifference curves are symmetric and have a slope of $tg\alpha=1$ at the respective 45° lines.

Now let us recall that A with (C^0_{11},C^0_{12}) and (C^0_{21},C^0_{22}) denotes the expected initial endowment with the consumption good in periods 1 and 2 for both consumers. Indifference curves I^0_1 and I^0_2 pass through this point. Both consumers can improve their positions by a mutual exchange moving them to a point like B, situated within the area limited by these indifference curves. A Pareto-optimal position will be reached by selecting any point at which two indifference curves are tangent to each other, as is the case in point B. The slope of the tangent in B describes the relative price at the equilibrium position. Since in our case, the consumption good of period 1 is exchanged against the consumption good of period 2, a commodity loan is given by consumer 1 to consumer 2. The relative price at B is thus $tg\beta=\frac{1+r}{1}$, where r is the real or own rate of interest. r is positive if $tg\beta>1$.

Now the slopes of the indifference curves at the respective 45° lines passing through O_1 and O_2 are $tg\alpha=1=tg45°$. Relative to the C_{11}-axis the indifference curves of the first(second) consumer become steeper(flatter) the bigger C_{12} is. This means, however, that tangency of indifference lines can only occur between the two 45° lines. But this implies $1+r=tg\beta>tg\alpha=1$ and consequently

$r>1$. Thus we have proved that in the equilibrium reached by exchange the real or own rate of interest is positive. This result is not dependent on the initial endowment, as can be seen by moving A to different positions. Even if it were such that no exchange would take place, and thus A be identical with B, a positive rate of interest would be implied.

Also, the greater amount of the consumption good in period 2 is the only reason for the positive rate in Fig. 2.1. By removing the former and thus by equalizing the length and height of the Edgeworth box, we get a zero rate of interest. For in this case the two 45° lines through O_1 and O_2 merge into one line (like in Fig. 2.2), and equilibrium point B is located on this very line where the indifference curves of both individuals have a slope of $tg\alpha = 1 = 1 + r$ because of the assumption of neutral time preference. Böhm-Bawerk's first reason is thus sufficient for the existence of a positive (own) rate of interest.

Our argument can easily be generalized to m consumption goods, n consumers and to a s-period horizon, though this would have to be done analytically. But the story does not end here. Two questions in particular are left unanswered: First, why should there always be a greater expected supply of goods for the future? And second, would the first cause be sufficient to explain a positive interest rate in a stationary state?

Böhm-Bawerk's answer to the first question, that goods can always be stored in the present for the future but not vice versa, is not really convincing since storing costs are not negligible, provided that storing is at all possible (Wicksell 1934, 170). But we can add, as another answer, that the third cause, to be discussed below, brings about a greater future supply of goods and thus works through the first reason to establish a positive interest rate.

Concerning the second question, it seems obvious that a greater supply of goods in the future cannot be assumed for a stationary state, so that the first cause cannot explain a positive rate of interest in such conditions.

Let us next turn to the second cause given by Böhm-Bawerk, namely the systematic undervaluation of future as compared to present wants, i.e., impatience, or time preference, as Irving Fisher called it (1930).

In Figure 2.2 positive time preference has been introduced into our two-consumer, two-period horizon model by assuming that for individual i intertemporal utilities are such that $U_i(C_{i1},C_{i2})>U_i(C_{i2},C_{i1})$ (i=1,2), if $C_{i1}>C_{i2}$. This implies that indifference curves are now (absolutely) steeper than tgα=1 at the 45° line. To remove a greater expected future supply of goods the box is now a square, i.e., $C^0_{11}+C^0_{21}=C^0_{21}+C^0_{22}$. Instead of two 45° lines only one through the two origins remains. Let the initial endowment be given by A. Then B is a possible (Pareto-optimal) equilibrium point after exchange has been completed. Now, as seen from the C_{11}-axis the indifference curves of consumer 1 have to be (absolutely) steeper than tg45° = 1 on and above the 45° line whereas those of consumer 2 have to be steeper on and below this line. Thus at any equilibrium point like B within the area enclosed by I^0_1 and I^0_2 the tangent to the two indifference curves touching each other has to be absolutely steeper than 1. Thus

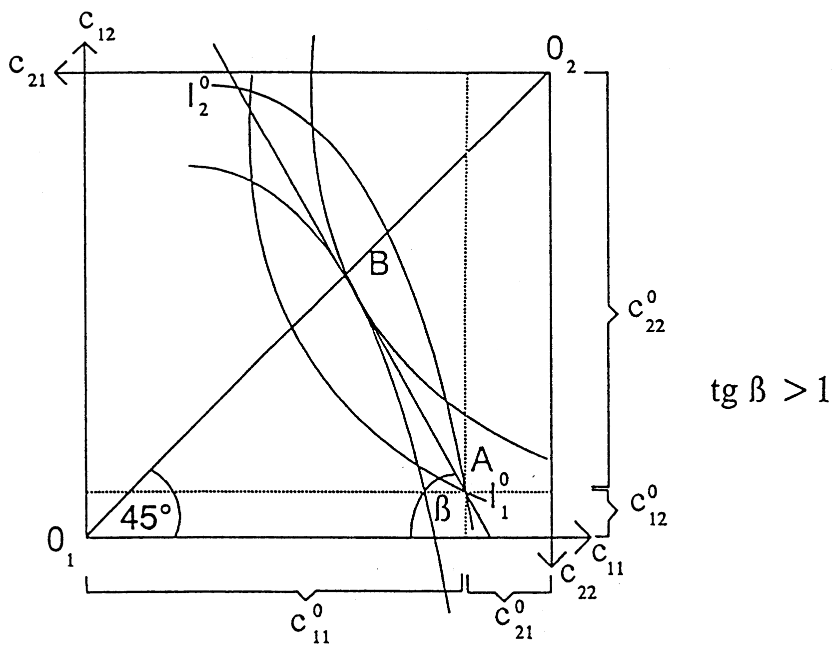

Figure 2.2

tgβ=1+r>tg45° = 1, r > 0. Again, this time the *second* reason is sufficient to bring about through mutual exchange a positive rate of interest in equilibrium. And this time, the argument is valid for a stationary state of the economy, since no greater (expected) future than present supply of goods was assumed. In this case, then, only the assumption of impatience may be doubted and empirically tested. Though most economists had no such doubts, some were of a different opinion. Thus Böhm-Bawerk's brother-in-law Friedrich von Wieser observed: "One may thus say that it is a sound maxim among all peoples of normal development to appraise alike the present and the future" (Wieser 1889, 17).

