

CAPITAL: THREE-DIMENSIONALLY SPEAKING

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1. Introduction

It is hardly controversial to say that the emergence of prosperity in the world has something to do with the phenomenon of ‘capital’. Karl Marx characterized that period of greatest creation of surplus as being ‘capitalist’ in nature, and his seminal work features *Kapital* in the title (Marx, 1867)). He was thinking in terms of social classes coterminous with economic function, and the “capitalists” were the employers who, by virtue of their financial power, were able to organize production and appropriate the surplus.

In this we see a connection back to the common notion of capital as finance, as a money value attributed to, or invested in, a productive venture. Adam Smith had expanded the meaning of capital to include physical produced means of production (capital goods – tools, machines, buildings, etc.) (Hodgson, 2014). And it was this latter, physical, connotation, with tenuous connection to its prior, common sense, financial meaning, that dominated subsequent discussion.

In expanding the essential vision of a “capital-structure” - a structure of production, articulated by Carl Menger (1871), Eugen von Böhm-Bawerk developed the well-known Austrian Theory of Capital (1890). Menger’s key insight and arguably most valuable contribution, was the role of time in production and, therefore, in production decisions.¹ He was not specific (in 1871) about the nature or form of “capital”. But Böhm-Bawerk followed the Smithian conception of capital as a collection of physical production-goods, produced by labor and nature (land) onto which he added the dimension of time. And it was Böhm-Bawerk’s seminal work that set off the famous subsequent debates or controversies that characterize the development of capital theory, echoes of which still reverberate through the metaphorical hallways of academic journals (see Cohen 2010 for a useful summary). These controversies share key essentials and they all involve the nature of capital, more specifically, the *dimensions* of capital. As early as 1888 Menger had expressed misgivings about Böhm-Bawerk’s approach and clearly stated his view that capital was about financial valuation not about physical production *per se* (Menger, 1888, Braun, 2015--, Braun et. al., 2016).

It was Böhm-Bawerk’s work that provided the basis for the development of the neo-classical approach to capital, though transformed in such a way that it suppressed the role of time in production. The conceptual device used was the production-function. The suppression of time is accomplished by the assumption of the enduring existence of equilibrium, by which one is able to think of time as perfectly analogous to space. In neo-classical equilibrium it is possible to write the variable K to represent the aggregate of all production-goods; the array of heterogeneous items is rendered commensurable by using their prices (values) to add them together. In this way it becomes possible to conceive of K as a “physical” quantity, albeit one aggregated in *value*-terms.

Unfortunately, the assumption of equilibrium banishes the important question of how the earnings of capital are determined. And the observation that a K magnitude thus obtained could not be shown to vary monotonically with the rate of interest (understood confusingly as the “rate of profit” on capital) added to the problem. It suggested the bankruptcy of neoclassical production theory since K could not be shown to be a

¹ Similarly, but differently, with William Stanley Jevons, another of the three initiators of the 1871 marginalist revolution. Jevons’s depiction of time in production was the basis of later contributions by Wicksell and Hayek among others.

well-behaved factor of production with a downward-sloping demand curve and a price determined to explain its marginal product and, therefore, its earnings.

In other words, whatever its other merits, Böhm-Bawerk's decision to treat capital as a physical entity set in motion a series of unfortunate events in the development of capital theory, that, arguably, might have been avoided had the focus remained on the real-world context of production and investment decisions and how decision-making in a money-using economy actually occurs, an economy notably in perpetual disequilibrium. The marginalist revolution in economics changed the way *economists* thought about capital, but not the way *capitalists* did. The latter has remained a constant, which, thanks to the theory of finance, we have come to understand better. But economists have remained all but oblivious to the gap between the nature of capital in the world and the nature of capital that features in their models.

This paper explores that theme. Section 2 following examines approaches to understanding capital that focus on each of its three dimensions in turn. We conclude that the "capital as value" approach is the most cogent and helpful. It is an approach that suggests that the concept of capital is "institutionally specific," a creature of particular social institutions that we associate with *capitalism*. We turn in section 4 to an examination of the benefits of this approach when applied in a macroeconomic context. Section 4 concludes.

