Abstract: Ludwig von Mises seems to be something of an outlier within the Austrian school when it comes to capital – though his position is clearly foreshadowed in a neglected article by Carl Menger (1888). In this paper we examine Mises’s view on capital and suggest that an incipient financial approach may be discerned, an approach to capital that integrates concepts from financial theory into a broader Austrian view of capital. We examine the distinction between physical and financial capital taking note of the contribution of Menger (1888) and, in more detail, of Mises. We apply modern financial theory to the financial concept of capital and conclude by noting some important implications of our discussion for the development of Austrian economics.
Ludwig von Mises never produced a work devoted solely to an exploration of the meaning of capital or its role in the economy. Böhm-Bawerk (1889), Hayek (1941), Lachmann (1956), and Kirzner (1966) all published books on the subject, in addition to numerous articles. But Mises’s views must be gleaned from his remarks in works devoted to other specific or general topics. He did not enter into any “capital controversy” or specifically consider them. Yet, his views on capital are interesting and highly suggestive in a way that we believe has not hitherto been explored. In particular Mises seems to be something of an outlier within the Austrian school when it comes to capital—though his position is clearly foreshadowed in a neglected article by Menger (1888). In this paper we examine Mises view on capital and suggest that an incipient financial approach may be discerned, an approach to capital that integrates concepts from financial theory into a broader Austrian view of capital.

In the next section we examine the distinction between physical and financial capital taking note of the contributions of Menger (1888) and of Mises. In section 3 we examine Mises’s capital theory in more detail. In sections 4 and 5 we apply modern financial theory to the financial concept of capital. Section 5 concludes by noting some important implications of our discussion for the development of Austrian economics.

2. Physical vs. financial-capital in the Austrian School

The term “capital” as used by economists is anything but unambiguous. Already the way Adam Smith expressed himself “invited confusion between money-capital on the one hand, and capital in the sense of capital goods on the other” (Hennings 1990: 112). This double meaning of capital—physical-capital or capital-goods vs. financial-capital or money-capital—has haunted economic theory ever since. Even three extensive and international controversies between leading economists on the role of capital in
economics have not settled the issue. Although the neoclassical side has, with Samuelson (1966), conceded the logic of the Neo-Ricardians concerning the neoclassical concept of capital as used in the aggregate production function, the concept is still employed as if nothing had happened. The settlement of the issue seems to have been adjourned sine die.

This ambiguity continues even within the Austrian School famous for its “Austrian Theory of Capital, which is suggestive of a high degree of uniformity on this. One could say that there is, in the Austrian School, a majority of economists who define capital in a physical way, as a technical requirement for considering roundabout methods of production. But there is also a minority consisting basically of two authors – Carl Menger and Ludwig von Mises – who want to confine the use of the term capital partly or totally to financial-capital. They do not regard capital as an ingredient to the production process, but as an important aspect of the organization of production by private agents when capital markets exist.

It must be added that the distinction between the minority and the majority view is not really a distinction between different authors. Carl Menger has contributed to both viewpoints as he changed his position on capital over the course of his life. In the words of Diehl (1926: 435), “in 1888, Carl Menger published his well-known essay ‘Zur Theorie des Kapitals’ [A Contribution to the Theory of Capital (Menger 1888)], where he adopted the point of view which he had fought in earlier days and considered it the nature of capital to be a sum of money dedicated to the acquisition of income.” Mises too adhered to the physical-capital concept in his early Theory of Money and Credit. In that work Mises was not addressing the nature of capital and decided to stick to Böhm-Bawerk’s viewpoint simply because he was not able to present his own one within the scope of the work.

Carl Menger’s later essay on capital is mostly ignored even by Austrian economists. Only very recently has the issue of a dissenting view on capital by the older Carl Menger been noted (Braun 2015a). Braun (2015a) focuses mainly on the differences between Menger (1871) and Menger (1888) and indicates the role of Menger’s turn to the concept of financial-capital for the further development of Austrian economics. Mises’s (1922; 1949) adoption of Menger’s (1888) financial-capital concept is only hinted at, leaving open the place of this concept in Mises’s whole system. In the remainder of this section, we demonstrate how Menger’s (1888) and Mises’s (1949) definition of capital deviate from the one usually connected to the Austrian school.

