

# Why Hayek Abandoned the Average Period of Production?

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**Abbreviations:** APP: Average Period of Production

## 1. Introduction

Between 1933 and 1936, Frank Knight and Friedrich Hayek engaged in a spirited dispute about the Austrian Theory of Capital through an exchange of articles that revealed Knight's criticism and Hayek's defense of the concept of the Average Period of Production (APP). The controversy began with attacks by Knight (1933) in his *Capitalistic Production, Time and the Rate of Return*, to which Hayek (1934) responded with *On the Relations between Investment and Output*. Later, Knight (1934, 1935) continued with his "*Capital, Time and the Interest Rate*" and Professor Hayek, with his *Theory of Investment*. Finally, Hayek (1936) accepted in *The Mythology of Capital* problems that the concept of the APP caused the Austrian theory of capital<sup>2</sup>, stating that he would never use it.

Hayek himself commented on the problems that Böhm-Bawerk caused his analysis of capital. According to Hayek (1992, 37) in the early 1930s while organizing *Prices and Production*, he realized the enormous difficulties of incorporating Böhm-Bawerk's theory of capital<sup>3</sup> into his analysis of capital and business cycles, "But I soon became aware that the theory of capital on which I had built was so much too oversimplified to carry the burden of the superstructure I had tried to build on it. The result was that I have [sic] to devote most of the next decade to providing a more satisfactory theory of capital than that I had to work with". Years later, Hayek (1984 - 88, 77 - 78) reaffirmed, "To give you the main illustration, from my simple exposition I could operate with a grave simplification in Böhm-Bawerk, operating with an average period of production. The average period of production is a beautiful simplification, but doesn't help you at all. I became aware later that the question of a simple average period of production was a complex structure; if

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<sup>2</sup> Cohen (2003), asserts that the dispute between the two authors came to an end with Hayek (1936) with Knight never responding publicly to Hayek's article. Knight, in a letter to Hayek said "I have lost interest in carrying the controversy any further in print" (Cohen, 2003, 474). Later Knight (1936a, 1936b) maintained his own approach to capital theory without ever mentioning Hayek.

<sup>3</sup> Ironically, Hayek (1931b, 279-80) criticized Keynes for not knowing the two fundamentals of Wicksell's theory of capital as coming from the work of Böhm-Bawer (1891): his wage fund and the formula that describes the relationship between the average period of production and the amount of capital. More curious still, is the critique of Hayek of Keynes's macroeconomics for the use of averages or aggregates, because the average period of production, which is a simple average.

I had been aware of this in 1931, I could not have given a beautiful simple exposition, but I could have confused everybody”.

Unlike Cohen (2003), this work will show in detail how the arguments of Knight persuaded Hayek of the inappropriateness of the APP as an instrument of general equilibrium analysis of the process of aggregate capital accumulation<sup>4</sup>, in both equilibrium and comparative statics. Therefore, Hayek had no alternative but to face the stability problem of the equilibrium. It is also worth mentioning that Knight also invited to the debate Morgenstern who developed a critical analysis of the use of this concept (Nakayama, 2010), while Machlup (1935), defended the applicability of APP. From the above, it is inferred that the Austrian School suffered from serious theoretical differences between some members, which lead to the recognition of the flaws in what was considered its most important contribution to economic theory: the theory of capital.

The article includes nine sections. The first is the introduction. The second analyzes the Böhm-Bawerk APP. The third contains Knight’s criticism of the APP concept. The fourth presents Hayek’s reply, and his suggestion of replacing “production period” with “investment period”. In the fifth, Knight rejects Hayek arguments trying to associate the period of production or investment with the duration of production of goods and exposes the problems in defining the mobility of capital in disequilibrium. The sixth section discusses Hayek’s final response he proposes to Knight: eliminate the APP, replacing production period for the investment period and recommends the use of another way to measure the aggregate capital. The seventh and eighth sections, using examples from Hayek (1935) in *The Maintenance of Capital* suggest the problems encountered in establishing the amount of capital when the economic system is in disequilibrium, in this way we compare the behavior of capitalist under perfect and imperfect foresight, which is not discussed by Cohen (2003). Under the latter situation Hayek found that uncertainty is an additional element that prevents the use of the APP to determine the new amount of capital. The last section is the conclusion.

## 2. The average period of production

Aware of the impossibility of developing a physical measure of capital, Böhm-Bawerk believed that APP<sup>5</sup> was the instrument that could measure the capital per capita in homogeneous units of time (Orosel, 1987), and defined it as the average time interval that the original factors of production are invested, from the time they are first applied to the point that takes the form of finished goods ready for consumption, (Hennings, 1987). The original factors of production were considered homogeneous units of labor and land; however, Böhm-Bawerk in his examples used only units of work.

Following Niehans (1990) the APP is taken as a technical data independent of the interest rate and with the help of other equations it determines the capital per capita of the economy. The assumptions used in the calculation are: free land, only one final product, simple interest rate and the working capital used (Wicksell, 1896, 1954), (Garegnani, 1982).