Let us finally take up the third and most controversial reason given by Böhm-Bawerk for a positive rate of interest, namely the greater productivity (or superiority) of more roundabout production processes. In Figure 2.3 a whole economy with a representative individual, or if you prefer, a central planning agency (following the convenient simplification introduced by Hayek 1941) is

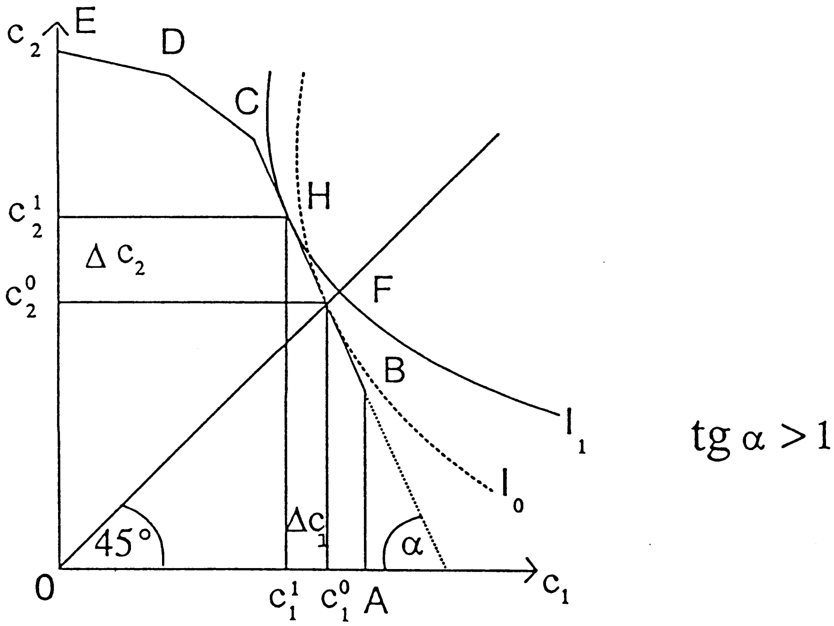

Figure 2.3

considered. We still use the assumption of a two-period economic horizon and postulate an initial stock of capital good(s)≥ 0 (in Figure 2.3 it is assumed that it is greater than zero). The intertemporal utility function is again represented by indifference curves I_0 and I_1. I_1 reflects an assumption of neutral time preference, I_0 of impatience to consume. A B C D E is the transformation curve limiting the feasible set of production plans of the whole economy, O A B C D E, from above and to the right. B C D E is the set of efficient production plans. A B C D E can be derived from linear production processes producing the only homogeneous consumption good and one or more capital goods used to produce the consumption good. These processes are grouped into several more or less time-consuming production technologies, each of which can be employed to produce the consumption good. Thus greater or smaller future quantities of the good can be produced depending on the relative extent to which the more productive and more time-consuming and the less productive and less time-consuming production technologies are applied (compare Bernholz 1971 for a simple model of this kind). Note that the transformation curve is absolutely steeper than 45° ($\alpha > 45°$) between B and C, reflecting the superiority of more roundabout processes. The production processes are superior since for each unit of C_1 foregone more than one unit of C_2 is gained. They are longer since some consumption in period one has to be postponed to be able to reach a higher consumption in period two.

The transformation curve has to be vertical between A and B, since resources of the second period cannot be used to produce the consumption good of the first period. It is only possible to do so as far as existing machinery, stocks and buildings are used up without replacement and/or repair. Because of this option, line CF extends beyond the 45° line to B. FB corresponds to the wear and tear of such resources for producing the present consumption good and/or of the resources which would be necessary for repairs and replacement.

Note also that if F is selected, everything would be maintained or replaced and consumption would be the same in both periods with $C_1^0 = C_2^0$. With indifference curve I_0, which implies a sufficiently strong impatience, stationary state F would thus be realized with a positive rate of interest $tg\alpha=1+r>tg45°=1$. We know already that impatience is sufficient to explain a positive rate of interest under stationary conditions in a pure exchange economy. If, however, time-consuming production is taken into account as in Figure 2.3, then neither impatience nor superiority of more roundabout production processes are sufficient to explain a positive rate of interest *for a stationary state.* Indeed, both reasons together are necessary and sufficient in this case. Without impatience no stationary equilibrium but one with positive growth would exist (point H in Figure 2.3). And without superiority a shrinking economy would be the outcome. For with a slope of BC $tg\alpha\leqslant1$ and impatience not F but B would be selected.

Is the greater productivity of more roundabout production processes sufficient to explain a positive real rate of interest? It is, but, according to Fig. 2.3, only for a growing economy. This becomes obvious if we introduce indifference curves like I_1 with neutral time preference. Then the only equilibrium is H with positive savings and net investment $-\Delta C_1$ and with production and consumption increasing by $\Delta C_2>-\Delta C_1$ compared to the stationary state.

It has been rightly argued that the third reason given by Böhm-Bawerk is not sufficient to explain the existence of a positive rate of interest (Fisher 1930, pp. 473-485; Bortkiewicz 1906, p. 951; Blaug 1985, p. 304 ff.). For, in a stationary state the second reason is necessary to bring about the latter. And in the case of a growing economy the third reason, superiority of more roundabout production processes, works via the first reason, greater availability of goods in the future, since the latter is the consequence of the greater productivity of more roundabout processes characteristic of growing economies.

It is true, however, that the first and the third reason can be combined in a life-cycle model to explain a positive real rate of interest in a stationary state. And in this case the first reason does not imply, like in Figure 2.1, a better supply of goods in the future than the present for the whole economy (Arvidson 1956, pp. 23-33; Negishi 1989, 301 ff.). In this sense, the first reason is not needed and the third reason is sufficient for a positive rate of interest. But in this model of overlapping generations "individual members of the economy" have "rising incomes" (Negishi, p. 301) and in this interpretation the first reason must still be present.

An extension of the ideas of Figure 2.3 allows us to take into account Schumpeter's (1934) insistence that the real rate of interest has to be zero in a stationary state. Let us assume that the work force is constant, but that growth is going on in our two-period horizon model. The plans of the representative individual or central planning agency are redrawn whenever another period has passed (Figure 2.4). For simplicity, however, it is now assumed that the (linear) transformation curve of period one is described by $A_1B_1C_1D$. C_iD is horizontal, since at C_i (i = 1, 2, ..., n) all the (constant) labour force is supplied with the most superior production technology.

