

A SECOND LOOK AT TWO EARLY CAPITAL CONTROVERSIES

KEEHYUN HONG*

I. INTRODUCTION

The second generation marginalists who searched for distribution theory in a market economy suggested various concepts of capital, and discussed which concept would be more appropriate. For a famous instance, there occurred a controversy between Böhm-Bawerk and Clark at the turn of this century. Clark criticized Böhm-Bawerk's concept of the average production period for being irrelevant in the consideration of a stationary economy in which production and consumption would occur simultaneously. Böhm-Bawerk argued that Clark's distinction between concrete capital goods and true capital would be spurious in that the latter would be nothing but an assumption of one-good world.

Two and a half decades after the capital controversy between Böhm-Bawerk and Clark ended, there was a revival of the discussion. This revival was largely owing to an offensive launched by Knight, which was answered by Hayek and Machlup on the Austrian side. Knight's criticisms of the Austrian capital theory within the framework of a static analysis is so similar to Clark's that the controversy of the 1930's is often viewed as a simple replay of the controversy between Böhm-Bawerk and Clark.

A closer look at Hayek's responses, however, reveals that there are two significant differences between two controversies. First, Hayek did not defend Böhm-Bawerk's simple device of measuring the quantity of capital, i.e. the average production period. He was quite aware of the impossibility of measuring the quantity of capital in terms of a single technical parameter, and even critical of the use of average production period as a characterization of capital structure, in the form of either the composition and level of given capital stock or the time distribution of dated inputs. Even though he praised Böhm-Bawerk's insight of the time-consuming aspect of a capital-using economy, Hayek thought of the average production period as applicable to simple cases, such as uniform distribution of input.

Secondly, Hayek was concerned not so much with the determination of the

*Department of Economics, Seoul National University.

This paper is a part of my Ph. D dissertation to Harvard University. I want to thank professor Dorfman and Professor Milgate for their guidance.

interest rate in static conditions, as with the dynamic change of capital structure. His concern in a dynamic change was stimulated not only by the practical need to find the appropriate theoretical tools to deal with the severe economic crisis of the 1930's, but also by Austrians' emphasis on the transition process where the investment decision depends upon cost and time to adjust the capital structure to the desired one.

To see what kind of implications these two early capital controversies have in the development of distribution theories, the next two sections will briefly explain the main contents of controversies in a chronological order. In the final section, the historical implication of these controversies will be discussed.

II. DEBATE BETWEEN BÖHM-BAWERK AND CLARK

There were two separate occasions in which Clark and Böhm-Bawerk exchanged their views on capital theory in detail. Most of these two exchanges, which were separated by an interval of a dozen years, appeared in the pages of *Quarterly Journal of Economics*, but we will see that their basic points did not change much. The changes can be noticed only in emphasis and some expressions.

The first exchange went back to the year 1893 when Clark criticized Böhm-Bawerk's treatment of interest as a premium on concrete goods for present consumption as compared with those for deferred consumption in *Fate Review*.

"True capitalization is permanent, and not transient. It does not consist in saving wealth today, with the intention of spending the principal so accumulated at any future period. It consists in saving with the intention of never spending the acquired principal at all. ... It is evident that there is in society a fund of capital that never disappears, and that always draws interest."¹

Defining true capital as a permanent fund of productive wealth, expressible in money, but not embodied in any specific good or money, he asserts that the existence of true capital makes production and consumption simultaneous, and annihilates time intervals, even though capital goods stand in time between labor and the ripening of the particular bit of material on which that labor is bestowed:

"...When a fund of permanent capital is once embodied in coordinated series of such goods, the owner does not have to look forward through an interval of waiting to a time when he can begin to enjoy the products created by the use of them. ...The laborer has no such waiting before him. For both of these men ripened products emerge, as the mills run, day by day. Industry and its fruition are

¹Clark (1893), pp. 303-04.

simultaneous.”²

For Clark, the physical time elapsed between work and its finished product does not affect the economic essence of transaction in a synchronized process, in which production and consumption appear to be simultaneous. Resorting to an hydraulic metaphor in which true capital is likened to a reservoir and capital goods to drops of water, he asserts:

“Drops of water that flow into a reservoir have periods of mechanical production. It takes time for them to ripen into the motion of wheels; but the water power as such has not such periods. The water that at this moment is flowing from the inlet into the upper end of the reservoir may consume a fortnight in reaching the turbine wheel; but if a full reservoir be presupposed, the inflow causes motion at once.”³

From what Dorfman (1959) calls “bathtub theorem,” we know that Böhm–Bawerk’s average production period is a sensible notion, because it tells us a relation between a stock of capital and a flow of output. When, at the rate of I gallons a day, a water flows in and out of a reservoir containing a constant amount of water, say K gallons, the average detention time of water molecules, T , can be measured by K/I . Equivalently, if K denotes the stock of capital, and I wage cost per year (or the size of labor force times annual wage rate), we have:

$$T = K/I \tag{1}$$

where T is what Böhm–Bawerk calls the average production period when the interest rate is disregarded.⁴

Moreover, contrary to Clark’s criticism, the average production period may not be infinite, even if a small amount of primary inputs were invested in the infinite past.

In his first reply to Clark’s attack, Böhm–Bawerk does not mention the average production period. His strategy to show the meaningfulness of production period is to compare a static with a dynamic economy. In a static economy where “the concrete production–periods closed are just as many as the new ones begun”, “one may, with theoretical inaccuracy but practically with impunity, imagine that, through some mystical quality of true capital, production–periods have been quite done away with in the world”, but in a dynamic economy “where concrete capital goods are, as it were, changing their stratification and production–periods no longer interlock in a perfect circle, it might be demonstrated whether or not true capital has the ascribed to it, the power to do away with production–periods.”⁵

²Clark (1893), P. 306.

³ibid., p. 310.

⁴Dorfman (1959), pp. 367–72.

⁵Böhm–Bawerk (1895a), p. 127.