The level of output produced depends on the amount of inputs  $Q$  (only labor), which are applied

from year  $i$  to  $n$  as shown in expression  $\sum_i^n q_i = Q$ . Additionally, if the way these inputs are spent

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<sup>4</sup> The controversy was reviewed by Kaldor (1937), Gaistkell (1936, 1938), Syed (1991), Blaug (1996, 1992, 1997) and Cohen (2003). Unlike Cohen, my paper discusses only the publications mentioned between 1933 and 1936. I excluded from my analysis the papers of Knight (1936) and Hayek (1941).

<sup>5</sup> A term introduced by Böhm-Bawerk (1891) in "The Positive Theory of Capital." See Book II, Chapter 2. According to Schumpeter (1994, 988), the concept is borrowed from physics and is defined as the center of gravity of a particle of mass located along a line.

in each of these periods is given by the expression,  $\sum_i^n (q_i t_i)$  ; therefore, Equation (1) determine the APP<sup>6</sup>  $\tau$  as a weighted arithmetic mean that shows how long on average each unit of labor was invested in the production process<sup>7</sup>:

$$\tau = \frac{\sum_i^n (q_i t_i)}{\sum_i^n q_i} = \frac{\sum_i^n (q_i t_i)}{Q} \quad (1)$$

Now, with this data we can elaborate the function of producing the good, relating output per worker  $p$  with APP  $\tau$ . As shown in equation (2):

$$p = p(\tau), \quad p'(\tau) > 0, \quad p''(\tau) < 0 \quad (2)$$

The explanation of the production process is as follows: each year, the capitalists (assuming they are the same as the entrepreneurs) start a production process by paying the annual market wage  $w$  that will yield profits of the order  $p - w$ . But, throughout the production process additional capital  $\tau w$  will be required consisting of a wages fund made up of consumer goods. At equilibrium, the rate of profit equals the simple interest rate, i.e.

$$i = \frac{p(\tau) - w}{\tau w} \quad (3)$$

This rate of return on the capital advanced  $\tau w$  will be maximized when the employer chooses the APP for any likely value of  $w$ . Expressed by (4)

$$p'(\tau)\tau = p(\tau) - w \quad (4)$$

By replacing (4) in (3) we get expression (5) where the interest rate and profit are equal.

$$i = \frac{p'(\tau)}{w} \quad (5)$$

This last expression shows that if the employer chooses the previous wage, the additional product produced by a worker to the ultimate increase in the APP should be equal to the rate of interest. Then  $w, \tau$  and  $L$  can determine also the capital per worker as the aggregate. As the

capital per capita  $k = \frac{K}{L}$  and as  $k = w\tau$  the aggregate capital would be (6):

$$K = (w\tau) L \quad (6)$$

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<sup>6</sup> According to Ahmad (1991), this concept has traditionally been defined for the cases of point input - point output, and flow input - point output.

<sup>7</sup> See the mathematical examples of Böhm - Bawer (1891) and Blaug (1996).

Expression (6) shows that increasing the APP ( $\tau$ ), also increases aggregate capital  $K$ . Hayek uses this reasoning in *Prices and Production* to explain the monetary expansions brought about by central banks reducing the monetary interest rate below its natural interest rate, stimulate production processes that lengthen APP causing capital accumulation processes that trigger economic crisis. Thus the APP constitutes the link between the monetary sector and real cycles of boom or bust.

### 3. Knight's criticism of the app

The controversy with Hayek started in 1933 after Knight<sup>8</sup> had developed some criticism of the Austrian theory of capital a year before (1932). This work rejects Hayek (1931) theory of capital that in his opinion does not fit his theory of business cycles. The objection of Knight is that there is no connection between the extension of the production period and the aggregate amount of capital. The arguments are the following:

- i. Production can not be based on the exclusive application of labor and land because from the beginning of the production process the capital was used in the form of capital instruments that were developed in previous periods.
- ii. You can not define the period of production in equilibrium because the services generated are produced and consumed at the same time, so there is no sacrifice involving a waiting period. Neither can it be defined in disequilibrium because the inclusion in the calculation of durable goods, whose construction is by means of an investment process (consisting of the use of the accumulated capital, labor and land), its value should be calculated back to the first process that did not use capital, that is, from a historical perspective. Additionally, the period would never end because the owners of capital are seen as if it were to deliver an income stream in perpetuity so it does not provide for any point of liquidation in the future.