2. The Dimensions of Capital

Capital (I am not the first to discover) is a very large subject, with many aspects; wherever one starts, it is hard to bring more than a few of them into view. It is just as if one were making pictures of a building; though it is the same building, it looks quite different from different angles. As I now realize, I have been walking round my subject, taking different views of it (Hicks, 1973: v).

The difficulties that attach to capital theory are related to the fact that capital has three "dimensions"², namely, *value*, *quantity (matter)* and *time*. These interact in any decision involving the concept of capital. The history of capital theory has focused at different times on each of these three aspects of capital. At all times all three dimensions of capital are part of its nature, what changes is what is the focus of the foreground and what is operating implicitly or less-notably in the background.

2.1. Capital as Time

For Böhm-Bawerk the time aspect is in the foreground. He picked up on Menger's insight that time plays a crucial role in production and in economic growth and development. As economic growth and rising incomes allows producers to take more time in the development of better, more efficient, production techniques, production becomes more "roundabout", more complex. Roundabout methods of production will only be chosen if they are more productive of value (utility). Complex production-goods and techniques (and the same might be said of labor-services) are developed.

In referring to roundabout production, Böhm-Bawerk wanted to highlight the role of time, namely the intuition that complex, specialized production processes have come to embody "more" time. Requiring more time is an important aspect of the project that the potential investor must take into account in appraising it. If one has to wait longer on average for its rewards, one must be compensated for the wait. But, as Böhm-Bawerk's discussions with his critics developed, he turned his attention to the question of how much time can be said to be embodied already in any given (even completed) project. A prospective or forward-looking perspective morphed into a retrospective or backward-looking perspective – or into a discussion in which the two are interchangeable – because of the assumption of equilibrium. In a changing world, "looking-back" is not the same as "looking forward" but in a static equilibrium world they are. In such a world, projects look the same at whatever point in time one looks at them (Hicks, 1973; Lewin, 2011, p. 102). Böhm-Bawerk tried to find a measure of the amount of time embodied in any project, looked at from any perspective, in the sense of how

² The scare quotes indicate that "dimensions" may not be quite appropriate to describe the relationship between capital as a value and the combination of physical (and possibly human and/or intangible) assets that are being valued by it. Perhaps we may more accurately say that there is a physical *aspect* to capital-as-value in its connection to what it is that is being valued. Of which more below. The same is true of the connection to time. Everything occurs "in time" and cannot be separated from it. So it might more accurate to say two dimensions – value-time and quantity-time. The terminology of three dimensions is, however, appropriate for what we want to convey.

much time it would take to set up that project from scratch (tracing its components all the way back to the original nature-given substances and labor). In pushing this line of reasoning, the more precise he endeavored to become, the more ambiguous and elusive his essential point became. We may explain this briefly as follows.

Böhm-Bawerk wanted to measure “embodied time” – the amount of time embodied in any production project. Realizing that some arbitrariness attached to the period over which any productive combination extends, from the original labor (and land) to the final product – having to contemplate points far back in time – Böhm-Bawerk proposed a more tractable measure of time that he called the average-period-of-production (APP). The APP is the labor-weighted average of the amount of time applied in the project. It is an input-weighted average. It relies on the ability to add-up units of labor – that is, it presumes that labor services are homogeneous and can be used to gauge the intensity of time applied (labor-hours).

The shift in perspective and the use of an input-weighted measure arguably departed significantly from the original vision laid out by Menger, which, purportedly led Menger to regard Böhm-Bawerk’s treatment of capital and time as a serious mistake. In any case, the APP provoked a vigorous response leading to the accumulation of a large literature. The measure itself is designed to be a physical (quantitative) measure. The weights are physical labor units and time is in units of time. There is apparently no value dimension. However, it soon becomes clear that whenever time is involved, value necessarily enters into the calculation in the form of the rate of discount (accumulation). Inputs applied at different points in time do not exchange one for one. In that way the APP came to be seen as problematic – and in other ways too that need not be repeated here (see Lewin, 2011, pp. 69–78).