Seeing this rebuttal, Clark wastes no time to claim that the increase of permanent capital does not have any direct relation with production period:

“Through the study of capital goods and their periods of production we may reach a theory of capital and its continuous production. As the capital, and not the time required for creating and using it, is the cause of product that takes the form of interest, so changes in the amount of capital itself, and not a lengthening or shortening of productive periods, are the causes that affect the rate of interest.”⁶

In response to Clark, Böhm-Bawerk tries to show the increase of capital involves the lengthening of production period, the extent of which can be measured by the average production period which lies between the successive expenditure in labor and uses of land and the obtaining of the final good.⁷ In this reply, he seems to understand the basic result of “bathtub theorem”, when he defends his concept of average production period against absolute period. “That the lengthening of the period in *my* sense, as a rule, goes hand in hand with an increase of invested capital, is just as evident in the light of my theory to me as it can be to Professor Clark in the light of his theory.”⁸ However, due to the lack of a mathematical tool, Böhm-Bawerk failed to convince Clark that the average production period is a meaningful concept even in a stationary condition.

This technical deficiency is partly responsible for Clark’s misunderstanding of average production period. When the capital controversy is resumed by Böhm-Bawerk, after the publication of Clark’s *Distribution of Wealth* (1899), Clark still argues:

“In connection with a particular bit of raw material and the finished product which will ultimately grow out of it, waiting is certainly necessary. In connection with a self-perpetuating stock of such goods it is no more necessary than, in pumping water into one end of a full conduit, it is necessary to wait without drinking till that same water flows out from the other end.”⁹

Besides this technical aspect, a more important reason why Clark adheres to his notion of true or pure capital is that this concept is essential for the explanation of interest rate in terms of marginal product of capital. In his famous article, ‘Distribution as Determined by Rent’ (1891), Clark has already made a distinction between a concrete capital as a mass of instruments and a pure capital as one and the same thing. After referring to “the parallelism between capital pure and concrete, on the one hand, and labor pure and concrete, on the other”, he argues

⁶Clark (1859a), p. 277.

⁷Böhm-Bawerk (1859b), p. 384

⁸ibid., p. 384.

⁹Clark (1907), p. 368.

that the last unit of pure capital fixes the interest rate, as the last increment of labor the wage rate.¹⁰

After the modern capital controversy of the 1960's, it is well-known that in general equilibrium, having homogeneous capital will not permit us to derive a rate of interest from the technical relationship between homogeneous capital and output, because the equilibrium price of capital in units of consumer goods depends on the rate of interest.¹¹ What we need to explain the interest rate in terms of marginal product of capital is the existence of only one good in an economy, which eliminates the problem of relative price. In addition, even in an one good economy, the lag between input and output should not be taken into consideration. As Wicksell points out, the marginal product of capital is not equal to the interest rate, if the production period is explicitly introduced into the model.¹²

In *Distribution of Wealth* and other related articles, Clark continues to think of capital as an abstract entity which transcends a physical aspect of heterogeneous capital goods. However, it is now obvious that his conception of true capital is nothing but a postulate of an amorphous good which changes its form instantly.

Not surprisingly, when Böhm-Bawerk resumes the controversy, he criticizes Clark's notion of capital for being deceptive. He also criticizes the application of marginal productivity theory to the explanation of interest rate, even though he is entirely in accord with Clark on the general theory of imputation. Characterizing Clark's theory as a typical productivity theory based on a single premise that the productivity of capital suffices to give an exclusive explanation of the fact that capital yields a net return which accrues to its owner as interest, Böhm-Bawerk accuses Clark of not explaining why there is a net product over what is necessary to replace the capital used up, and why this amount should be ascribed to the owner of capital:

“Professor Clark does not touch the question why the product imputable to a given capital good is not to be ascribed to the previous labor which created that good. If so imputable, the whole product of capital would be identical with its wear and tear, and no net product of capital would remain. But according to the reasoning now under consideration no question of wear and tear can arise, nor any need of considering the previous labor.”¹³

In Böhm-Bawerk's opinion, these two crucial questions are avoided by Clark's double-faced Janus aspect of true capital. First, since true capital operates without wear and tear, “whatever is created by true capital is from the outset en-

¹⁰Clark (1891), p. 303ff.

¹¹Sen (1974), p. 329.

¹²Wicksell (1893), p. 137.

¹³Böhm-Bawerk (1907a), pp. 267-68.

dowed with the property of being a completed net product.”¹⁴ Secondly, Clark endowed his true capital with the qualities of capital goods the use of which yield real product as net rent, and the “hobgoblin of true capital claims as his share whatever part of the output cannot be due to current labor.”¹⁵

Despite Böhm-Bawerk’s legitimate complaint, Clark’s view does not change at all. Clark defends his position by ascribing Böhm-Bawerk’s concern to the study of economic dynamics:

“In a full study of distribution it is necessary to take account, not only of the replenishment of the waste of substance which capital undergoes, but of the creation of new capital. ... That, however, is a phenomenon of economic dynamics, and the work which is under criticism has restricted itself entirely to problems of economic statics. The assumption made in this latter department of the theory is that neither capital nor labor is increasing in quantity, ...”¹⁶

Even in stationary conditions, the time-structure of capital in relation to its construction and maintenance cost is worthy of being considered, and this raises the thorny problem of valuation of capital. It is true that this problem is not adequately dealt by Böhm-Bawerk, but it is completely hidden in Clark’s conception of capital as a permanent fund.

In sum, we can conclude that Clark’s criticisms of Böhm-Bawerk are based on his misunderstanding of the “bathtub theorem”. He justifies his disregard of the time-consuming aspect of a capitalist production by inventing the notion of “true capital”. This spurious notion becomes the basis of his explanation of the interest rate in terms of the marginal product of “capital”.