Knight uses the following example to show that it would be impossible to establish a lengthening of the period of production<sup>9</sup>: "Suppose that one is figuring on a contract to produce a million units of a new product, all to be delivered on a certain day and with no prospect of further sales. We assume that the farther in the future the delivery is set (within relevant limits) the more cheaply one can fill the order (abstracting from the possibility of prohibitive storage costs), and also that a part of the longer period would be used in making "intermediate goods" (Knight, 1933, 222). Knight's analysis is reduced by the following points:

1. The production period lacks a beginning and an end. The production period lacks a beginning and an end. There will be no beginning at liquidation of the contract. When capital is settled, the new intermediate goods built with the cooperation of existing capital and the primary factors should undergo a procedure that tracks the primary factors that were applied for the first time, going back to a remote era<sup>10</sup>. Without an end it is assumed the capital is immortal<sup>11</sup> and there could be no settlement (unless, say, the date of the end of the world is disclosed in advance) because the capitalist believes that the income from his possession will be eternal, after discounting for provisions in perpetuity for maintenance and replacement. For the latter, Knight considered it irrelevant to include the duration of capital goods in the analysis due to their aggregated value coming from the sum of the income that is provided in perpetuity.

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<sup>8</sup> Emmett (2009) sets out the reasons that led to Knight's interest in capital theory.

<sup>9</sup> Therefore, it is assumed that the same applies to APP.

<sup>10</sup> Depending on how much the generation of new wealth was the result of what has occurred in the past.

<sup>11</sup> Knight believes that the owners of capital do not think about its liquidation but to keep it intact in order to obtain a perpetual income.

2. The production period can not be calculated in either equilibrium or in disequilibrium, thus invalidating the use of comparative statics<sup>12</sup>. In equilibrium, the production period and the aggregate capital would be zero<sup>13</sup>, because it is impossible to define a waiting period between production and consumption, as these magnitudes will remain the same. According to Knight, the economic system functions as an organic unit which maintains the value of capital stock constant by generating, on the one hand, a supply of consumption necessary, and on the other hand, the materials for the continuous maintenance and replacement of all the fixed assets that comprise the existing capital stock.

In the dynamic case, the economy increases its production capacity through the generation of net investment, which makes the use of comparative statics difficult because at the end of the production period the magnitude of capital would be simultaneously zero and infinite and in infinite disequilibrium. Growth prevents the initial capital to be considered as a mere fact, because historically this emerged through a process that used a portion of it to reproduce and expand. Therefore, in disequilibrium we should go back to a past whose onset is unknown and, equally, the new capital would look to a future whose horizon is considered eternal.

With these criticisms, Knight concludes that the aggregate capital and the production period (defined by him as the time required for their preparation) are not related. Therefore, Hayek's theory of cycles would face serious difficulties because the magnitude of the aggregate capital<sup>14</sup> depends on a variable that can not be calculated.

#### 4. Hayek's reply

Hayek (1934) simultaneously addresses the questions of Knight (1933), Burchardt (1932-33) and Hill (1933). Burchardt's work has already been discussed by (Hagemann, 1990) (Hagemann and Landesman, 1998) and as Hayek makes no reference to Hill's arguments<sup>15</sup>, we will refer only to the responses of Hayek to Knight.

First, Hayek proposes to replace the term "period of production" with "period of investment"<sup>16</sup> without elaborating a definition of it, but considered it as the period of time the current supply of original factors are invested<sup>17</sup>. However, Hayek believes that this period of investment can not be calculated as a technical data when the lifespan of a capital asset can be modified and extended beyond its useful life. For this reason, Hayek argues that it is preferable to use durable capital goods with a finite useful life.

Second, accepts that the determination that APP is not independent of the compound interest rate and therefore the aggregate capital can not be calculated: "because the reinvestment of interest accrued up to any moment of time has to be counted as part of the total investment. It is for this reason, too, that it is impossible to substitute any one-dimensional magnitude like "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 been invested for the range of periods described by a given investment function, whatever the rate of

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<sup>12</sup> Weintraub (1991), devotes his second chapter to the 1930's as a period rich in ideas about the equilibrium, statics, dynamics and stability that were the central issues in Hayek's decision to abandon the production period.

<sup>13</sup> See equation (6).

<sup>14</sup> Gehrke and Kurz (2008) show that APP is calculated under very restrictive conditions.

<sup>15</sup> Hill (1933) was critical of the concept of the period of production because it alters in the short term the equilibrium. And changes in the period of production will not allow inferences to be made during the transition to equilibrium, concerning whether the economy is using more or less capital intensively. It means that in disequilibrium, in the short term, the period of production will not work as an index of capital intensity.

<sup>16</sup> Jevons (1911, 231) called it "average time of investment" and Wicksell (1896, 1906) was the first to suggest its change.

<sup>17</sup> Hayek (1934, 226).

interest. The mean value of these different investment periods which would satisfy this condition would have to be different for every rate of interest.” Hayek (1934, 217).

Third, if the equilibrium<sup>18</sup>, defined as the equality between the natural interest rate and Wicksell's monetarism, is altered, the monetary interest rate will indicate the direction in which the quantities of work are distributed among the different stages of production and also, will determine the direction of investment flow. Indeed, Hayek (1931) begins his analysis with an equilibrium characterized by equality between the natural interest rate and monetary policy. If the monetary interest rate is below the natural interest rate, it triggers an increase in the price of the factors that mobilized labor and capital in the initial stages to the final stages, until the marginal physical product of each of these work units equals the value of that unit plus the interest received by those invested units. Thus, an extension in the investment period is justified.