Böhm-Bawerk’s approach was very influential and provided a basis for work done by Austrians, neoclassicals, and Marxists (Neo-Ricardians). And the vast literature in capital and growth theory related directly or indirectly to Böhm-Bawerk’s conception raised some interesting questions from which the Austrians in particular learned a lot, even as they attempted to grapple with what was right and what was wrong with Böhm-Bawerk’s approach (Lewin, 2011, pp. 73–78). This involved a change in the focus from the dimension of *time* to the dimension of *quantity* – to the focus of capital as composed of physical production-goods.

2.2. Capital as Physical Stuff

When it became obvious that the APP could not provide a measure of capital in purely physical terms, the question of alternative ways to measure and aggregate physical-capital arose. Ludwig Lachmann (1956, Lewin 1997) maintained that, outside of equilibrium there was simply no way to aggregate the bewildering variety of heterogeneous production-goods. In reality capital was not a stock of anything. It was, rather, a structure of different things fitting together to serve the purposes of their employers.

In a now famous quote, Lachmann explains:

The generic concept of capital without which economists cannot do their work has no measurable counterpart among material objects; it reflects the entrepreneurial appraisal of such objects. Beer barrels and blast furnaces, harbor installations and hotel room furniture are capital not by virtue of their physical properties but by virtue of their economic functions. Something is capital because the market, the consensus of entrepreneurial minds, regards it as capable of yielding an income... [though heterogeneous in nature] the stock of capital used by society does not present a picture of chaos. Its arrangement is not arbitrary. There is some order to it. (Lachmann, 1956, p. xv).

Lachmann’s work in the 1940’s, culminating in his 1956 book, was prompted in large part by the experience of his mentor and colleague Friedrich Hayek in the 1930’s and 1940’s. In the ferment of the rise to dominance of the economics of John Maynard Keynes, Hayek struggled to present a counter point of view that relied on the Austrian Theory of Capital. In his explanation of the business cycle Hayek used a stylized version of Böhm-Bawerk’s story, known today as Hayek’s triangle, in which input-time could be measured along one side of a triangle with output being measured along the other side. The diagonal represented the accumulation of output (and input) value with time.

Hayek spent many years reexamining the problem of how effectively to represent the role of time in production in a more satisfactory way, a quest that ended unsatisfactorily with his book *The Pure Theory of Capital*

(1941). Lachmann's book was, in a sense, the culmination or the abandonment of that project. In equilibrium it was difficult enough, outside of equilibrium there was no way to aggregate physical capital. Nor was it necessary to do so for an understanding of the workings of a "capitalist" economy. Such economies were characterized by complex, dynamic, multi-level production structures that were the result of human action in the pursuit of profit, but manifestly in their complexity, not of human design. These structures are prime examples of the spontaneous ordering ability of market economies, that continually shuffle the complementary, multi-specific elements of production, resulting in an ever-changing assortment of consumer-goods (Endres and Harper, 2011).

This vision of the capital structure has become a staple of Austrian scholarship alluded to particularly in expositions of Austrian business cycle theory (ABCT). ABCT relies on the idea that credit-induced cycles, by reducing interest-rates below their equilibrium (sustainable) levels, cause malinvestments by making "longer-term" investments appear relatively more profitable than previously. The increase in longer-term investment, based on the illusion of cheap money, cannot be sustained. The end-result is a reversal back toward more sustainable shorter-term investments. The cycle is costly and painful because production-goods are heterogeneous and specific to particular types of production – not easily redeployed. Capital losses are inevitable.

Heterogeneity and specificity add to the plausibility of the story, but it is a two-edged sword. As our discussion above explained, there is no unambiguous meaning that can be attached to the descriptors "longer-term" and "shorter-term" investments in the sense of the "amount of time" embodied in the production-goods used. Hayek used the notion of stages of production, suggesting that some stages were "further back" in the production process and therefore took "more time" to come to completion. The cycle was characterized by a shift toward earlier stages and then back again. But in a world of complex, ever-changing production structures, this picture of a linear supply chain is inadequate. It does not yield the relationship between discount rates and production processes that is required for the ABCT (Cachanosky and Lewin, 2014, 2016).