III. CONTROVERSY BETWEEN HAYEK AND KNIGHT

Knight’s main criticism of the Austrian capital theory originates from his dissatisfaction with the Austrian conception of the production period. He summarizes the fallacies of the Austrian version of the production period theory in four points: (i) The compound interest relation makes it impossible to bring the quantity of capital in a single investment into correspondence with any definable average period of production; (ii) capital goods are not the product of agencies other than capital goods but of all agencies, including capital goods, working in a collaboration; (iii) it is meaningless to compute an average period of production for capital as a whole, because every economic agency derives its value from cooperative relations with other agencies; (iv) the service life of an individual

¹⁴Böhm-Bawerk (1907a), p. 264

¹⁵ibid., p. 265.

¹⁶Clark (1907), pp. 365–66.

capital item is much less determinate still than is its construction period.¹⁷

Among these four points, the first and the last were discussed in previous researches by Wicksell as legitimate complaints about Böhm–Bawerk’s average production period.¹⁸ New criticisms made by Knight are the second and the third argument, in which his unique view of production is revealed.

The starting point of Knight’s critique is his departure from the tripartite classification of factors of production, by which labor and land are conceived as primary, and capital as produced means of production. According to Knight, labor, land, and other non–physical inputs are indistinguishable from physical capital at an analytical level, because they are all produced at a cost and subject to investment. This organic view of production is the basis on which he defines “capital” as an entity inclusive of all sources of want–satisfying power. In Knight’s words, capital is “the ideal factor of production”¹⁹, and “a general fund, embodied in particular goods or ideas, but contrasting with any particular example of the latter.”²⁰

This reminds us of Clark’s concept of capital as a permanent fund which lasts forever, even though its contents may change. In this light, Knight is often viewed as a successor of Clark’s position. But it should be noted that capital is treated as a single factor comprehending all inputs in Knight’s analysis, as opposed to Clark’s three factor analysis. In Knight’s interpretation of the economic activities, human and nonhuman agencies produce and reproduce each other in an organic fashion. In this sense, capital as a single factor may be taken as perpetual or immortal. In his critique of Hayek’s theory of investment, Knight argues:

“It cannot now escape observation that ‘capital’ is an integrated, organic conception, and the notion that the investment in a particular investment comes back periodically in the form of product, giving the owner freedom to choose whether he will reinvest or not, is largely a fiction and a delusion. To show this conclusively it should suffice to mention the case of a part of a machine. And the machine as a unit is in a similar sense a ‘part’ of an integrated productive organization which is not bounded by the scope of ‘plant’ or firm, but extends outward indefinitely to indeterminate limits. Moreover, the capital structure and every unit in it is typically planned itself, and not for liquidation....”²¹

¹⁷Knight (1935b), pp. 49–50.

¹⁸see Wicksell (1893) and Wicksell (1901); Garegnani (1960) confirms that the absence of compound interest rate and durable capital is one of indispensable assumptions to use Böhm–Bawerk’s average production period.

¹⁹Knight (1935d), p. 57.

²⁰Knight (1930), p. 198.

²¹Knight (1935a), p. 83.

In the above passage, we notice that the concept of the period of production is blurred. According to Knight, the period of production may well be taken either as zero due to the simultaneity of production and consumption or as infinity due to the existence of what Sraffa (1960) calls a “basic” good:

“Passing over the case of a society in the course of liquidation, the interval by which production precedes consumption is either zero or infinity. It is zero for the production of final product(services) currently consumed, which production includes the maintenance of capital goods used, maintenance in turn including any replacements necessary. The interval is infinity, as regards the consumable product, for that “production” in which present services of productive agents are used to create new productive agents to be used in the future to produce consumable services.²²

As Dorfman (1959) points out, Knight’s arguments are false. First, the average production period *per se* is a valuable concept, because even under stationary conditions a large stock of capital does permit a long detention time.²³ Secondly, even though a machine is used to produce a machine, the average period of production of the economy as a whole is finite, because it is the weighted average of the investment period of labor and that of “waiting”, both of which are finite.²⁴

Knight committed the same mistake that Clark had made thirty years before. This is one reason why the capital controversy of the 1930’s has been often viewed as a simple replay. Moreover, in *Prices and Production*, Hayek applies Böhm-Bawerk’s average production period to the analysis of economic fluctuations, without analyzing the relation between a quantity of capital and time-dimension of production structure, because he thinks that the average production period is appropriate for the simplest presentation of his basic idea. However, he clearly feels the necessity of a further investigation, and this issue is examined in the article published in *Economic Journal* (1934b), entitled ‘On the Relationship between Investment and Output’.

In this article, he tries to express the time structure of investment in terms of a cumulative distribution function²⁵ of “labor” which represents all original factors of production. Defining the investment function, $f(t)$ where $0 \leq t < T_1$, as a

²²Knight (1935c), p. 625.

²³Dorfman (1959), pp. 354–55.

²⁴ibid., p. 363.

²⁵In Hayek’s article, it is unclear whether the investment function, $f(t)$ indicates the absolute amount of total labor, or the proportion of total labor. As is noticed from Hayek’s paper (Hayek, 1934b, p. 211 n), Hayek seems to think of the absolute amount of total labor for the period before the completion of the process of length of t or longer. Here we choose the proportion of total labor for a rigorous treatment of distribution.

function of length of time(t) that shows the proportion of the total labor invested for that length of time or longer, we can express the flow of labor input used, at any moment, in order to produce a particular amount of good as the first derivative of the investment function, i.e. $f'(t)$. Then, the relation between the investment function and the output function, $\theta(t)$, defined as the rate of flow of output stream at any moment, $t(0 < t < T_1)$ is:

$$\theta(t) = Wf'(t)e^{rt} \quad (2)$$

Where $0 < t \leq T_1$, and $\int_0^{T_1} f'(s)ds = 1$

As he points out, this output function can be derived from the investment function only under the assumption of a given rate of interest, and that, it will change its shape with every change in the rate of interest. He adds that this output function from the single process should not be confused with usual production function as a function of labor, since a given quantity of labor can be invested for different ranges of periods. In this case, the quantity of consumers' goods produced have to be regarded as a functional of the investment function, i.e. $\theta = \phi [f_j(t)]$.