Fourth, Hayek accepts that the period of production produces a theoretical confusion. Blame Böhm-Bawerk for its alleged historical sense and reaffirms its replacement by *period of investment* because it can be used in analyzing the change of aggregate capital in the future. Hayek remarks (1934, 226) that “the essential concept is not that of the length of the process from which current output results, but the range of periods for which the current supply of factors is being invested”.

Fifth, recognize that at equilibrium there is no time lag between production and consumption of the productive services that define the period of production. This resembles a synchronized process<sup>19</sup> according to Hayek (1934, 226): “under perfectly stationary conditions the stock of intermediate products existing at any one moment of time will exactly correspond to all the different stages through which the “labor” invested at the same moment will have to pass before it matures into consumers goods”.

Sixth, a process synchronized process can not be maintained under dynamic conditions. When the equilibrium position is altered by an unforeseen change, the new equilibrium will be characterized by a new wave of investment in the construction of more or less durable goods, which in turn will modify the composition of capital stock. However, Hayek did not analyze in detail how capital is obtained in the new equilibrium point, so the investment period precludes the accumulation analysis using comparative statics<sup>20</sup>.

The sixth refers to Hayek most contentious disagreement with Knight<sup>21</sup>: the need to include the detailed composition of each of the pieces of the capital stock. Hayek suggests that the economy subject to unexpected changes makes impossible to determine the income stream of the aggregate capital stock independently of the capital structure previously chosen, that is the initial capitalization. Unlike Knight who only pays attention to the invariant aggregate flow of income from capital stock which he takes as eternal.

Hayek argues that given the heterogeneity of capital stock, unexpected changes cause transfers of capital goods between the different stages of production, and it is during this process of adaptation in their alternative use that individual values change, and thus the income stream of the aggregate capital stock is altered: “The notion that capital as such, i.e. the quantity of value which it represents-is completely mobile and can at will and without any loss of value be transformed in any concrete form, has already played much havoc in economic theory. It would

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<sup>18</sup> Wicksell defined it as equality between the natural and monetary interest rate.

<sup>19</sup> Expression of John Bates Clark.

<sup>20</sup> It is strange that Hayek (1934, 208) circumvents the problem by stating, "It will appear that, contrary to a widely held opinion, the concept of a definite time-structure of investment is even more important for the understanding of the dynamic of the accumulation processes and consumption of capital than for the mere description of the conditions of a stationary equilibrium"

<sup>21</sup> Discussion previously made by Böhm-Bawerk and John Bates Clark.

be true only if the concrete capital goods were just so many units of homogeneous “energy” which could be put to any use, i.e. if they were completely non-specific” (Hayek, 1934, 228-29).

Thus, for Hayek the relationship between time-capital does not come from the analysis of aggregate value but from the relative prices of capital goods that determine the direction of the investment. As an example, Hayek says that if an unforeseen change increases the value of capital goods located in the early stages, then resources and investment will be reassigned for extended periods and, therefore, the aggregate value of capital stock, also will increase.

This section concludes that Hayek suggests replacing the production period for the investment period and discards APP when including compound interest<sup>22</sup>. Hayek approves the use of investment period that will allow the use of comparative statics to understand what it is happening during this period, as long as the adjustment process which causes the mobility of capital is described.

## 5. Knight's reply

Knight (1935) responded to Hayek disappointed at not finding any evidence that would link the aggregated capital to the period of production or investment, or support for Hayek's arguments based on the three-dimensional graphics to fend off criticism.

Indeed, Knight (1935, 79) says that the problem of Hayek's capital theory should be focused on, “increasing the amount of capital invested lengthens the production process, rather than what is its effect on the investment structure”<sup>23</sup>. For this reason, Knight returns to the fray with his arguments, new examples and analogies that reinforces his criticism of Hayek. These are Knight's main comments<sup>24</sup>:

First, the Böhm-Bawerk fund theory of wages should be eliminated from the theory of capital as it applies only in a primitive agricultural economy. Finally, through examples, Knight wrongly concludes that the period of production is equivalent to the duration of the period of the process of developing the goods.

Second, Knight states that capital mobility does not contribute to the understanding of the capital-time. Knight considers to be the difference between real mobility (physical), technical and economic mobility and provides an example for each case.

The analysis of the process of capital mobility must incorporate uncertainty. The reason is that in economic cycles, depressions<sup>25</sup> are characterized by physical immobility and deferred maintenance processes or replacement of capital equipment over their useful life, which leads to failures in performance and impairs its mobility. During this phase, the company faces problems in transforming their assets into cash due to changes in cash flow, price changes and the

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<sup>22</sup> Blaug (1996, 497) shows the equation that determines the APP as dependent on interest rate:

$$\tau = \frac{\log(2 + 3r + r^2) - \log 2_a}{\log(1 + r)}$$

<sup>23</sup> This would require a detailed description of the transformation process of the production structure.