We consider a time span t=1, 2, ..., n. In the first period F_1, with (C^1_1, C^1_2), is planned as a production and consumption plan. After one period has elapsed, we set t=2 and t+1=3. Because of the net investment of the first period the transformation curve has now shifted to the right in a parallel fashion. For since the set of

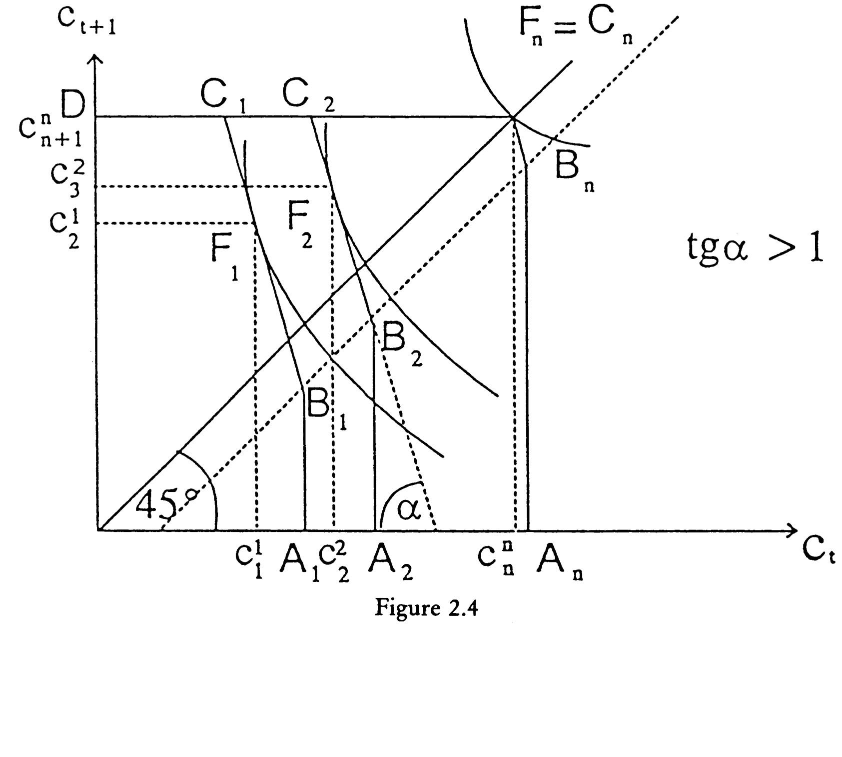

Figure 2.4

available processes has not changed tgα remains the same. But $\overline{B_2C_2} < \overline{B_1C_1}$, because the use of the superior technology can now be extended after constructing the capital goods necessary to apply it on a greater scale. The size of the shift of the transformation curve is given by $\overline{A_1A_2}$, where $\overline{OA_2}$ is C^1_2, the output and consumption planned at the beginning of period 1 for the second period.

With the 3rd period within the economic horizon, plans are now revised to (C^2_2, C^2_3) corresponding to F_2. After period 2 has elapsed, t=3, and the transformation curve has moved to the right again, plans are revised, etc. Note that $\overline{B_tC_t}$ becomes ever shorter until it is equal to $\overline{B_nF_n}$ in F_n, i.e., $C_n=F_n$. This means that more and more and finally, in the n-th period, all available labour is employed in the most superior production technology. But then net investment stops, for no more of the capital goods belonging to this superior technology could be used, since all labour is already employed by it. Now, from the above analysis, during the growth process in periods t=1, 2, ..., n–1 the real interest rate is positive because of the greater productivity of more roundabout production processes, even if time preference is neutral or (not too) negative. But at t=n a stationary state is reached and the interest rate becomes zero with neutral time preference. New growth and positive real interest can thus only be maintained if new inventions discover even more superior technologies which can be introduced. Thus Schumpeter's (1934) insistence on the importance of invention and innovation can in this respect be modelled within the Böhm-Bawerkian framework. And it follows that he is partly right concerning a zero rate of interest under stationary conditions (p. 175). For if the most superior production technology known has been introduced, the rate of interest becomes zero if time preference is neutral, but not otherwise. And it should be recalled that Schumpeter rejects the second reason (p. 158).

Note also, that this theoretical framework supports innovations far better than neoclassical capital theory. An invention adds at least one new feasible production process to the set of processes available before and thus adds a new production technology for an already existing or a newly invented good. This usually leads to a new production possibility frontier and thus changes the rate(s) of interest and relative prices. In the simple setting of Fig. 2.4 with only one (physical) consumption good, the transformation curve B_kC_k may be changed in period $k \leq n$ and lengthened beyond DC_n. The latter happens, if more of C^n_{n+1} than OD could now be produced with the newly invented technology. Innovation would take place if the new were more profitable than some old technology. Since in general (a) new capital good(s) has(have) to be formed in the innovative process, the time span would extend until a stationary state with interest rate(s) zero (corresponding before the invention to C_n in Fig. 2.4) were reached.

3. Generalizations and the Neoclassical Theory of Capital and Growth

We show first that the theorem derived in the neoclassical theory of balanced growth, namely that the real rate of interest is greater than or equal to the growth rate (for a very general demonstration see Gale and Rockwell 1975, p. 347), can be easily explained within the Böhm-Bawerkian framework. It becomes also clear that the assertion of Gale and Rockwell (p. 347) is not true that roundabout methods of production or impatience "are probably not the essential ones. Thus, even in a world using only direct rather than roundabout methods and made up of patient rather than impatient consumers, it would still be true that efficient competitive programs would exhibit positive interest rates".

It has been shown in the last section that superiority of more roundabout production processes and neutral time preference or impatience imply a positive real interest rate and net investment, and thus a growing economy. This proposition can be turned around: an efficient growing economy implies net investment and, thus, together with neutral time preference or impatience, it implies the presence of superior roundabout production processes. It is obvious that this is also true for the special case of balanced growth (Bernholz, Faber and Reiss 1978).

Next let us turn to the theorems that in non-golden rule balanced growth the real interest rate is greater than the growth rate, whereas in golden rule balanced growth the interest rate is at least equal to the growth rate (Gale and Rockwell 1975, 1976; Atsumi 1980).

The fact that these theorems can be derived without using the assumptions of superiority of more roundabout production processes and/or impatience does not imply that the latter are not necessary conditions for the validity of the two theorems. One might already suspect this from the proposition just mentioned. But, as will be shown subsequently, neutral time preference and superiority are necessary conditions for the second theorem; and impatience and superiority have to be implicitly assumed for the first theorem to be valid (for a formal proof of these propositions see Faber and Stephan 1986).

It should first be recalled that in balanced growth all absolute magnitudes increase with the same constant growth rate g, whereas relative magnitudes remain constant. Thus denoting the number of workers (or of the population) in period i (i = 1, 2, ...,) by n_i we have $n_{i+1}=(1+g)n_i$. For total consumption and production of the consumption good alone we get similarly $c_{i+1}=(1+g)c_i$. It follows that $c_{i+1}/n_{i+1}=c_i/n_i$, i.e., per capita consumption and production remain constant.

Now consider Figure 3.1, which is similar to Figures 2.3 and 2.4 with one important difference. On the axes we now substitute per capita consumption and production $a_{t+1}\equiv c_{t+1}/n_{t+1}$ and $a_t\equiv c_t/n_t$ which are planned for the future periods t + 1 and t.