In a stationary state in which output of the amount θ is constantly produced, the value of capital(K) can be calculated by the summation with respect to different production methods with different production periods, and then by the usual integration. In our notation:

$$K = W \sum_{i=1}^n \int_0^{T_i} f'_i(s)(e^{rs} - 1)/r ds \quad (3)$$

where i denotes i -th method of labor investment with the production period T_i , and $i = 1, 2, \dots, n$.

(3) shows that, even when the rate of interest is given, we can not determine the value of capital stock if we know only the aggregate or average of these periods, instead of having a full description of the range of investment periods such as is provided by the investment function. According to Hayek:

“It is for this reason, too, that it is impossible to substitute any one-dimensional magnitude like the “average period of production” for the concept of the investment function. For there is no one single average period for which a quantity of factors could be invested with the result that the quantity of capital so created would be the same as if the same quantity of factors had be invested for the range of periods described by a given investment function, whatever the rate of interest. The mean value of these different investment periods which would satisfy this condition would have to be different for every rate of interest.”²⁶

²⁶Hayek (1934b), p. 217.

Thus, the concept of investment function contains complete information about the capital structure. However, in this paper, after analyzing the case in which labor is invested at a constant rate, i.e. $f(t) = at/T_1$, he concludes that the fact that “anything which will tend to lengthen this investment structure of current labour will lead to increases of the quantity of capital and anything which tends to shorten it will lead to a reduction of capital, remains a point of fundamental importance.”²⁷

This sounds as if the unique relation between physical length and the value of capital stock would exist, not only in some special cases like a uniform distribution of labor input, but also in any type of distribution. However, this should not be interpreted as a comparative-static argument that the increase of the given value of capital stock will increase the optimum length of production process. Actually, in the same page of this article, Hayek emphasizes the importance of the concept of the investment function in a dynamic analysis:

“..... even if there should be no correspondence whatever between the technical composition of the existing stock of real capital and the kind of capital goods in which current labour is invested, yet the value of the existing real capital limits within fairly narrow ranges the time dimension of current investment. the existing stock of real capital determines the investment structure of current labour, rather than in the inverse form, It is the emphasis which the concept of the period of production(investment function) places on this time structure of the stock of real capital, on the fact that it is not a homogeneous mass”²⁸

It is quite clear that Hayek was very cautious about the usage of the term “period of production”. He clearly recognizes that it is impossible to measure the quantity of capital in terms of a technically given measure, except some simple cases like a uniform distribution.

But using the term “production period” induces an immediate criticism by F.Knight (1935a), who has already begun his crusade against the Austrian notion of production period. As was seen in the previous section, Knight’s basic complaint is that the production period does not have any meaning, in either a stationary or a growing economy. In a stationary economy there is no interval between production and consumption. In a growing economy, the increase of capital can be created in any period of time, depending on the rate of saving, and there is no connection between the amount of capital and the construction period or the durability of capital goods. In an article which directly criticizes Hayek’s paper (1934b), he argues:

²⁷ibid., p. 231.

²⁸Hayek (1934b), p. 231.

“It is only under the arbitrary and absurd assumption that capital is eaten up at a fixed rate that there is any correspondence between a quantity of capital and the length of a production cycle. In determining both construction cost and service life, time is one factor or dimension among a practically infinite number, and quantity of capital may and does vary quite independently of either of these time intervals.”²⁹

Seeing heated controversies on capital theory inspired by Knight’s criticism, Hayek feels a need to keep his dynamic analysis, i.e. his idea about the “Ricardo effect”, from being endangered by the attack on the production period. In the article, ‘The Mythology of Capital’ (1936), which is written in direct response to Knight, he argues that some misconceptions on the production period has nothing to do with his main theme:

“..... the assertion that it is conceptually possible to conceive of the aggregate capital of a society in terms of possible waiting periods does not mean that *the total period of production*(or the aggregate of all periods of production) of an economic system is necessarily a *phenomenon capable of measurement*. Whether this is the case(and in my opinion it is very unlikely) is altogether irrelevant for the problem at issue. What is essential is solely that whenever a change occurs in any part of the economic system which involves that more(or less) capital is used in the industry or industries concerned, this always means that some of the factors used there will now bring a return only after a longer(or shorter) time interval than was the case in their former use.”³⁰

Here we find that, at this stage of controversy, the measure of total capital is no more an issue to Hayek, because he is concerned not with the determination of the equilibrium interest rate and optimum production period, but with the movement of the interest rate during the course of structural change.

His awareness of the impossibility of measuring the value of capital stock in terms of a single physical unit is even more evident in his theoretical work on capital theory, *The Pure Theory of Capital* (1941). In this book, he gives an example in which the time distribution of input is not characterized by a single physical measure:

“The total length of time which elapses between the very beginning of the process and the completion of the product may be shorter in one process than in another, and yet by far the greater part of the input used may be applied very early in the first process and very late

²⁹Knight (1935a), p. 82.

³⁰Hayek (1936), p. 207.

in the second process. Which of these two processes is to be regarded as the longer? It is impossible to answer this question at the present stage, and there is in fact no general answer to it."³¹

A similar example can be found, when he explains the usefulness of input function, which he called investment function earlier. He shows that either of two input functions with the same average of investment periods might correspond to the greater value of capital, depending on the rate of interest.³² He adds that any attempt to provide an answer by introducing the concept of average production period is not only unnecessary, but also highly misleading. Criticizing Böhm-Bawerk's assumption of given subsistence fund, or the value of capital stock, he gives a reason why the answer cannot exist:

"This stock of non-permanent resources in the form in which it exists as a datum is not some definite quantity of capital; for it can be expressed as a single magnitude only after the relative values of the items of which it is composed have been determined. And these values are clearly a resultant of the same equilibrating forces as determine the investment periods. The initial datum from which we have to start is simply an enumeration of all the items of which this stock of non-permanent resources is composed, and of all their technical attributes.the quantity of capital as a value magnitude, no less than the different investment periods, are not data, but are among the unknowns which have to be determined."³³

The above remark is nothing but a reassertion of Hayek (1934b)'s recognition about the impossibility of measuring heterogenous capital goods in terms of a single physical index, and this has long been noticed, since Wicksell (1901).³⁴ Thus, it is understandable that Hayek regards the production period as a shorthand expression for a complex time distribution. After pointing out the difficulties with the use of "changes in investment periods" and "changes in the length of the process", Hayek says:

"It is rather unfortunate that the time aspect of production should have been first introduced into theoretical analysis in this form, for it has led to much unnecessary confusion. But since use of the expression "changes in the length of the process" is a convenient way of describing the type of change in a whole process where the changes in the investment periods are predominantly in one direction, there is probably something to be said for retaining it, provided it is used

³¹Hayek (1941), p. 76.