<sup>24</sup> Knight offers the top 10 problems which capital theory must face. I'm only going to take those that relate exclusively to Hayek.

<sup>25</sup> Referring only to depression- Is Knight accepting Hayek's arguments on the mobility of capital in an economic boom? The answer depends, I owe this comment to Professor Ross Emmett, who mentioned in an email that Knight refers to changes in capital, only if, we are observing actual history (hence, comparative statics). So if capital is or is not mobile will depend upon the conditions surrounding the capital in real time.

behavior of debt. Therefore the mobility of capital goods would depend on the possibility of selling them and not their technical properties.

In addition, departing radically from Hayek, Knight (1935, 94) states that economic fluctuations occur even in societies devoid of capital goods: "Such a situation may be visualized by considering what might be happen if all economic production had the form of the chorus. The phenomena of training periods an resistance to retraining, in relation to changes in demand, and to money, credit, and price changes and resistance to change, would be present and adequate to give rise to all characteristic manifestations now met with. The example is especially in point since the "production period" would be clearly zero length. Under these conditions no one would think of trying to compute and average period of immobility for a fraction of the productive resources of society and treat it as a "period of production". In this case, music production is provided by the choir and simultaneously enjoyed in the form of consumption and therefore a waiting or production period can not be deduced from this economic organization.

In conclusion, for Knight, Hayek's theory lacks tools that capture the dynamic effects that a lengthening or shortening of the investment structure has on the economic system.

## 6. Hayek's reply

Finally, Hayek (1936) agrees with Knight in the inability of APP to measure aggregate capital or capital intensity. In the words of Hayek (1936, 200) "I have full sympathy with those who see in the concept of a single or average period a meaningless abstraction which has little if any relationship to anything in the real world." Additionally, Hayek shares with Knight criticism of the theory of determining the interest rate based on time preference. Thus, the theoretical apparatus of Hayek fails to successfully integrate his monetary theory, his interest theory and capital theory.

The answers to Knight shown below are related to Hayek's explanations on how to move from equilibrium to disequilibrium by increasing the aggregate net investment without sacrificing the importance attached to time in determining the present and future production of the capitalist economy.

First, the "period of investment" means the number of periods of the invested factors, but not the way that Knight (1935) confuses the production period with the duration of the production of goods<sup>26</sup>.

Second, investment periods can not be reduced to a simplified time dimension as an average. According to Hayek (1936, 206): "In general it is sufficient to say that the investment period of some factors has been lengthened, while those of all others have remained unchanged; or that the investment periods of a greater quantity of factors whose investment periods have been lengthened than the quantity of factors whose investment periods have been shortened by an equal amount; or that the investment period of a given quantity of factors has been lengthened by more than the investment period of another equal amount has been shortened". Finally, the net effect of an average period would produce different investment periods would be unpredictable. For Hayek, the obstacle to overcome is the inclusion of accrued interest, which has to be taken into account together with the corresponding value of the invested factors in that period and the uncertainty that directs capitalists to establish different investment periods.

Third, the investment period only looking to the future depends on the distinction between original factors of production and the means of production. This concern is shared by Schumpeter (1954, 908) "One of those features of Böhm-Bawerk's schema that seemed most ridiculous to critics-

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<sup>26</sup> However, Hayek and Machlup finally recognized (1935, 584) that the term 'period of production' causes an unfortunate interpretation, which Machlup affirms by saying, "one thinks of the duration of the process of production proper". Later he adds "First, frankly it should be stated that all objections to "period of production" as a name for composite period that meant by Böhm's concept are fully justified" (Machlup 1935, 585).

that his period of production seems to start from a state in which all production proceeds without any tools or materials at all and people catch fish with their bare hands-can be removed so soon as we realize that all economic theory is a theory of planning and inevitably had to accept the results of the past-plant equipment, and stocks all included-as data. We shall then cease to try to construct an economic process *ab ovo* and, looking forward looking only, consider instead of the 'amount of the investment of capital,' the 'amount of investment' to be done". However, the aggregate capital prior to the initiation of a investment process that aims to increase the capital, is taken as a mere datum, an exogenous factor that deserves no justification, so that leaves part of the cumulative process without explanation. But to avoid circular reasoning he only wants to know how long the different factors of production are invested before they mature into production and thus preventing his theory depends upon the distinction between original factors, primary factors or means of production.

However, Hayek said that the information on that initial capitalization allows deducing the appropriate current income among all the possible alternatives that may be generated by increasing the net investment. The income stream selected will depend, according to Hayek (1936, 220), "on which will best combine with the services of the permanent factors which are expected to become available during the future- best in this context meaning that it will combine into a total stream of the most desired time-shape."

Fourth, for Hayek, the initial capitalization also restricts the choice of production methods. Indeed, by choosing the number of time periods of the invested capital, it will establish the required output growth worth waiting for the increased returns on invested resources<sup>27</sup>. However, the difficulty emerges when "it has to deal largely with joint-product and joint-demand relationships between goods existing at different moments of time" (Hayek 1936, 221).