In Figure 3.1, A B C D E denotes the transformation curve, but now per capita, of the economy for the case of golden age balanced growth. C denotes consumption and production $a^0_{t+1}=a^0_t$ in balanced growth. BG and HJ represent the additional consumption per capita which would be possible in periods t and t + 1, respectively, if net investments necessary to supply the additional number of workers gn_t and gn_{t+1}, in the following periods, with the same capital goods, and if necessary reinvestments were not undertaken. Given the assumption of golden age balanced growth, production possibilities are such that per capita consumption cannot be raised permanently to a new path of balanced growth by foregoing consumption, in, say, period t for investment to reach a higher level $a_{t+1}=a_{t+2}=a_{t+3}=...$ in the following

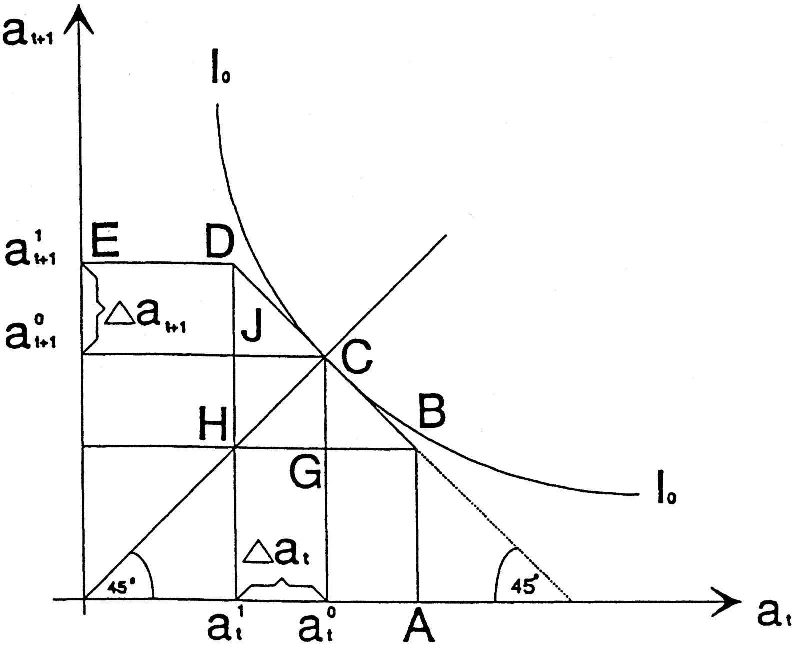

Figure 3.1

periods. This means that the transformation curve in Figure 3.1 must have an absolute slope of tg45° = 1, and that $\overline{BH} = \overline{HD}, \overline{GH} = \overline{JG}$. Note that for all other pairs of future periods the same must be true for the respective transformation curves.

Indifference curve I_0I_0 touches the transformation curve BD in point C. It is thus the only indifference curve allowing golden age balanced growth. Note that in drawing this indifference curve, we have assumed a utility function of the representative individual of the form

$$U = U(a_1,a_2,a_3,\ldots,a_t,a_{t+1},\ldots)$$

with the usual characteristics. This means that the representative individual is only concerned with per capita consumption in all future periods at time zero (or similarly later), but not with $n_ia_i=c_i$ (i=1,2,...), i.e., with total consumption in the economy.

Granted this assumption, it follows immediately that neutral time preference is a condition for golden age balanced growth, since the absolute slope of I_0I_0 in C and thus on the 45° line from the origin has to be one.

Before turning to the two theorems of balanced growth theory mentioned, let us discuss the per capita transformation curve K L F M for non-golden age balanced growth (Figure 3.2). In this case, LF is absolutely steeper than 45°, so that $tg\alpha > 1$. For the available technology must be such that by foregoing consumption per capita, for example, in the amount of Δa_t in period t and investing instead, it must be possible to produce a greater additional amount per capita Δa_{t+1} in period t + 1, which can be partly used for consumption. The other part would be saved in period t + 1 to be invested, such that per capita consumption in all future

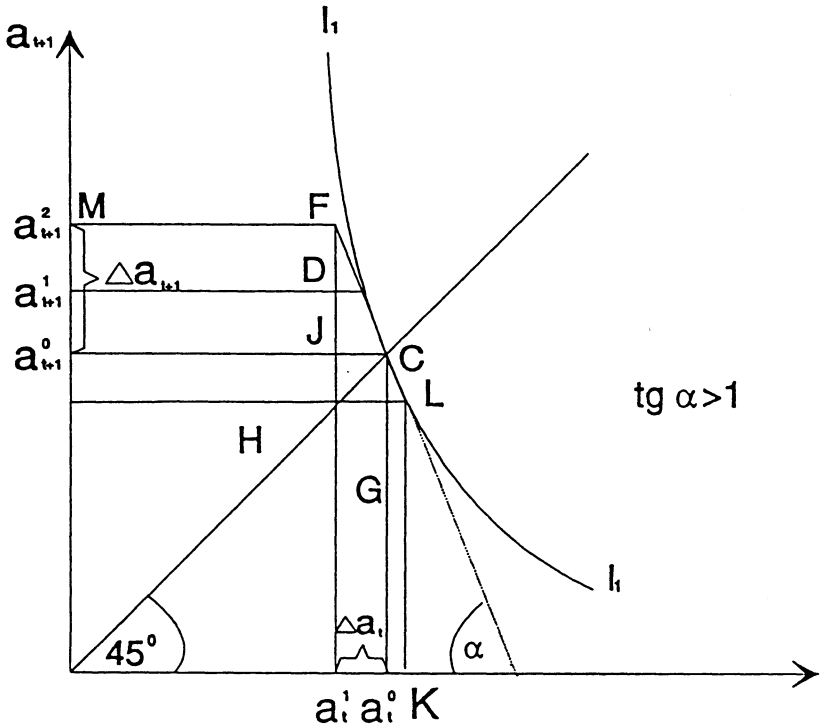

Figure 3.2

periods would reach the same higher level. Thus for the new balanced growth path $a^0_{t+1}=a^0_{t+2}=a^0_{t+3}=...>a^0_t$ of the old path.

To maintain the old non-golden age balanced growth path, $a^0_{t+1}=a^0_t$ has to be realized in point C of Figure 3.2. But since the per capita transformation curve is absolutely steeper in C than 45°, only indifference curve I_1I_1 can bring about C. This means that impatience or positive time preference is a condition for non-golden age balanced growth, since the absolute slope of I_1I_1 is greater than one at C on the 45° line out of the origin.

Let us now turn to the two theorems, to superiority of more roundabout production processes and the derivation of the rate of interest. In doing so we discuss both cases of balanced growth together (Figures 3.1 and 3.2). For equilibrium point C we have:

$$(3.1) \qquad \frac{\Delta a_{t+1}}{\Delta a_t} = \frac{a^2_{t+1}-a^0_{t+1}}{a^0_t-a^1_t} = \frac{da_{t+1}}{da_t} \leqslant tg\alpha = 1,$$

with $a^2_{t+1} \geqslant a^1_{t+1}$. Strict equality holds only for $a^2_{t+1}=a^1_{t+1}$, that is for golden age growth (Figure 3.1). $\frac{da_{t+1}}{da_t}$ denotes the slope of the indifference curve.

Since

$$a_1 = \frac{C_i}{n_i}$$

we derive

$$(3.2) \; \frac{n_t}{n_{t+1}} \frac{\Delta C_{t+1}}{\Delta C_t} = \frac{n_t}{n_{t+1}} \frac{dC_{t+1}}{dC_t} \geqslant tg\alpha = 1$$

with $\Delta C_{t+1}=C^2_{t+1}-C^0_{t+1}$ and $\Delta C_t=C^0_t-C^1_t$.