Thus, even while shifting to a focus on the physical dimension of capital by affirming the heterogeneity of production-goods and the implication that they existed as a structure and not as a stock of commensurable, aggregable items, Austrians persisted in referring to individual production process as being "longer" or "shorter" in an indefinable but intuitive way. Some authors were at pains to point out that these descriptors referred only to the perception of the would-be investor as he appraised the particular production-process. But the nature of this perception and how it was supposed to vary with changes in interest (discount) rates was left unspecified. In this way the attempt to "hold onto" the dimension of time, even while embracing a physical definition of capital, has proven illusory. There is something missing.³

2.3. Capital as Aggregate Stuff

In neoclassical economics capital theory all but disappeared and became subsumed into growth theory (Solow, 1956, 1957). This theory evaded the implications of physical and functional heterogeneity using the construct of the production function and the assumption of enduring equilibrium. The later Austrian (Lachmannian) theory of capital moved away from the time aspect of capital toward a focus on the physical aspect (physical properties influencing economic function). While this was true of the neoclassical treatment as well, the details were very different and diametrically opposed in their implications. The neoclassical production function makes use of categories or aggregates of inputs that are composed of homogeneous elements. Insofar as attempts are made to connect the implications of the theory to real world phenomena, aggregation is accomplished by transforming physical production-goods to their estimated *value*. What results is what Franklin Fisher (2005)⁴ has called aggregate "quantities measured in value terms". Measured in value

³ To be sure, Lachmann (1956) tries to preserve the intuition of Böhm-Bawerk's 'roundaboutness' by using the notion of increasing "complexity" of production, by which he (like Hayek) means basically an increase in the number of "stages of production". A more up to date notion of 'complexity' in terms of our current understanding of the nature of complex systems indicating multiple interactive forces, as, for example, addressed in Hayek's discussion of "complex phenomena" (Hayek, 1964), is even more descriptive of reality. But, interesting and helpful as this is, it does not directly address the role of time in relation to value) as perceived by the entrepreneurial decision-maker.

⁴ For some time now work by Franklin Fisher and his collaborators have shown conclusively that the notion of an aggregate production function (and by implication most likely also most of all microeconomic (disaggregated) production functions cannot be said to "exist" in any economically meaningful sense (Fisher, 1993). In a 2005 article Fisher proclaimed.

terms, but interpreted in physical terms – these aggregates are meant to depict a mechanistic relationship between inputs and outputs that obscures completely the role of time in production and elides the value dimension.

Ironically, the necessity to resort to value-weights in order to come up with the notion of K in the production function, invited the criticisms of the neo-Ricardians as to the logical cogency of the whole enterprise. Their criticisms applied equally whether the aggregate K was considered to be a dollar aggregate or an aggregate of labor-inputs. In effect, in the latter case, marked-up dated-labor was used as the unit of value. Either way it was easy to show that K did not, could not, possess the characteristics necessary for a quantity-input into a well-behaved neoclassical production function, namely a quantity whose marginal product was well defined and diminished with the quantity employed. Rather, the notion of “capital intensity” (K/L) proved difficult to sustain and optimum “techniques” defined in terms of these aggregates did not vary monotonically with their price ratio (w/r). Instead, variations in this price ratio could be shown to produce switches in technique to more and then less “capital-intensity”, an apparently paradoxical result.⁵

In fact, the result is neither paradoxical nor surprising but a necessary result of the surreptitious use of *values* to measure *quantities*. The definition of “optimum” technique must employ some notion of value. And this being the case, reswitching is a logical possibility of the fact that the value of any project may rise and fall non-monotonically with changes in the rate of interest depending on the pattern of outputs over time, of which more below. The key point here is that this approach to capital fails in its attempt to suppress the heterogeneity of capital-goods and the role of time – the dimensions of value and time. We are left with a very limited one-dimensional reflection of a three-dimensional phenomenon.