Fifth, Hayek rejects Knight's analysis of aggregate capital because it is a quantity that can not be considered as an exogenous factor with constant value. In that sense, capital is a perpetual entity consisting of fixed assets that are replaced by others of equal value, so that the aggregate gain obtained by adding the perpetual income of each component remains constant. Hayek thinks otherwise, worn-out capital equipment can be replaced by new equipment that will produce new services that will change the value of the aggregate stock of capital.

Sixth, Hayek stresses the importance of analyzing in detail the effects of changes in capital mobility when altering the value of some capital goods will modify the aggregate value of the capital stock. The aggregate capital treated by Knight as a fixed homogeneous entity excludes analysis of this possibility. In this way, Hayek argues that the appropriate way is to specify all the components of the initial endowment of capital, as there is not a common attribute to classify them into a specific group. However, Hayek did not respond to Knight's objections about the immobility of capital in economic downturns.

The conclusion in this section is the impairment of the capital theories of Knight and Hayek to explain the determination of the new equilibrium under dynamic conditions<sup>28</sup>. Knight was able to be incisive and Hayek was forced to abandon not only the use of APP to calculate the aggregated value, but to use the term period of investment.

However, the difficulties of APP or investment were revealed by Hayek (1936) in *The Maintenance of Capital*. At equilibrium, the magnitude of the aggregate capital may be supposed constant, provided that the process leading to the equilibrium state is described. In other words, we must ask, why should the magnitude of the capital remain constant when conditions that determine the equilibrium of the economic system are changing?

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<sup>27</sup> The maximization process can be inferred from Hayek should answer the question-What is the period of investment a given capital stock will generate the highest level of production?

<sup>28</sup> Knight assumes perfect foresight.

The key for Hayek resides in the mobility of capital, because in discussing the conditions of equilibrium the capital has been considered quantitatively determined as a fund whose resources can be reallocated between different production lines without altering its value. Then, the analysis should establish the conditions under which the changes suffered by the economic system do not alter the aggregate size of capital.

Indeed, by altering the initial conditions of the equilibrium, the value of the initial aggregate capital will change as a result of changes in the value of some of its components, and the capitalists will then make investment decisions that will keep their stock with the same value before the change. In this manner, the capitalist will select readjustment processes to maintain and replace the existing capital, processes to generate net additions of capital (net investment) and to reduce investment.

According to Hayek, the analysis of each process starts with a given allocation of capital that defines the level of income and savings after deducting from the gross output the cost of the maintenance of the capital, and in parallel, the net additions or the required quantities of capital goods destined for depreciation. Thus, the discounts would determine the value of savings and the corresponding investment magnitude<sup>29</sup>. That means, if the invested resources produced capital goods “in exactly the quantity and composition that is required to keep the stock of capital intact” (Hayek 1935, 244).

Then Hayek asks, why capitalists should maintain their capital constant? For the capitalists, this avoids spending inadvertently the income earned by their capital and therefore, they make maintaining their capital constant as a starting point or standard for comparison with other cases in which different income streams might be preferred. Also, because the decisions made by capitalists on their capital affect other incomes such as the worker's.

Therefore, the following two sections discuss the decision of the capitalists<sup>30</sup> concerning their capital equipment and the effects on the stability of equilibrium, after the initial equilibrium is altered under perfect and imperfect foresight.

## **7. The action of the capitalist with perfect foresight**

According to Hayek (1935), every capitalist tries to maintain a constant stream of income from its capital stock. To do this, we will assume that capitalists anticipate all the changes that affect the profitability of their investment for the duration of it without concern for the investment sector. Also, the expectation on the interest rate at which the capital recovered will be reinvested, will be taken into account.

By the following example, the objective of Hayek is to explain how capitalists react to foresight changes. Since the beginning equilibrium is defined as a constant amount of capital whose value depends on the income stream and assumes that the capitalist anticipates the following:

- i. Changes in relative prices originate in changes in demand for goods.
- ii. Changes in the cost and supply of production factors strengthen changes in factor prices (including changes in interest rate).

Because of this, the capitalist will reinvest the monetary contributions that constitute the amortization fund of its capital in industries that provide the highest returns. In addition, if the work (available and uniform) is assumed as scarce, the value and the trend of its expected investment returns will depend on the relative amount of work required in industries where there is high demand for goods.

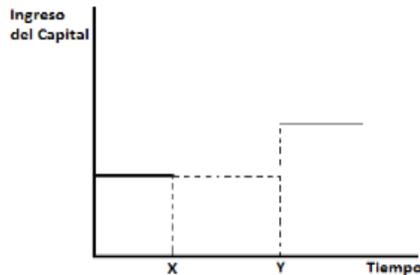
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<sup>29</sup> For Hayek, this is the main problem of his theory of cycles, a lack of a concept of income.