³²ibid., p. 200.

³³ibid., pp. 191-92.

³⁴Wicksell (1901), pp. 202-3

cautiously, until we are ready to give a fuller explanation of what is meant by one process as a whole involving more waiting than other."³⁵

It is now obvious that Hayek uses the production period to convey his basic idea easily to the audience. For Hayek, this device is only applicable to what Stigler (1965) calls the "strong cases" which are designed for the convenience of easy presentation. If he had been equipped with more complicated analytical tools suitable for dynamic analysis, he could have stated his theory without facing criticisms made on this shorthand expression.³⁶

In the heated controversy between the Austrians and Knight, the special features of the Austrian capital theory, as well as the superficialness of Knight's criticism, were made clear. Knight takes the same position that Clark took thirty years before, and criticizes the Austrian concept of production period. Knight's criticism is based on his definition of capital as a perpetual fund, which is similar to Clark's notion of true or pure capital. Knight derives this concept by resorting to the capitalization formula by which the maintenance and replacement of capital is calculated, instead of directly appealing to the stationary condition in which the amount of capital is kept constant by definition, as Clark did. However, Knight's formula suffers from the difficulty that the data about cost and yield of investment may not be given, prior to the determination of the interest rate. To avoid this circular reasoning, Knight devises "Crusonia" where only one good is produced and consumed. The construction of "Crusonia" makes it clear that either Knight's capital as a single factor of production or Clark's true capital requires the one-good assumption. This finding is only one positive achievement by Knight, whereas most of Knight's criticism repeats the same mistakes Clark made, as both authors show their lack of the understanding of "bathtub theorem."

On the Austrian side, Hayek departs from the position of precedent Austrians. He clearly recognizes that Böhm-Bawerk's notion of the average production period is sensible only under the strong cases like a uniform distribution, and suggests that a technical relation with a general time distribution of input and output be characterized by multiple parameters. Hayek's suggestion originates not only from his dissatisfaction with Böhm-Bawerk's device, but from his different concern. Instead of asking the comparative static question of how the increase of capital will affect the optimum production period and the equilibrium interest rate, Hayek asks what will happen in the course of structural change of capital. In other words, Hayek's analysis is focused on the dynamic effect of the change in the interest rate on the capital structure. His theory is not a theory of the

³⁵Hayek (1941), p. 70.

³⁶See Hicks (1970)'s analysis of "traverse" i.e. the transition from one equilibrium to another, and also Zamagni (1984) as a recent application of Hicks' analysis to this specific problem.

determination of the equilibrium interest rate and optimum production period, but the explanation of the off-equilibrium path of the interest rate during the course of structural adjustment of capital, either in the form of compositional or time-distributional change.

IV. A CHANGE OF THE NOTION OF EQUILIBRIUM

In the previous section, we have seen that the concept of the production period became the target of criticisms, especially by F.Knight and the capital controversy comparable to the debate between Böhm-Bawerk and J.B.Clark ensued. However, it is erroneous to view the capital controversy of the 1930's as a simple replay of the earlier controversy, Hayek being the proponent of Austrian concept of "production period" and Knight being the advocate of Clarkian notion of capital as "a permanent fund". Actually, Hayek is very critical of the use of the "average production period". He warns against any attempt to measure the value of capital goods in terms of a single physical unit. This point is made clearer, in his theoretical work on capital theory, *The pure Theory of Capital*:

"..... the amount of waiting involved in a particular investment is not simply proportional to the length of the investment period and the value of the input invested, but is dependent also on the rate of interest..... there is no way in which the variety of technical period during which we have to wait, either for the products of different kinds of input or for particular units of the product, can be combined into an aggregate or average which can be regarded as a technical datum."³⁷

Thus, in his latest analysis of dynamic effects, we can notice that Hayek deliberately avoids Böhm-Bawerk's average production period:

"When, however, the inflow of money through investment ceases, the spreading of its effects will continue and will tend to restore something similar to the initial position. Prices of investment goods at this stage will fall; prices of consumer goods will for some time, continue to rise. This will make some of the investment which has been taking place less profitable than it was before, at the same time that the flow of investable fund is reduces. The result will be that some of the factors which during the boom will have become committed to producing very capital-intensive equipment will become unemployed."³⁸

This is Hayek's latest elucidation of a famous "Ricardo effect." The "Ricardo

³⁷Hayek (1941), pp. 144-45.

³⁸Hayek (1969), pp. 281-82.

effect” has nothing to do with results from the comparison of two steady-state (or stationary) equilibria. The “Ricardo effect” is one phenomenon which can occur during the transition from one equilibrium to another, and thus the production period as a measure of aggregate capital is not needed to show the “Ricardo effect.” In simple cases where the quantity of aggregate capital is expressed in terms of a single technical parameter, for example, the average production period, the reverse movement of credit-induced booms can be easily shown, because the quantity of capital can be expressed in terms of this parameter. In general, what Hayek needs to show this reverse movement is the possibility that some of the longer projects which started as the interest rate is lowered by credit expansion become unprofitable, due to the rise in the consumers’ good price and the consequent fall in the real wage.