We recall that $n_{t+1}=(1+g)n_t$ and from Section 2 that in equilibrium $\frac{\Delta C_{t+1}}{\Delta C_t} = 1+i$. Then it follows

$$\frac{1}{1+g}\,\frac{\Delta C_{t+1}}{\Delta C_t} = \frac{1}{1+g}(1+i) = \frac{1}{1+g}\,\frac{dC_{t+1}}{dC_t} \geqslant 1 \text{ or}$$

$$(3.3) \qquad \frac{\Delta C_{t+1}}{\Delta C_t} = 1+i = \frac{dC_{t+1}}{dC_t} \geqslant 1+g.$$

Thus we have shown that

$$(3.4) \qquad \Delta C_{t+1} \geqslant (1+g)\Delta C_t \text{ and}$$

$$(3.5) \qquad i \geqslant g.$$

The equality in (3.4) and (3.5) holds only if $a^2_{t+1}=a^1_{t+1}$, since $a^1_{t+1}-a^0_{t+1}=a^0_t-a^1_t$. It follows then, from (3.5), that $i > g$ for non-golden and that $i = g$ for golden age balanced growth. But we also notice from (3.4) that $\Delta C_{t+1}>\Delta C_t$ in both cases of balanced growth, which means that superiority of more roundabout production processes is present. In golden age growth, the superiority is just sufficient to maintain the growth rate g. The degree of superiority is $(1 + g)$, whereas in non-golden age growth it is greater and thus would allow a new balanced growth path with higher per capita production and consumption.

As shown above, neutrality of (a positive) time preference is necessary to maintain the present balanced growth in golden (non-golden) age. Thus we have proved that:

1. Neutrality of time preference and an adequate superiority of more roundabout production processes are necessary conditions for golden age balanced growth and for the equality of growth rate and interest rate.

2. Impatience and a greater superiority of more roundabout production processes are necessary conditions for non-golden age growth. They together determine $i > g$.

We can now also conclude that the stationary states discussed by Böhm-Bawerk and Schumpeter (Section 2) are just special cases of golden and non-golden age balanced growth with $g = 0$. For then it follows from (3.4) and (3.5) that

(3.4a) $\Delta C_{t+1} \geqslant \Delta C_t$ and

(3.5a) $i \geqslant 0$.

Thus in the Schumpeter, in contrast to the Böhm-Bawerk stationary state, no superiority of roundabout production processes is present and the interest rate is zero.

We have to mention some other extensions of the Böhm-Bawerk framework. First the two-period horizon approach discussed in the last section has been extended to several consumption goods, which can also serve as intermediate goods, and to several capital goods and primary factors, without affecting the results (Bernholz, Faber and Reiss 1978). Note that the use of consumption goods as intermediate goods takes into account the "putting back" (*Rückversetzung*, Eucken 1936) of goods to 'higher' stages of the production hierarchy, i.e., the circularity of production which is often characteristic of it: steel is used in producing coal and coal is used in producing steel, etc. The theory has also been generalized by extending the economic horizon to T periods by Reiss and Faber (1982) in a general multisector model with convex production instead of a linear production technology. Here, however, own rates of interest need not be positive in *all* periods for *all* goods as a consequence of the presence of more roundabout superior production technologies. But they have to be positive for all goods in at least one period, though not the same.

Finally, the theory has been extended to infinite horizon models (Stephan 1983, 1985). It is known that efficiency prices in multisector models with infinite horizons pose additional problems compared to models with finite horizon. These problems have been solved by neoclassical economists by making different additional assumptions to secure the existence of efficiency prices for each period (see Peleg and Yaari 1970, for an overview). Here I will only discuss one of these assumptions, non-tightness (Kurz 1969, Stephan 1983). Non-tightness "requires that in each period the total output of production can be increased by increasing the stocks of capital goods and leaving the amount of primary goods unchanged" (Stephan 1986, p. 139). This assumption is not very appealing to economic intuition. It is too strong since it postulates that "more capital intensive is more consumption productive». Also the assumption "is not fulfilled in models with polyhedral technologies such as those of Leontieff or von Neumann" (see Kurz 1969, p. 139), i.e., with linear production processes. Now Stephan (1983, 1985, 1986) has demonstrated that non-tightness implies roundaboutness and that patience and superiority of roundabout production imply efficiency prices and also so-called Malinvaud prices. But roundaboutness makes more sense intuitively and includes more cases, especially linear technologies. Thus, in infinite horizon models the Böhm-Bawerkian approach is superior to the neoclassical approach which is, however, included as a special case.

4. The Time Structure of Capitalistic Production

As I see it, Böhm-Bawerk's most important contribution is his stress on the time structure of capitalistic production. Though his own analysis was certainly inadequate, the problems involved are so complex that they have not been fully understood or even solved until now. Böhm-Bawerk made clear that production is a process in time in several respects: the construction of capital goods needs time, the production of consumption and of capital goods with the help of machines, tools and buildings requires time and capital goods (including durable consumers goods) can be and are used in production (or consumption) for years.

The time structure of the production process was in Böhm-Bawerk's thinking intimately connected with the third reason for a positive rate of interest. But the problems involved were beyond his analytical skills, a fact exacerbated by his dislike of mathematics. Briefly, Böhm-Bawerk tried to express the time dimension of production by creating an index, the average period of production. He obviously thought this necessary for his third reason, since he found no other way to measure the length of the production processes, to formulate his law of the greater productivity of more roundabout production processes. But the concept of an average period of production leads to insurmountable difficulties (Faber 1979, 29-33; Morgenstern 1935; Kaldor 1937) similar to those of the concept of capital in terms of an aggregate value (but see Reetz 1971, von Weizsäcker 1971, Orosel 1979). If several final consumption goods are considered, weighing by prices becomes necessary. Also if such goods are produced or their services delivered in different periods the rate of interest has to be used to calculate the average period of production. But the rate of interest is supposedly determined by using the average period of production. And present prices of the same good at different periods are also related through the rate of interest. Moreover, the average period of production is not necessary to define longer production processes (see e.g., Bernholz, Faber, Reiss 1978; Jaksch 1975). It even detracts from the time structure of production.

We conclude that Böhm-Bawerk opened our eyes to the importance of time in capitalistic production but faltered in inadequately analyzing the complex problems involved. He had the right intuition, but better analysis and the further development of mathematical economics were needed to work out its implications. Wicksell (1954/1893) and Fisher (1930) used their superior mathematical skills to deduce some of them. But Wicksell limited himself to the point input-point output case and assumed a stationary state and Fisher in his general theory removed the complexity of capitalistic production by considering only the shape of income streams over time instead of taking into account the time structure of production and the composition of capital goods given as a heritage of the past in any initial position. Wicksell's student Gustaf Akerman (1923-24) tried to handle the difficult problem of durable capital goods, influenced by the earlier work of John Rae (1834). There is no doubt that he made remarkable progress in solving this point input-continuous output problem, as testified by Wicksell's review article (1923) which also put the theory into a more readable mathematical formulation. Akerman's accomplishment, like Stackelberg's (see below) later, was thus to take into account the use of durable capital goods in production.