2.4. Capital as Value

The old and ubiquitous conception of capital as a sum of money available for investment in a productive venture, is a key element of the value dimension of capital. That sum of money is equivalent to the present value of the returns to the investment in the productive venture where the internal rate of return is used as the discount rate. At the prevailing market interest rate (or any rate considered the appropriate opportunity cost of capital) the expected present value of those returns (net of expenses) constitute the “capital” of the business.

This approach to capital is shared by small number of significant economists, including Irving Fisher, Frank Fetter and Ludwig von Mises (Fisher, 1906; Fetter, 1930, 1977; Mises, 1949). This view sees the concept of capital not as a physical entity, but rather as a mental tool of *evaluation, estimation* and *calculation*, a product of social evolution developed in order to facilitate the making of investment decisions. According to Fetter,

Capital is defined as a conception of individual riches having real meaning only within the price system and the market where it originated, and developing with the spread of the *financial calculus* in business practice (Fetter, 1930, p. 190, *italics added*; Hodgson, 2014, p. 1069).

And according to Mises,

Capital is the sum of the money-equivalent of all assets minus the sum of the money-equivalent of all liabilities as dedicated at a definite date to the conduct of the operations of a

While, over some restricted range of the data, approximations may appear to fit, good approximations to the true underlying technical relations require close approximation to the stringent aggregation conditions, and this is not a sensible thing to suppose. ... When one works – as one must at an aggregate level – with *quantities measured in value terms*, the appearance of a well-behaved aggregate production function tells one nothing at all about whether there really is one. Such an appearance stems from the accounting identity that relates the value of outputs to the value of inputs – *nothing more* (Fisher, 2005, p. 489; first set of *italics ours*).

⁵ This refers to the famous debate of the Cambridges, the details of which need not concern us here and which will be familiar to many readers. The standard neoclassical production function is of the form $Q = F(K, L)$, Q , K and L are composites (aggregates) purportedly measuring the *quantity* of production, *quantity* of capital employed and *quantity* of labor employed. w is the wage rate of labor L , and r is the “rate of profit” of capital K . More accurately there are two separate concepts, the rental rate on capital-goods, being the price of their productive services divided by the price of goods, and the rate of interest, being the price of time (the cost of financial capital). In the Cambridge debate these two concepts are confounded, as the “rate of profit” with unfortunate results (See Lewin and Cachanosky, 2019: appendix).

definite business unit. It does not matter in what these assets may consist, whether they are pieces of land, buildings, equipment, tools, goods of any kind and order, claims, receivables, cash, or whatever (Mises, 1949, p. 262: italics added).

So, the connection between the capital of the business (any productive venture or investment) and the *physical* components of production is clear. Capital refers to the value (evaluation, capitalization of the returns) of the outputs that the employment of those physical inputs produce. There is a distinction between "capital" and "capital goods", and, concerning the latter, there is no real distinction between the services of physical production goods and the services of labor.⁶

Fisher (1906) develops a book length accounting approach to the theory of capital according to which valuable phenomena can be classified into two broad categories, *stocks* or *flows*, or, more specifically, capital and income. Income consists of a flow of services that consumers value, like nutrition, shelter, security, entertainment. The physical items that produce these services have value because, and only because, they produce these valuable services. The value of the sources of these services is the valuer's estimation of the (net) value of the services that can and will be produced by them for oneself or for sale for money, taking due account of the time-value of money (discounting). Thus, Irving Fisher, makes no distinction between different sources of income, physical or human, owned or unowned. A capital-value is an individualistic, institutionally contextual, phenomenon. It is the value an interested individual puts upon a particular productive project or process.⁷

Where is the time dimension in this capital-as-value approach? In fact, the focus on value reveals the role that time plays quite clearly. It is an important aspect of the investor's decision-making process. Production takes time, and, therefore, one frequently has to wait for the return on one's investment. Since a dollar received at different times, notably, in the present compared to sometime in the future, are not valued equally, account must be taken of the point in time of receipt of the (cash-flow) returns. There is a "time-value" to money (aka. time-preference) which is the basis of the universal arithmetic of present-value calculations. The investor is concerned not only about the magnitude of the return on his investment, and the uncertainty that attaches to it, he is also concerned about the *time-pattern* of the expected returns. The "longer" he has to wait the less attractive, *ceteris paribus*, the investment will appear. But, as with the closely associated considerations faced by Böhm-Bawerk, this prompts the question, what do we mean by "longer"?