In *Prices and Production*, Hayek’s analysis starts with stationary long-run equilibrium, but his own description of equilibrium is incomplete in that the equilibrium condition for saving and investment is not explicitly mentioned. In a lecture delivered two years after the publication of the book, he gives far more precise conditions for equilibrium³⁹. After characterizing his theory as a restatement of the Wickseil–Mises theory of industrial fluctuations, he mentions serious shortcomings of a traditional concept of capital, as “one finds not only that the concept of the maintenance of capital has no definite meaning, but also that there is no reason to assume that even the most rational and intelligent entrepreneur will ever in dynamic conditions be either willing or able to keep his capital constant in any quantitative sense, that is with respect to any of the measurable properties of capital itself.”⁴⁰ Then he argues that his theory of crises is free from objections to the traditional concept of capital:

“Fortunately, however, there is no such necessary connection between that theory and these concepts. ... It appears to me to be quite independent of any idea of absolute changes in the quantity of capital and therefore of the concepts of saving and investment in their traditional sense. The starting point for a fully developed theory of this kind would be (a) the intentions of all the consumers with respect to the way in which they wish to distribute at all the relevant dates all their resources (not merely their “income”) between current consumption and provision for future consumption, and (b) the separate and independent decisions of the entrepreneurs with respect to the amounts of consumers’ goods which they plan to provide at these various dates. Correspondence between these two groups of decisions would be characteristic of the kind of equilibrium which we now usually describe as a state where the idea of an equilibrium rate of interest is connected.”⁴¹

³⁹Hayek (1933)

⁴⁰ibid., p. 152.

⁴¹ibid., p. 154–55.

Here Hayek introduces an intertemporal equilibrium which he developed in the 1928 paper written in German. In addition, the uniform rate of interest is described as characteristic of equilibrium, probably because Hayek still considers the long-run(stationary) state as a convenient starting point of dynamic analysis. Then, he continues to analyze the situation in which entrepreneurs lengthen the investment period by more than is justified by the voluntary saving without taking full account of the "impatience" of the consumers, as the rate of interest is below that equilibrium rate:

"It needs not therefore be capital consumption in the absolute sense of the term, which is the essential characteristic(as I have myself suggested on earlier occasions) but merely that the consumers demand a more rapid supply of consumers' goods than is possible in view of the decisions of the entrepreneurs as to the form and volume of their investments. Practically this correction probably makes little difference, but theoretically the statement of the theory can be made unobjectionable only if we free it from any reference to the absolute quantity of capital."⁴²

Here it is clear that Hayek is concerned about dynamic process in which the adjustment speed matters. After a recent revival of interest in the Austrian dynamic approach, most interpreters of Hayek will agree with this conclusion.⁴³ However, there is no agreement as to why a measure of capital is not needed in Hayek's analysis.

First, M.Milgate (1979) argues that Hayek's recognition of the impossibility of measuring the capital stock in terms of a single magnitude facilitates the abandonment of long-run equilibrium which had been an object of inquiry by Classical and early Neo-Classical economists, and the invention of intertemporal equilibrium with which is associated a stock of capital not yielding a uniform rate of return.⁴⁴ This view is fortified by the fact that the notion of intertemporal equilibrium was originated by Hayek (1928).⁴⁵

However, recently from the camp of modern Austrians, S.Boehm (1986) objects to Milgate's account:

"The abandonment of the "traditional long-period method" was then emphatically not primarily motivated to salvage a supply and demand approach to the theory of capital and interest from the problems posed by the measurements of capital outside the convenient assumption of a

⁴²Hayek (1933), p. 154.

⁴³Moss and Vaughn (1986), and O'Driscoll (1975).

⁴⁴Milgate (1979), p.8. See also Milgate (1982) pp. 139-40.

⁴⁵This was recognized earlier by Ellis (1934), and confirmed by Milgate's research (Milgate, 1979)and Hick's testimony (Hicks, 1979).

one-commodity world, as Milgate alleges, but it rather distinctly reflected Hayek's lifelong crusade against the use of average magnitudes such as the general rate of profits and the average price level.

Moreover, a definition of intertemporal equilibrium as a set of market-clearing prices for both current commodities and for titles to future commodities utterly fails to do justice to Hayek's rich notion of a perfectly coordinated set of individual plans."⁴⁶

His objection can be divided into two parts: First, Hayek's abandonment of long-run equilibrium is owing to his view of market as a coordination process of individual plan with incomplete information. And, second, Hayek's new notion of equilibrium is different from intertemporal equilibrium *a la* Debreu.

The second part of his objection does not pose a serious problem for understanding Hayek's approach, because Hayek himself seemed to extend the definitions of equilibrium from a full-information intertemporal equilibrium to more game-theoretic notion of a set of consistent plans under uncertainty. R. McCloughry (1984) argues:

"Hayek would be sharply critical of those economists working within the Arrow-Debreu tradition of General Equilibrium theory in that it assumes the very thing to be explained, *viz.*, the givenness of the information. This 'givenness' of market information was questioned by Hayek in this famous paper on 'Economics and knowledge' published in 1937, a year which marks a watershed in Hayek's thought. Previous to that date Hayek's own thought was dominated by General Equilibrium theory."⁴⁷

The first part of his objection, however, raises an interesting question about the origin of intertemporal equilibrium. As an answer to this question, S. Boehm's suggestion is more convincing, because Hayek is basically concerned with dynamic processes, as is revealed by his various expositions of the "Ricardo effect" which occurs after entrepreneurs' expectation are disappointed by a new set of relative prices generated by their own investment activities. For Hayek, an intertemporal equilibrium is considered to be a convenient device for true dynamics. Commenting on the ambiguity of the concept of dynamics, Hayek says:

"When it is used in contrast to equilibrium analysis in general, it refers to an explanation of the economic process as it proceeds in time, an explanation in terms of causation which must necessarily be treated as a chain of historical sequences. What we find here is not mutual interdependence between all phenomena but a unilateral dependence of the succeeding event of the preceding one. This kind of causal ex-

⁴⁶Boehm (1986), pp. 23-24.