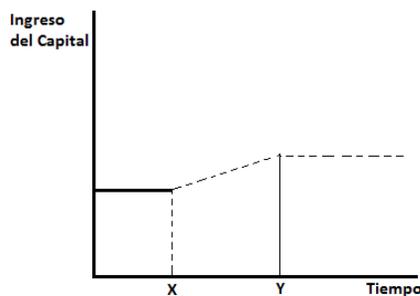
<sup>30</sup> Hayek assumes they are the same for entrepreneurs.

Indeed, if the industry where demand is increasing is relatively capital intensive, in general the wages of its workers will fall. This reduction will be enhanced by the transference of amortization resources belonging to other industries, and returns from capital will increase.

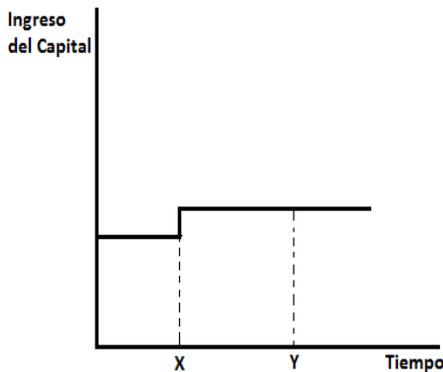
In short, gross profits of the capitalists will increase due to increases in income that are then redistributed between consumption and investment and by increase of expected returns from reinvestment of these resources. From this moment, there will be a maximum investment period that elapses between the time that change is anticipated (X) and the time when it occurs (Y). When the moment of change is going to occur is known the rational behavior of the owners of capital will be to maintain a constant income stream by reinvesting their increased gross income. The three stages of analysis are<sup>31</sup>:



*The capitalists consume as before.* From the moment (X) they will increase their income stream, increasing the monetary value of reinvestment. When change does occur (Y), they will have accumulated a larger stock of capital that will provide them with high and constant returns.



*The capitalists reinvest the same amount of revenue.* From the moment (X), the capitalists will increase demand for consumer goods and because they favor present consumption before future consumption, the interest rate will raise. For this reason, during the investment period X-Y, the monetary value of capital will remain constant. But the reinvestment rate with the higher interest will raise gradually incomes until they reach (Y) and thereafter will remain at a higher level.



*The capitalists increase consumption.* From the moment (X) capitalists will increase consumption to keep it unaltered permanently, and at the same time reduce their reinvestment in such a way that at (Y) they will possess a lower capital stock with a higher interest rate. However, despite the fall in investment that reduces the capital stock, income increases from (X) and thereafter, remains high because of the higher interest rate. According to Hayek, this scenario exemplifies a rational behavior that capitalist will get capital income that remains stable after the disturbance of equilibrium.

<sup>31</sup> Graphics in Hayek (1935, 253)

## 8. The action of the capitalist with imperfect foresight

The capitalist notices unanticipated changes after the investment is made- we will call that moment (X). If anticipated changes affect the return on that investment, Hayek asks how the capitalist will react after that change to maintain a constant income stream. He answers that the unexpected change will generate more or less gross earnings to those they expected to get in advance during the lifetime of their capital equipment. Also he pointed out that the investment period will elapse when the time change occurs until the end of .the life of the investment. Unlike the planned changes, Hayek assumed that incomes from capital will decrease due to a fall in the prices in the following cases:

*The capitalists consume as before.* If at the time (X) capitalist's income decreases to par with the previous level of consumption, the capitalist may keep it for the duration of its investment, but this will reduce funding for depreciation. Therefore, this action ends up depleting income from investment, leaves the capitalist with a very small amortization fund, which resources, reinvested in that period at the current interest rate, will generate a capital income stream lower than that obtained after the change.

*Capitalists reduce consumption after the change to a level that keeps it constant.* If at the time (X), capitalists reduce their consumption below the new income, a little surplus will be generated. The reinvestment of this surplus- with constant capital value- at the prevailing interest rate during the investment term, will allow the capitalist to maintain the consumption level after the change to the end of the investment. Thus, the income stream will remain constant after the alteration of the equilibrium.

*The capitalists reduce their consumption.* If at time (X), the capitalist decreases income and maintains the same amounts allocated to depreciation, the capitalist will have no other option than to sacrifice most of their consumption during the remaining period of the investment. Thus, in this period the capitalist will recover the value of the capital originally invested and will be able to reinvest the proceeds of this capital at the prevailing interest rate. Therefore, when the life of the investment ends, the capitalist will have enough income to increase his consumption until it becomes constant at the same level as it was before the change occurred.