In this case, in stark contrast to that of Böhm-Bawerk, the quest is not for a measure of time in physical non-value terms, but rather, value is front and center, as it is in any real investment decision. And in this context there is a well-known logically coherent measure, namely, the average time for which an investor has to wait for a dollar, a measure that helps to characterize the investment. This is known as the *duration* (*D*) of the investment. Whereas Böhm-Bawerk's APP is a labor-input-weighted measure of production-time, *D* is a present-value-weighted measure of investment-time (of course equally applicable to an investment of any kind). As a forward-looking concept there is no difficulty demarcating the beginning and ending (investment horizon) times of the investment. And there is no ambiguity in calculating the weights once the discount rate is given.⁸

In fact, John Hicks had already suggested this measure as an alternative to Böhm-Bawerk's APP as early as 1939 (Hicks, 1939, p. 186; see also Lewin and Cachanosky, 2018, pp. 62-65), which he called the average period

⁶ J.B. Clark's includes the same claim regarding the financial nature of capital.

Ask a manufacturer, "What is your capital?" and he will probably express his answer in dollars. Ask him, "In what is your capital invested?" and he will specify the buildings, machines, land, materials, etc., in which his productive fund now chances to be embodied. These concrete things will figure in his thoughts as the containers of his capital; while the content itself will appear to him to be a value, an abstract quantum of wealth. He will think of it as a fund that is permanently his, though it may not retain for a single day its exact present form of embodiment . . . Capital is, in this view, an abstract fund, the destiny of which is to migrate thru an endless series of outward forms (Clark, 1888, pp. 9-10).

In other respects of course Clark and Böhm-Bawerk argued about the nature of capital in relation to its time dimension and its relevance in a real world disequilibrium market process.

⁷ He notes that, as a matter of accounting practice, only owned resources feature in capital accounts, though the services of all resources feature in income accounts, and he indicates at length how this inconsistency can be remedied by a more complete capital accounting procedure. For a discussion of this accounting aspect see Lewin and Cachanosky (2018).

⁸ The discount rate is conceptually distinct from the prices of the services of the factor inputs (their earnings) in contrast to the case involved in the context of the Cambridge debate.

(AP) and which had been independently discovered by the financial actuary Frederik Macaulay, who called it *duration*. Yet it remained neglected all through the following decades including the Cambridge debate.

The paradox noted by the Cambridge UK protagonists in that debate manifests in this context as a simple reversal in the change in magnitude of the present-value estimate of the investment. Changing the discount rate may produce non-monotonic changes in the ranking of the present-value of any investment that has non-uniform returns over time. For example, the time pattern of returns may be bi-modal, that is, the peaks may occur very early in the investment and then reduce for a while and rise to another peak late in the investment. Increasing the discount rate will decrease the present value of late returns relative to early returns (they are more interest-elastic because they are discounted over a longer period) and at some interest rate this effect may dominate causing the value-ranking of the investment to rise, with an increase in the discount rate, relative to an alternative investment that previously dominated it, sufficiently to reverse that ranking.⁹

This is not a paradox, it is a consequence of the logic of discounting. Any ranking of investments, involving different time-patterns of returns may thus be inconsistent over a range of different discount rates. If one understands "capital intensity" as the relative capital-value (present-value) of the business, the famous "paradox" emerges.¹⁰ But it is of no importance to the fundamental existence of "capital as such". It does not serve to invalidate the claim that the earnings of the factor inputs (to workers and the owners of physical production-goods) are determined by the value of their contributions (their value marginal products) to the capital-value of the investment – and this applies both in and out of equilibrium. Perhaps a capital-value approach to capital if accepted could have avoided the whole Cambridge debate and the two capital-controversies that preceded it!