Next I would like to mention Walter Eucken (1954) who was probably the first to introduce "Rückversetzung" (backwardation), i.e., the circular character of much of capitalistic production in verbal form, though Strigl (1935, p. 210) had already referred to it implicitly. Strigl, in the same article, tried to work without a period of production. He accomplished this by analyzing a lengthening (or shortening) of the time during which original factors of production are bound (of their "Bindungszeiten") until they mature into consumption goods. It is also interesting to note that he asserted that superiority of more roundabout production processes follows from the existence of a positive rate of interest (p. 217). Obviously this assertion is true, if neutral time preference and investment are assumed, too, as can be seen from our deliberations in Section 2.

Stackelberg took all these different threads of development into account in his important though widely unknown article "Kapital und Zins in der stationären Volkswirtschaft" (1941-42). He constructed four mathematical models beginning with the simplest model structure, point input-point output, then taking up continuous input-point outpoint, point input-continuous output and finally, continuous input-continuous output. So he developed the theory much further than even the later model by Dorfman (1959). But unfortunately he stuck to the stationary state and used the average period of production, though in a sense only as a measuring device. It is true, however, that Stackelberg, in his dynamic model, took into account savings and net investment (1941). But since he made savings dependent only on national income, he did not elaborate the consequences of superiority of roundabout production *and* time preference on interest rate, consumption and investment. (For the most recent review of Stackelberg's work see Möller 1993, Niehans 1992).

The further development of the time structure of capitalistic production had to wait until new theories like input-output analysis, activity analysis, the von Neumann growth theory and nonlinear programming had been introduced. Influenced by the thus available techniques and by Hayek's (1941) proposal to use the (unrealistic) simplifying assumption of fully informed central planning over several periods to tackle the complex problems of capital theory, Bernholz (1971) constructed a simple two-period horizon model with three linear production processes combined into two production techniques each producing the same consumption good. In this model a central agency maximizes an intertemporal utility function over two periods. More importantly, the only durable capital good can be available in any amounts initially. Thus no stationary equilibrium is required. The "longer" production technique and its superiority is defined without using the period of production. In this setting, a positive real rate of interest is derived from the dual solution of the planning problem, given neutrality of time preference or impatience and the greater productivity of more roundabout production processes.

It is true that this model, because of its simplicity, would, by itself, not have been too important. But as expected, it turned out that it could be extended to include many consumption, durable and non-durable capital goods and economic horizons extending over several periods (Bernholz, Faber and Reiss 1978; Jaksch 1975 and 1975a; Reiss 1979; Reiss and Faber 1982). The model could also be used to bring in explicitly production processes producing waste or using exhaustible resources (Maier 1984). On the basis of such models Faber, Niemes and Stephan (1983a) developed an interdisciplinary approach, based on the entropy law, to analyze the long-run effects of environmental problems and of resource extraction. The approach has also been used for empirical field studies of water quality management (Faber, Niemes and Stephan 1983b, Stephan 1989). Finally, the irreversible nature of the time structure of environmental and resource processes can be explicitly considered in this framework (Faber and Proops 1985; Faber and Wagenhals 1987).

Let me finally mention the potential of the Böhm-Bawerkian framework for business cycle theory. Planning by economic agents has to be revised again and again because of unforeseen developments, among them inventions of new superior, shorter or longer production technologies. But capital goods like tools, machines, buildings etc. can only be used to produce one or a few consumers and/or capital goods. Thus, unexpected developments may change their value, make them obsolete or require their substitution by newly innovated superior production processes. As a consequence a strong investment push may take place heating up the economy and changing the time structure of production and the composition of capital goods. After some time, feasible net investments may decrease because the substitution of capital goods has been virtually completed. But even then, echo effects have now been built into the age structure of capital goods which in time lead to new swings of the business cycle. Theories along this line were first developed by Hayek (1929, 1934; see also Strigl 1934, pp. 34-41)) and Stackelberg (1941). The latter, in fact, developed a mathematical theory of the business cycle based on the – "non-plasticity" of capital goods. Unfortunately, he still used the period of production in his approach. Wenig (1982) gave up this limitation and presented an interesting mathematical approach to the dynamics of the business cycle based on Hicks's (1973) earlier work. In two further papers, he and Thalenhorst (Thalenhorst and Wenig 1984) employed the Austrian model of capitalistic production with an explicit description of the time patterns of inputs and outputs to reformulate mathematically Hayek's earlier work.

5. Böhm-Bawerk and his Evaluation of the Work of his Precursors

In this Section we propose to evaluate whether or not Böhm-Bawerk's attitude towards his precursors was too critical. We begin by presenting some evidence from the writings of three of the most important contributors among them and by confronting them with Böhm-Bawerk's critique. Subsequently we will stress the differences which may explain the position of the latter.

It has already been mentioned (Section 1) that many economists were and are critical of what they thought was an inadequate and too critical assessment of the work of his precursors by Böhm-Bawerk. Edgeworth's opinion was not untypical (1890, p. 462):

> "It appears to be the motive of this 'Critical History of Economic Theory' to prove that all preceding economists have gone astray, and fallen short of the glory which we fully concede appertains in a special degree to Prof. Böhm-Bawerk as the formulator of the true theory of interest".

And indeed

> "from Thünen came the idea of marginal productivity and the notion of a production function; Rodbertus provided much of Böhm's theory of capital. Moreover, the fundamental idea of the influence of time on the evaluation of goods came from Turgot. Böhm's theoretical endeavour is therefore best described as an attempt to integrate via the element of time he had taken from Turgot, Thünen's analysis of production and Rodbertus's view of the role of capital into the theory of value he had learnt from Menger and the Continental tradition.
>
> At a later stage, Böhm clearly learnt much about the structure of his work from Edgeworth, Marshall, Clark and Fisher, whose critiques and critical objections prompted him to elaborate and to clarify several aspects of his thought. The rediscovery of John Rae's *Statement of Some New Principles* had a similar effect" (Hennings 1972, pp. 311 ff.).

I think that this evaluation by Hennings as the conclusion of his careful work on Böhm-Bawerk should be accepted. Böhm-Bawerk was probably too critical of his precursors on whose original ideas he built. But his critique was written not as a history of economic ideas on capital and interest, but rather as a preparation of his own "positive" theory. Also since subjective value theory had been developed only recently and thus had not been applied to the problems of intertemporal production and consumption, to interest and the time structure of capital goods, Böhm-Bawerk probably felt that his critique was warranted. Finally, there can be no doubt that he was the first to integrate the diverse original ideas of his precursors into a general intertemporal theory, so that from this vantage point their accomplishments seemed to be smaller to him than to his critics, who perhaps interpreted too much into this earlier work after having studied Böhm-Bawerk's theory.