However, Hayek is aware that these scenarios have deficiencies because of imperfect foresight. The capitalists do not have an objective standard because they do not possess the same degree of foresight, because their anticipations depend on the level of knowledge on which they are based on<sup>32</sup>. This diversity of estimates is what determines how much the capitalists can gain in different projected periods, making it difficult to obtain a unique path in the income stream of capital. Hayek (1935, 262): ) says: "where the probability of the occurrence of the change was correctly anticipated, deviations of the individual cases from what was regarded as most probable are likely to balance in their effect, so that capitalists as a whole will succeed in keeping their income stream constant. But, where the changes were completely unforeseen, there is no reason to expect that gains and losses will balance in this way, so that at least total incomes from capital would remain constant. It is much more likely that in such a case, if the capitalists behave as described, it will have the effect of either permanently decreasing or permanently increasing the income from capital".

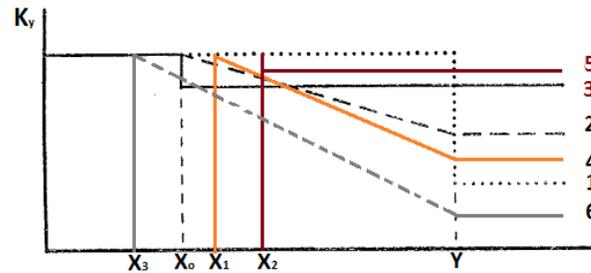
For this reason, the main obstacle of APP arises when the effects of changes as inventions, real demand and supply factors in the future are planned at different points in time by every capitalist.

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<sup>32</sup> Probably, this idea may come from the Hayek's knowledge of the work done by the "Mayer Circle", as presented in Boehm (1992). In particular, the work of Morgenstern (1935b), translated in 1976 by Knight from German into English, showing the arguments against the use of the notion of perfect foresight is plagued by inconsistencies that prevent an adequate basis for considering the equilibrium theory. According to Boehm (1992), Hayek (1937) acknowledged his debt to the "Mayer Circle" but I think that Hayek (1935) shows that he was being influenced by it.

If we take the cases on the behavior of capitalists under imperfect foresight, we would find that they anticipate the occurrence of a change at different points in time which prevents the determination of an average investment period. Both uncertainty and the use of compound interest rate conspire against APP as a tool for analyzing the processes of capital accumulation. As shown in Diagram No. 1<sup>33</sup>, each capitalist makes a subjective advance of the exact moment that the change can occur (at time X).

Diagram No 1



As a result of this, Hayek sought to demonstrate whether changes in the initial state of equilibrium characterized by maintaining aggregate capital constant produce adjustments that will lead to a new equilibrium point at which the system will converge; that is, a globally stable adjustment (Gandolfo, 1987). Against unforeseen changes, the use of comparative statics is irrelevant; it is not possible to predict the path that will determine the new extent of income from the capital, whether it is increasing, decreasing or remains constant.

## 9. Conclusions

Knight's (1933) sharp criticism of the production period and APP are accepted without objection by Hayek (1936). For the latter, with imperfect foresight, the difficulties of measuring aggregate capital in dynamic situations are obvious<sup>34</sup> and can not prove that a path can be developed *ex ante* to the new equilibrium. Therefore, Hayek's theory of capital under the general equilibrium theory lacks tools to adequately describe the process that will redirect the economic system towards a new equilibrium, highlighting the problems of ensuring stability.

Although Knight (1933) forced Hayek to replace the term *period of production* for *period of investment*, could not escaped the criticism of circularity in production. For example, Gaistkell (1938, 591) argues that Hayek "He does not however make any attempt to examine how far the criticisms may also apply to the "looking forward" version which he is apparently defending".

However, Knight's concept of capital also suffers analytical deficiencies in dynamic situations. For Hayek (1936), it is an error to define the aggregate capital as a constant value with eternal life, and insists that they must first determine the conditions that maintain the value of aggregate capital intact. Hayek suggests that the best way is to describe the initial endowment of capital goods, would be to be aware of the discounts that would arise for maintenance and depreciation. Hayek therefore considers that his theory of capital, like that of Knight, only makes sense in an equilibrium situation with perfect foresight on the part of venture capitalists.

<sup>33</sup> Elaborated by autor.

<sup>34</sup> Although Hayek (1936) proposed that the way of measuring the aggregate capital through the production period should be changed. However, in this same work, he doesn't present the new way to calculate it. His only interest is to make clear that the investment period can determined the number of periods required by a given capital to get a steady income stream.

The mobility of capital is the most complex issue in the dispute. For Hayek the mobility of capital is subject to the differences between profit rates of different industries. In contrast, for Knight it depends on liquidity, price rigidities, the organic functioning of the economic system and the complementary transfer of capital and labor, that depression can be a barrier that interrupts the transfer of productive resources. However, according to Kurz (1987), Knight's theory of capital naively tries to avoid the problem of circularity by letting the interest rate depends only on the rate of investment made and its future stream of income brought to present value.

Hayek also tried to explain how the process of capital mobility in disequilibrium would end in over-investment of capital in society. However, his theory of business cycles built upon the Walrasian general equilibrium theory and the capital of Böhm-Bawerk lacked tools to calculate the aggregate capital and arguments demonstrating that the greater the investment period, the greater the aggregate capital. For this reason, it can not be determined if the economy would expand or contract.

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