3. Capital and the Institutions of Capitalism

Considering capital to be a conceptual component of financial calculus as suggested by Fetter, we can understand it as the an aspect of the evolved institutional nexus of capitalism. A capitalist economy consists of calculating individuals participating in a dynamic social process. Those who are socially positioned to decide where and how to deploy productive resources have need of conceptual tools to decide among the possible alternatives according to their expected profitability. These conceptual tools include market prices for products and hired inputs and accounting procedures for estimating depreciation and calculating profitability. *Capital accounting* – along with the institution of money - is an evolved social institution of capitalism. The capital of a business is the result of financial calculation, using money values. It is the calculator's estimate, given the information available to him and his expectations of the future events (transactions), namely, revenues, expenditures and internal costs, of the worth (profitability) of the business. Actual profits (losses) earned provide a judgement on his estimate, and condition his further actions through time. Without the conceptual apparatus of profit and loss accounting this would not be possible. Capital-value is made possible by the existence of money, enforceable claims to property, prices, and accounting methods. And without capital-value, potential investors could not make decisions. The financial face of capital is a necessary and inevitable component of the capitalist economy.

Yet, capital as value, within this institutional context, is easily connected to the other two dimensions of capital - time and quantity. Every capital-value is "capitalized" value, the result of the conceptual accumulation of a flow of additions and subtractions (cash flows) over time. This accumulation (or discounting) must take account of the time-value of money. Time is *accounted* for. Furthermore, given that the pattern of cash-flows over time is of importance to the investor, that pattern can be expressed in various ways using financial descriptors, most notably, the *duration* (D) of the investment, discussed above. D is a summary measure of "length" of the investment in the manner conceived by Böhm-Bawerk and Hayek. And it is also a measure of sensitivity of its capital-value with respect to changes in the discount rate. The dimension of time is fully

⁹ Duration, D , very closely approximates the percentage change in the value of the investment with respect to changes in the discount rate – for very small (instantaneous) changes it is exact. So, those investments with the higher D will change more for the same in rate of discount, even if having the same present-value to start with. A higher D , or a higher AP, average period in Hicks's terms, implies that on average its returns are received later rather than earlier – they are "back-loaded" rather than "front-loaded" (see Cachanosky and Lewin, 2014).

¹⁰ One could see this equally considering the internal rates of return of the various investments – of which there may be more than one. Every time-value of money equation has multiple roots (rates of return) the number being equal to the number of time periods in the investment. Some (most) of these might be complex numbers, some will be "orthodox" (real). See Osborne (2014).

represented in the financial approach. It is not simply the *magnitude* of value, but also the *time-pattern* of earnings that is captured.

All investments are connected at some remove to stocks of physical inputs conventionally referred to as "capital-goods". The capital-value of any business venture reflects the value of these owned resources obtained by estimating the earnings (cash flows) they make possible. Productive resources must be financially capitalized if they are to be part of a rational allocation decision. A financial approach to capital suggests that while capital is not composed of physical goods (tools), these goods, together with labor inputs, provide the physical backdrop to the financial facade that is necessary for investment decisions. The financial concept of capital is indispensable for the rational organization of productive resources in a capitalist economy.

4. Capital in Macroeconomics

The place of capital in the various approaches to macrocosmic is ambiguous at best and confused at worst.

4.1. Mainstream Macroeconomics

In the Keynesian-neoclassical mainstream capital features as a factor of production in growth theory and as the stock which is augmented by investment. In Keynes's work, the price-level takes a decidedly back seat. The focus is on quantities of productive equipment. But the issue of units is avoided. In Keynesian models, I is understood as the (aggregate, net) addition to the economy's "capital stock" K , ΔK . The inherent problems (both practical and theoretical) attaching to "quantities measured in value terms", such as K , and, therefore, I , have been explained above. Such notions as the "marginal efficiency of capital" or the "marginal efficiency of investment" seem to be vulnerable to the same criticisms that attach to the idea of capital as a factor of production in an aggregate production function.

This, however, needs to be qualified. If instead of understanding I in terms of quantity it is understood as the investment of financial capital for the economy as a whole – the funds spent on the addition of productive capacity as financed through the financial markets (not excluding self-financing) – it is perfectly sensible to think of this as yielding a (combined or weighted average) "rate of return" in value terms (though the result may have to be adjusted for estimated inflation). The same is true of so-called "government investment", G , of the $C + I + G$ equation. Debates in macroeconomic policy can be seen to hinge in part over the magnitude of these aggregate returns on aggregate investments.