It may be useful to provide the reader with some quotations from the work of Turgot, Senior and Rae so that he can judge for himself to what degree Böhm-Bawerk's theory is already contained in the works of his precursors. Let us begin with Turgot. He explains (1913-23/1766, 171):

> "Now, if a sum currently owned is worth more, is more useful, is preferable to the assurance of receiving a similar sum in one or several years' time, it is not true that the lender receives as much as he gives when he does not stipulate interest, for he gives the money and only receives an assurance. Now, if he receives less, why should this difference not be compensated by the assurance of an increase in the sum proportioned to the delay? This compensation is precisely the rate of interest" (quoted from Groenewegen's 1971, translation p. 330).

Note that Turgot says nothing in this quote about why borrowers are able or prepared to pay interest. Whether the quote can thus be read as implying an assumption of impatience is not obvious to me, though the insecurity of the "assurance" might be a reason for this. On the other hand, could not the higher value of present compared to future money (or goods) be a consequence of the positive rate of interest? Which, in its turn, could be brought about by neutral time preference together with a greater productivity of more roundabout processes?

We have thus to turn to the motives behind the demand for loans as explained by Turgot. Turgot mentions the following fundamental motives: borrowing for consumption purposes, to buy a landed estate, and borrowing to invest in agricultural, industrial or commercial enterprises. Only the first could point to the first two causes of a positive interest rate given by Böhm-Bawerk. Concerning the other cause, Turgot clearly recognizes the time-consuming character of production and the necessity to wait for its products:

> "It is only by means of considerable advances that we obtain a large return, and that the lands produce a good deal of revenue. ... In every craft ... it is necessary that the Workman should have tools in advance, that he should have a sufficient quantity of the materials upon which he has to labour. It is necessary that he should subsist while waiting for the sale of his finished goods" (1971/1770, p. 45).

Whether the time-consuming character of production leads to greater productivity is thus not clearly stated, and may be doubted. In contrast to Groenewegen (1971), I thus believe that Böhm-Bawerk (1959, vol. 1, pp. 40 sq.) is right in speaking of a "Fructification Theory", in the sense that Turgot was convinced that only land is productive if applied in roundabout processes:

> "It is he who will wait for the sale of the leather to return to him not only all his advances but a profit in addition, sufficient to make up for him what his money would have been worth to him if he had employed it in the purchase of an estate, ..." (Turgot 1971, p. 53).
>
> "Not only does there not exist nor can there exist any other revenue than the net produce of land, but it is also the land which has furnished all the capitals which can make up the sum of all the advances of agriculture and commerce" (pp. 96 ff.).

It seems to follow from this that only land is productive. It may be even more productive the longer the time it takes for its produce to be available and thus, the more advances and waiting are necessary. Whether this is implied by Turgot is doubtful. With neutral time preference (or impatience caused by the risk of assurances) such an assumption would lead to a positive rate of interest for investments in land. But then, in a monetized economy, interest would also have to be paid for advances in commerce and in industry, since otherwise nobody would give loans to them.

It follows, that Turgot's theory contains, with all its limitations, original ideas which could be developed further and freed from their defects. It is also not circular as asserted by Böhm-Bawerk (p. 42). But the approach remains still far removed from the latter's comprehensive theory of capital and interest.

Let us next turn to Senior, of whose theory Böhm-Bawerk said:

> "Senior made [abstinence] the central thought of a well-developed interest theory. No matter what opinion one may have concerning the correctness of his conclusions, ... he was outstanding for his unified system of thought, his impressive consistency, and the profound treatment of his material" (1959, vol. 1,180).

But let Senior speak for himself:

"The most laborious population, inhabiting the most fertile territory, if they devoted all their labour to the production of immediate results, and consumed its produce as it arose, would soon find their utmost exertions insufficient to produce even the mere necessaries of existence.

To the third Principle, or Instrument of Production [besides Labour and Natural Agents], without which the two others are inefficient, we shall give the name of *Abstinence*: a term by which we express the conduct of a person who either abstains from the unproductive use of what he can command, or designedly prefers the production of remote to that of immediate results.

It was to the effects of this Third Instrument of Production ... that *the Powers of Labour and of the other Instruments which produce Wealth may be indefinitely increased by using their Products as the means of further* Production" (1836, 58).

"...we consider the use of all implements as implying an exercise of abstinence, using that word in our extended sense as comprehending all preference of remote to immediate results.

...It is obviously true as to the *use* of all those instruments and materials which may be used at will, either for the purpose of present enjoyment, or for that of further production ... It is equally true as to the *making* of all those implements which are incapable of any but productive use, such as tools and machinery ..." (68).

Besides the use of implements

"The second of the two principal advantages derived from Abstinence, or, in other words, from the use of Capital, is the Division of Labour."

From these quotations one gets the impression that Senior put forward the proposition that Superiority of More Roundabout Production Processes is present. And the time-consuming nature of these processes can only be overcome by abstinence from present consumption. But abstinence will only come forth if it is rewarded:

"*By the word Abstinence, we wish to express that agent, distinct from labour and the agency of nature, the concurrence of which is necessary to the existence of Capital, and which* *stands in the same relation to Profit as Labour does to Wages*" (59).

"...but it is clear that every capitalist, as a motive to abstain ... must require some remuneration ..." (140). "By *Cost of Production*, then, we mean the sum of the labour and abstinence necessary to production" (101).

I leave it to the reader to decide how much of Böhm-Bawerk's theory is already contained in Senior's approach and whether the former slighted the merits of the latter. But it seems to me that since neoclassical utility theory was not available to Senior, he was forced into defining abstinence as a cost factor, certainly a doubtful approach. Thus Böhm-Bawerk seems to be right in reproaching Senior that he was doubly counting sacrifices (1959, vol. 2, 184-190). If one day's labour has been expended which matures only in two periods instead of in one into some product, you can either count the product foregone as consumption good at the end of the first period or the labour exerted as sacrifice or cost, but not both: "But if we nevertheless decide in favor of it [future satisfaction], we are prone to measure the extent of the sacrifice we have made by the extent of the gratification we forego. And since the latter is invested with the alluring character of instantaneousness, the scales will tip to that side and make our sacrifice seem even harder than it would otherwise have appeared. This does not mean that we are making a *second* sacrifice. ... And that is the true state of the facts of which Senior's theory renders a misinterpretation" (189-190).

Of course, Senior's approach could be mended. If abstinence would refer only to the fact that one has to wait until more roundabout production processes are completed and not imply impatience, then – as we already know – the superiority of those processes postulated by Senior, would result in a positive rate of interest.

Let us finally turn to Rae, keeping in mind that Böhm-Bawerk only learned about his work after he had completed and published his own theory. He expressed his appreciation of Rae's work as follows: "... Rae held a number of exceedingly original and remarkable views and those views exhibit unmistakable similarity to views which were developed about a half century later by

Jevons and myself" (1959, vol. 1, p. 208).

What were these views? Let us quote Rae (1834):

"All instruments ... are all either *directly* formed by human labour, or *indirectly* through the aid of other instruments themselves formed by human labour.