In his early “Principles of Economics,” Carl Menger laid the foundations for what was later to become the Austrian Theory of Capital. In contrast to the classical British authors, he distinguished not only between production-goods and consumption goods each as a homogeneous quantity, but divided the production process into several consecutive stages. Thus, the complex of production goods was structured into goods of different orders, where the goods of higher-order were farther away in time from the final output than the goods of lower order (see for example Skousen 2007: 16). In this way, Menger (1871) was able to conceptualize the role of time for the production process and use it to explain what he considered to be a very important cause of wealth creation, namely the extension of human plans to the goods of higher-orders (Menger 1871: 73). Capital, in his opinion, is the

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1 “The fact that I have followed the terminology and method of attack of Böhm-Bawerk’s theory of interest throughout this chapter does not imply that I am an adherent of that theory or am able to regard it as a satisfactory solution of the problem. But the present work does not afford scope for the exposition of my own views on the problem of interest; that must be reserved for a special study, which I hope will appear in the not-too-distant future.” (Mises 1912: 339, n.)
combination of economic goods of higher-order in the present for purposes that lie in the future (Menger 1871: 155, 303 f.).

Eugen von Böhm-Bawerk took over Menger’s (1871) discussion of the role of time in the production process and built his theory of interest upon it. Böhm-Bawerk (1889: 22) too defined capital physically and in relation to the time-consuming production process, namely as “the complex of intermediate products which appear on the several stages” of production. He also clearly worked out an important cornerstone of the Austrian theory of capital: the trade-off between more roundabout ways of production and the needs of present consumption. On the one hand he argued, in the spirit of Menger (1871), production leads to better results when more roundabout (i.e. time-consuming) methods encompassing more intermediate stages of production are employed (Böhm-Bawerk 1889: 20 ff.). On the other hand, the ability of entrepreneurs to implement more roundabout methods of production is limited. There must be a fund of consumption goods – what Böhm-Bawerk called subsistence-fund – which supports the owners of the factors of production while the more roundabout production processes are getting installed (Böhm-Bawerk 1889: 400).

With this trade-off, Böhm-Bawerk outlined the problem area around which many later contributions to Austrian capital theory would revolve. Most notably, the Austrian Business Cycle Theory as developed by Mises (1912) and expanded on by Strigl (1934), Hayek (1935), Rothbard (1962) and Huerta de Soto (2012) is based on this aspect: Only when people reduce consumption is it possible to lengthen the structure of production and to undertake more roundabout ways of production. If people do not save more yet the banking system, by artificially lowering the interest rate, makes entrepreneurs believe that savings have increased, the production structure is ‘lengthened’ despite a lack of savings. As a consequence, the new roundabout ways of production must turn out to be unsustainable, and ultimately their abandonment or truncation triggers an economic crisis.

Those treatments of Austrian Capital Theory which are not primarily concerned with the said trade-off or the business cycle, especially Lachmann (1978) and Lewin (2011), focus rather on the fundamental heterogeneity of capital-goods. They do not only stress the different order of goods in the time-consuming production process, but the complexities of the myriad of interwoven capital-goods that characterize modern economies, and deal with the question as to how this heterogeneity can be handled and ordered by entrepreneurs.

All these contributions have in common that they define capital in a physical way. For them, capital consists of tangible capital-goods that allow for higher productivity. Financial-capital, insofar as it is dealt with, is considered as something that might be important from the individual entrepreneur’s private point of view, but does not help in the explanation of the modern production process as a whole, as seen from a bird’s-eye perspective of the economic theorist. That is the reason why economy-wide physical-capital used to be called “social” capital, i.e. by Böhm-Bawerk (1889: 38). Physical-capital is capital from the standpoint of society, means of production that help to increase the tangible output of the (national) economy.

Unnoticed by most Austrian authors, a different viewpoint on capital has been introduced into the body of Austrian economics which rejects the definition of capital as a physical concept. In 1888, Carl Menger published an essay on the theory of capital where he implicitly and significantly alters his earlier definition and instead advocated a financial-capital concept. He opposed all attempts to define capital as something physical because he thought it necessary to stick with common parlance where capital does not relate to physical assets or capital-goods, but to sums of money dedicated to the
acquisition of income (Braun 2015a). Furthermore, Menger (1888: 10) remarked that a definition of capital as goods of higher-order does not capture the idea the respective theorists want to capture. Each household employs hundreds of higher-order goods, for example kitchen appliances, which could impossibly be called ‘capital’ from any standpoint (Braun 2015a: 86 f.).