⁴⁷See editor's introduction in *Money, Capital and Fluctuations* (1984), p.viii.

planation of the process in time is of course the ultimate goal of all economic analysis, and equilibrium analysis is significant only in so far as it is preparatory to this main task. But between the concept of a stationary state and the problems of dynamics in this sense, there is an intermediate field through which we have to pass in order to go from one to the other. The term dynamics is sometimes also applied to this intermediate field, but here it refers to phenomena which still come within the scope of equilibrium analysis in the wider sense.⁴⁸

Here an intertemporal equilibrium is treated not as an object of economic analysis, but as an intermediate step toward true dynamics. This does not mean that Hayek succeeds in analyzing the whole spectrum of dynamic paths, including deviations from a short-run intertemporal equilibrium where there are as many own rates of return as there are commodities with the given endowments.⁴⁹ However, his dynamic analysis sheds some light on the time path of an economy when it departs from a long-run equilibrium position. Hayek's "Ricardo effect" is one such example which can be easily shown in strong cases where the technique is characterized in a single measure of capital. and is most likely to happen in more general cases.

In this light, when Hayek is talking about a more appropriate treatment of "time", the term "time" would mean this dynamic aspect of economic events, not an intertemporal equilibrium, which was a by-product of his continued investigation of "time". Moreover, Hayek's finding that there are as many equilibrium rates as there are commodities is also a result of his abandonment of stationary equilibrium, not a cause of abandoning of long-run equilibrium analysis.⁵⁰

REFERENCES

- BOEHM, STEPHAN (1986), "Time and Equilibrium: Hayek's Notion of Intertemporal Equilibrium Reconsidered," in I. M. Kirzner (ed.), *Subjectivism, Intelligibility and Economic Understanding*, New York: New York Univ. Press, pp. 16-29.
- BÖHM-BAWERK, E. VON (1889), *Capital and Income*, 3 Vol.(s) English translation by G. D. Huncke and H. F. Sennholz(1959), South Holland: Libertarian Press.

⁴⁸Hayek (1941), p. 17.

⁴⁹In relation to this, Sraffa argues that the policy maxim that the money rate of interest should be equal to "the" natural rate of interest is inconceivable, if there are as many "natural" rates as there are commodities (Sraffa, 1932b, p.251).

⁵⁰This does not mean that a long-run equilibrium logically presupposes a stationarity.(see Milgate (1982), pp 141-42 on this point) However, the abandonment of a stationarity condition by Hayek should be regarded as an important step toward the notion of intertemporal equilibrium because for the lack of appropriate tools, a stationarity is included in the analysis of long-run equilibrium by most economists.

- BÖHM-BAWERK, E. von (1895a), "The Positive Theory of Capital and Its Critics, Part I," *Quarterly Journal of Economics*, 9, pp. 113–31.
- _____ (1895b), "The Origin of Interest," *Quarterly Journal of Economics*, 9, pp. 380–87.
- _____ (1906), "Capital and Interest Once More: I. Capital vs. Capital Goods," *Quarterly Journal of Economics*, 21, pp. 1–21.
- _____ (1907a), "Capital and Interest Once More: II. A Relapse to the Productivity Theory," *Quarterly Journal of Economics*, 21, pp. 245–82.
- _____ (1907b), "The Nature of Capital: A Rejoinder," *Quarterly Journal of Economics*, 22, pp. 28–47.
- BUECHNER, NORTHRUP, M. (1976), "Frank Knight on Capital as the Only Factor of Production," *Journal of Economic Issues*, 10, pp. 598–617.
- CLARK, J.B. (1891), "Distribution as Determined by a Law of Rent," *Quarterly Journal of Economics*, 5, pp. 299–318.
- _____ (1893), "The Genesis of Capital," *Yale Review*, pp. 302–15.
- _____ (1895a), "The Origin of Interest," *Quarterly Journal of Economics*, pp. 255–78.
- _____ (1895b), "Real Issues concerning Interest," *Quarterly Journal of Economics*, 10, pp. 98–102.
- _____ (1899), *The Distribution of Wealth*, New York: Macmillan.
- _____ (1907), "Concerning the Nature of Capital: A Reply," *Quarterly Journal of Economics*, 21, pp. 351–70.
- DESAI, MEGHNAD (1982), "The Task of Monetary Theory: The Hayek–Sraffa Debate in a Modern Perspective," in M. Baranizini (ed.), *Advances in Economic Theory*, Oxford: Basil Blackwell, pp. 149–70.
- DORFMAN, ROBERT (1959), "Waiting and the Period of Production," *Quarterly Journal of Economics*, 73, pp. 351–72.
- ELLIS, H. S. (1934), *German Monetary Theory: 1905–1933*, Cambridge: Harvard University Press.
- GAREGNANI, P. (1960), *Il Capitale nelle Teorie della Distribuzione*, Milan: Giuffrè, Japanese translation by H. Yamashita (1966).
- HAHN, FRANK H. (1982), "The neo-Ricardians," *Cambridge Journal of Economics*, 6, pp. 353–74.
- HAYEK, F. A. (1928), "Das intertemporale Gleichgewichtssystem der Preise und die Bewegungen des "Geldwertes"," English translation in R. McCloughry (ed.), 1984, *Money, Capital and Fluctuations: Early Essays*, pp. 71–117.
- _____ (1931), *Prices and Production*, 1st ed., London: George Routledge & Sons, Ltd.
- _____ (1932), "Money and Capital: A Reply," *Economic Journal*, 42, pp. 237–49.
- _____ (1933), "Price Expectations, Monetary Disturbances and Mal-investments," reprinted in Hayek (1939), pp. 135–56.
- _____ (1934a), "Capital and Industrial Fluctuations," *Econometrica*, 2, pp. 152–67.
- _____ (1934b), "On the Relationship between Investment and Output," *Economic Journal*, 44, pp. 207–31.
- _____ (1936), "The Mythology of Capital," *Quarterly Journal of Economics*,

pp. 199–228.

(1937), “Economics and Knowledge,” *Economica*, 4, pp. 33–54, reprinted in Hayek, 1949, *Individualism and Economic order*, London: Routledge and Kegan Paul, Chapter 2.

(1939), “Profits, Interest and Investment,” reprinted in Hayek, 1939, *Profits, Interest and Investment*, London: George Routledge and Sons, Ltd., pp. 3–71.