Sometimes, though rarely, instruments are constructed by labor alone" (p. 91).

"All instruments ... either produce, or contribute to the production, of events supplying some of our wants" (p. 92).

"Between the formation and exhaustion of instruments a space of time intervenes. This necessarily happens because all events take place in time. Sometimes that space extends to years, sometimes to months, occasionally to shorter periods, but it always exists" (p. 93).

"...no instruments will be designedly formed, but such as leave greater capacity, or issue in events, equivalent to more than the labor expended in their construction" (p. 100).

The capacity of instruments may be increased, by adding to their durability, or to their efficiency; that is, by prolonging the time during which to bring to pass the events, for the purpose of efficiency for which they are formed, or, by increasing the amount of them which they bring to pass within the same time" (pp. 109-110).

"Instruments are all formed by one amount of labour, or some equivalent to it, ... and they return another greater amount of labour or its equivalents. The formation of every instrument, therefore, implies the sacrifice of some smaller present good, for the production of some greater future good" (p. 119).

"The determination to sacrifice a certain amount of present good, to obtain another greater amount of good, at some future period, may be termed the *effective desire of accumulation*" (p. 119)

"A mere reasonable regard to their own interest, would, therefore, place the present very far above the future, in the estimation of most men" (p. 120).

It seems to follow from these citations that Rae postulated and gave reasons for the existence of the greater productivity of more roundabout production processes and for impatience to consume. He states, however that the latter is mitigated by prudence combined with the regard of the wants of others, especially one's own family (pp. 121-124).

These accomplishments of Rae as a precursor of Böhm-Bawerk were, however, marred by his value theory, which seems to be a labour and/or a cost theory of value, where the costs are the costs of reproduction (pp. 166-169). As a consequence, a positive interest rate is not clearly derived from the factors mentioned above, and Böhm-Bawerk seems to be right in his critique (1959, vol. 1, pp. 224-240). With this comment I do not deny that Rae took important steps in the direction of such proof:

> "...even in such cases where labour alone seems to be paid for, time generally also forms one of the items to be taken into account. Thus, an individual contracts, within three months, to fell the trees in a certain piece of forest land ... If then he be paid at the commencement of the three months, he will expect to receive less than if payment be deferred until the expiration of that time, ..." (Rae 1834, p. 170).
>
> "But the wants which they [all instruments] supply, and the labour which they save, are in general not immediate, but future. Now we cannot estimate the same amount of labour saved, or wants supplied tomorrow, and five, or fifty years hence, as equivalent, the one to the other" (pp. 171-172).
>
> "The natural measure would seem to be the relative estimate, which the individuals concerned themselves form of the present and the future, ..." (p. 172).
>
> "There is a general average time elapsing from the period of the formation of every commodity, until it pass from the individual having formed it, to the individuals who exhaust it in the supply of their wants, or employ it in the formation of other instruments. The merchant who effects the transfer of commodities between the other members of society is entitled to receive an amount exceeding that which he gave, by the return which the labour embodied in the commodity exchanged should yield for this average time, according to the general rate of return of capital in the community" (p. 175).

These quotations seem to show that Rae is groping for the answers Böhm-Bawerk gave, but that he, in fact, did not succeed in providing them. The huge gap between a labour or cost theory of value and a different valuation of labour and costs referring to the present and to different periods in the future has not been bridged, and thus no consistent explanation of a positive rate of interest been given.

Let us sum up. We have shown in Sections 2 and 3 that neutrality of time preference and impatience together with superiority of more roundabout production processes (working possibly via a greater supply of consumption goods in the future) are necessary and sufficient reasons for the existence of a positive rate of interest. Impatience alone is sufficient, but not necessary, since a positive interest rate is also implied under certain conditions by superiority of more roundabout processes or a greater supply of future consumption goods and neutrality of time preference.

Now it is obvious that all these results have only been obtained with the help of intertemporal utility theory, which was not available to the precursors of Böhm-Bawerk discussed above. It is true that Turgot, Senior with his "abstinence" and even Rae with his "effective desire of accumulation" *may* have been groping for the idea of impatience. But impatience certainly could not be formulated correctly without the help of a more general theory, like utility theory. Thus, we certainly cannot follow Rothbard's (1987, p. 645) evaluation that "One of the notable injustices in the historiography of economic thought was Böhm-Bawerk's brusque dismissal of Turgot's anticipation of his own time-preference theory of interest as merely a 'land fructification theory'". Moreover, the proofs given above show that we cannot share Rothbard's and Mises's (1949) view that impatience is the only reason for a positive rate of interest.

The difficulties faced by these earlier economists because they could not use utility theory, were not surmountable. We have seen that Senior was forced to define abstinence as a cost factor and that Rae seems to have wavered between a labor and a cost theory of value. Thus these authors were not able to present a consistent and conclusive theory of interest. From this perspective, Böhm-Bawerk's critique of their ideas seems to be warranted.

Concerning the superiority of more roundabout production processes, the three authors discussed were in a better position to formulate their ideas. But Turgot, as a Physiocrat, wrongly restricted superiority to the use of land.

6. Conclusions

What were Böhm-Bawerk's accomplishments? We have seen, even from our limited discussion of the ideas of his precursors, that virtually all the important ingredients of his theory were available when he began his work. His originality consisted in bringing them together into an integrated theory of interest and capital capable of explaining the existence of a positive rate of interest, though his own efforts were not sufficient to derive consistently the complete theory. But his theoretical approach even proved to be fruitful in other respects. By developing the time structure of production, consumption and the services of capital goods, he laid the foundation for the development of intertemporal and (non-balanced) growth theory, of the explicit inclusion of externalities and of exhaustible resources, and even of the theory of real business cycles. Moreover, inventions and innovations could be fitted into his theoretical framework.

It is also important to stress that it was Böhm-Bawerk who developed the foundations of a theory of intertemporal exchange and of the relationships of present and future (expected) prices and values as connected by the rate(s) of interest. And this aspect of his theory is quite independent of whether "the" rate of interest is positive or not. "What Böhm had to say about intertemporal exchange was refined and altered in details in the work of Fisher [1930], Lindahl [1929/39], and Hicks [1939], but its essence has stood the test of time" (Hennings 1972, p. 327).

Böhm-Bawerk has been, perhaps, too critical concerning his precursors. But, as we have seen, his critique was not without merits. In particular, the fact that utility theory was not available to Turgot, Senior and Rae prevented them from creating a consistent and conclusive theory of interest. How many of Böhm-Bawerk's ideas had already been developed by earlier economists is often a question of interpretation, as we have seen. It seems clear that many later interpreters of these ideas were influenced in their evaluations by the knowledge they had of Böhm-Bawerk's approach.

All the implications of an original theory cannot be treated exhaustively by its author, or even by many of his successors. Its very originality shows itself in the many unknown results to be detected. In this sense the fecundity of Böhm-Bawerk's approach cannot be doubted and he himself stands out as one of the most original thinkers on capital, interest and time.

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