4.2. Austrian Macroeconomics

In the debate over macroeconomic policy in the 1930's between Keynes and Hayek, at least as far as Hayek and the Austrians were concerned, capital theory played a key role. Hayek was disturbed by the microeconomic detail that Keynes's aggregates obscured, particularly with regard to the structure of production. And to expose this problem he turned to the Austrian theory of capital, at the time the most well-known contribution of the Austrian School, and to an application of it by his mentor and colleague Ludwig von Mises, that subsequently became known as the Austrian Business Cycle Theory (ABCT). It is the go-to theory of Austrian macroeconomic analysis of business cycles. Interestingly, the ABCT contains internal tensions or contradictions that derive from the capital theory of Böhm-Bawerk.

The ABCT rests on the claim that government credit-financed investment spending creates "malinvestment" – unsustainable investment projects. A monetary policy that expands the supply of money, pushing down interest rates, creates the mistaken impression that "long-term" investments have risen in profitability relative to "short-term" ones. Resource flow into these longer term investments only to be undone when it is ultimately revealed that the profits are illusory, there having been no real change in the resource abilities or availabilities for earning profits. It is the story of a boom-bust cycle, one that evidently has a degree of supportive intuition.

The theoretical, academic exposition of the ABCT (Mises, 1912; Hayek, 1931; Garrison, 2001) relies (implicitly and sometimes explicitly) on a notion of "production period" deriving from the Austrian tradition – from Böhm-Bawerk through Hayek. Hayek in his debate with Keynes used a simplification of Böhm-Bawerk's period of production in a two-dimensional triangle diagram (originating with Jevons, Hayek, 1931). It is a

quantity-based idea. Some researchers have connected it (following Hayek) to the number of “stages of production” and other “quantitative” manifestations of the time involved in production.¹¹

As discussed above, measures of time based on quantity are fundamentally incoherent. The ABCT is a value-based story. The fundamental idea is that falling interest rates lead to decreases in the discount rates used by entrepreneurs to calculate the (present) values of prospective investments. Falling discount rates lead to higher assessed values, more so for “long” versus “short” investments. But distinguishing investments on a spectrum of long versus short in *quantitative* terms (quantity-weighted units of time) is like using a piece from the wrong jigsaw puzzle to complete the picture. It does not fit. Consequently, versions of the ABCT using this quantitative measure of time are both incoherent and incomplete. Instead, one needs a value-based measure of the time involved in the investment, namely, the *duration* of the investments, as explained above. Projects of *higher duration* will appear to rise in profitability relative to those of *low profitability* in response to falling discount rates (Lewin and Cachanosky 2019). Recast in this way the ABCT obtains a degree of consistency that it was missing and poses clear implications for further discussion and examination.

5. Conclusion

Adhering consistently to the distinction between “capital-goods” and “capital” one is able to incorporate fully all the dimensions and nuances that attach to the concept of capital. The value approach to capital fills in the essential value element that the physical or quantitative approaches of Böhm-Bawerk and others were in danger of ignoring. At the same time, it is important to note that simple sums of money are not capital. To be capital a money value must be connected to, must refer to, the value of a flow of services expected from the use of a stock of productive resources (what is often in themselves referred to as “capital”, but more accurately should be called “capital goods”) over time. Such a value must, indeed, take account of time by incorporating a value adjustment for the elapse of time (and all that that involves) – hence discounting. Without the valuing procedure there is no capital, just as without the productive resources there is no capital. Capital is, in this sense, necessarily a three-dimensional entity.

¹¹ Hayek’s later work trying to remedy the problems with his stylized portrayal in *Prices and Production* led him to abandon the quest for a single-valued period of production to characterize a project in favor of multiple production periods for any project depending on both the *valuation* of inputs and outputs, and on the discount rate. This level of detail has not been incorporated into the ABCT, nor, it seems, could it be.

6. References

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