(1941), *The Pure Theory of Capital*, London: Routledge & Kegan Paul.

(1942), “The Ricardo Effect,” *Economica*, 9, pp. 127–52.

(1969), “Three Elucidations of the Ricardo Effect,” *Journal of Political Economy*, 77, pp. 274–85.

HICKS, JOHN R. (1946), *Value and Capital*, 2nd ed., Oxford: Clarendon Press.

(1967), “The Hayek Story,” in *Critical Essays in Monetary Theory*, Oxford: the Clarendon Press, pp. 203–15.

(1970), “A Neo-Austrian Growth Theory,” *Economic Journal* 60, pp. 257–81.

(1979), “The Formation of an Economist,” *Banca Nazionale del Lavoro Quarterly Review*, reprinted in D.Helm (ed.), 1984, *The Economics of John Hicks*, New York: Basil Blackwell, pp. 281–90.

KALDOR, N. (1937), “Annual Survey of Economic Theory: The Recent Controversy on the Theory of Capital,” *Econometrica*, 5, pp. 201–33.

(1938), “On the Theory of Capital: A Rejoinder to Professor Knight,” *Econometrica*, 6, pp. 163–76.

(1942), “Professor Hayek and the Concertina-Effect,” *Economica*, 9, pp. 359–82.

KNIGHT, FRANK H. (1930), “Statics and Dynamics: Some Queries Regarding the Mechanical Analogy in Economics,” *Zeitschrift für Nationalökonomie*, 2, reprinted in Knight, 1956, *On the history and Method of Economics*, Chicago: Chicago Univ. Press, pp. 179–201.

(1931), “Professor Fisher’s Interest Theory: A Case in Point,” *Journal of Political Economy*, 39, pp. 176–212.

(1933), “Capitalistic Production, Time and the Rate of Return,” in *Economic Essays in honour of Gustav Cassel*, London: George Allen & Unwin, pp. 327–42.

(1934), “Capital, Time, and the Interest Rate,” *Economica*, 1, pp. 257–86.

(1935a), “Professor Hayek and the Theory of Investment,” *Economic Journal*, 45, pp. 77–94.

(1935b), “The Theory of Investment Once More: Mr. Boulding and the Austrians,” *Quarterly Journal of Economics*, 50, pp. 36–67.

(1935c), “Comment on Machlup” *Journal of Political Economy*, 43, pp. 625–27.

(1935d), “The Ricardian Theory of Production and Distribution,” *Canadian Journal of Economic and Political Science*, reprinted in Knight (1956), pp. 37–88.

(1936a), “The Quantity of Capital and the Rate of Interest, I,” *Journal of Political Economy*, 44, pp. 433–63.

- _____. (1936b). "The Quantity of Capital and the Rate of Interest, II," *Journal of Political Economy*, 44, pp. 612–42.
- KUENNE, ROBERT E. (1971), *Eugen von Böhm-Bawerk*, New York: Columbia University Press.
- LACHMANN, L. M. (1986), "Austrian Economics under Fire: The Hayek–Sraffa Duel in Retrospect," in W. Grassl and B. Smith (ed.), *Austrian Economics: Historical and Philosophical Backgrounds*, New York: New York Univ. Press, pp. 225–42.
- MACHLUP, FRITZ (1935), "Professor Knight and the Period of Production," *Journal of Political Economy*, 43, pp. 577–624.
- McCLOUGHRY, R. (1982), "Neutrality and Monetary Equilibrium: A Note on Desai," in M. Baranzini (ed.), *Advances in Economic Theory*, Oxford: Basil Blackwell, pp. 171–82.
- MILGATE, MURRAY (1979), "On the Origin of the Notion of "Intertemporal Equilibrium," *Economica*, 46, pp. 1–10.
- _____. (1982), *Capital and Employment: A Study of Keynes's Economics*, London: Academic Press.
- MOSS, L. S and K. I. VAUGHN (1986), "Hayek's Ricardo Effect: A Second Look," *History of Political Economy*, 18, pp. 545–65.
- O'DRISCOLL, G. P. (1977), *Economics as a Coordination Problem: The Contributions of Friedrich A. Hayek*, Kansas City: Sheed Andrews and McMeel, Inc.
- _____, and M. J. RIZZO (1985), *The Economics of Time and Ignorance*, Oxford: Basil Blackwell Ltd..
- SEN, AMARTYA (1974), "On Some Debates in Capital Theory," *Economica*, 41, pp. 328–35.
- SRAFFA, PIERO (1932a), "Dr. Hayek on Money and Capital," *Economic Journal*, 42, pp. 42–53.
- _____. (1932b), "Money and Capital: A Rejoinder," *Economic Journal*, 42, pp. 249–51.
- _____. (1960), *Production of Commodities by means of Commodities*, Cambridge: Cambridge University Press.
- STIGLER, G. J. (1965), "Textual Exegesis as a Scientific Problem," *Economica*, 32, pp. 447–50.
- THALENHORST, J. and A. WENIG (1984), "F. A. Hayek's 'Prices and Production' Re-Analyzed," *Jahrbuch für Nationalökonomie und Statistik*, 199, pp. 213–36.
- VALIENTE, W. S. (1980), "Is Frank Knight the Victor in the Controversy between the two Cambridges?," *History of Political Economy*, 12, pp. 41–64.
- WEIZSÄCKER, C. C. von (1971), *Steady State Capital Theory*, Lecture Notes in Operations Research and Mathematical Systems, 54, Berlin: Springer-Verlag.
- WICKSELL, K. (1893), *Value, Capital and Rent*, English translation by S. H. Frowein, 1954, New York: Rinehart & Co.
- _____. (1901), *Lectures on Political Economy*, Vol. 1, English translation by E. Classen, 1934, Fairfield: August M. Kelly.
- ZAMAGNI, S. (1984), "Ricardo and Hayek Effects in a Fixwage Model of Traverse," *Oxford Economic Papers*, 36, pp. 135–51.