Menger (1888) does not do much more than criticizing other definitions of capital, opting for the abandonment of physical-capital concepts in economics. In particular, he does not indicate what a capital-theory that is based on the financial-capital concept he endorses would look like (Braun 2015a: 91). Of the later Austrians only Mises based his discussion of capital on Menger’s (1888) financial-capital concept. Both in his treatise on socialism (Mises 1922: 123) and in his opus magnum *Human Action* (Mises 1949: 262) Mises stuck to the more common understanding of capital and chose to orient his definition of capital to business practice. For him, capital is a sum of money which is determined by accounting.

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 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: 262).

For an understanding of capital the physical characteristics of goods are not relevant to Mises. Rather it is the operations of business units that is of primary interest (Lewin 1998). Thus, Mises, together with Menger (1888), deviates from the majority view of the Austrian school on capital. Different from Menger (1888), however, Mises (1920; 1922; 1949) actually contains several hints as to what a capital theory based on a financial-capital concept would look like.

### 3. Mises’s take on the theory of capital

Mises does not abandon the contributions of his predecessors to the Austrian theory of (physical) capital. He elaborates at quite some length on Böhm-Bawerk’s trade-off between longer periods of production, characterized by additional higher-order goods, and the need for consumption (Mises 1949: 476 ff.). He differs from Böhm-Bawerk and most other Austrians in that he tries to separate these “physical” considerations from the theory of capital. His attempt in this regard is somewhat muted, however, because of a terminological choice he makes at the outset of his discussion of capital.

Early in *Human Action* he is clear on the matter.

> From the notion of capital-goods one must clearly distinguish the concept of capital. The concept of capital is the fundamental concept of economic calculation, the foremost mental tool of the conduct of affairs in the market economy (Mises 1949: 260).

After he has presented his definition of capital as the money-value of the assets and liabilities of a business unit, he investigates the physical-capital concept employed by most other economists. But although he considers physical-capital, defined as “the totality of the produced factors of production,” to be “an empty concept” he nonetheless calls these factors ‘capital-goods’ (Mises 1949: 263). These goods are, in his (1949: 490) words “intermediary stations on the way leading from the very beginning of production to its final goal, the turning out of consumers’ goods.” That he is well aware of the problematic nature of this terminology can be seen in the very sentence where he introduces the concept: “We may acquiesce in the terminological usage of calling the produced factors of production
capital-goods. But this does not render the concept of real [=physical] capital any more meaningful” (Mises 1949: 263, emphasis added).

Though mostly clear on the distinction between capital and capital-goods, in Human Action, Mises himself at one point, later in the book, jumbles up the two notions. On the one hand, he maintains that the “idea of capital has no counterpart in the physical universe of tangible things” (Mises 1949: 511), but on the other hand he declares that capital “is always in the form of definite capital-goods” and that “every unit of capital is therefore in some way or other fixed capital, i.e., dedicated to definite processes of production” (Mises 1949: 500). That he is less than clear about his actual understanding of capital also shines through in his methodological comments on capital. In one instance he wants capital to be “a praxeological concept” (Mises 1949: 512), but elsewhere he argues that the notion of capital “is not a category of all acting” (Mises 1949: 264) and definitely not present in Robinson Crusoe’s world (Mises 1949: 262).

Mises obviously had difficulties keeping his two concepts of capital and capital-goods apart in his analysis. This is why his take on capital theory cannot be unambiguously pinned down. In his chapter on “Action in the Passing of Time,” he clearly adheres to the Austrian theory of capital with its emphasis on the role of physical-capital in the time-consuming production process. Capital, in this chapter, becomes more or less another word for capital-goods. His discussion of the “scarcity of capital” does not relate to the money equivalent of assets and liabilities, but to capital-goods as needed in production (Mises 1949: 493 ff.). Mises more or less identifies capital-goods with capital:

Shortage of capital means that one is further away from the attainment of a goal sought than if one had started to aim at it at an earlier date. Because one neglected to do this in the past, the intermediary products [= capital-goods] are wanting, although the nature-given factors from which they are to be produced are available. Capital shortage is dearth of time (Mises 1949: 494).

Mises’s discussion of capital in this chapter might explain why other Austrians have not given much weight to his departing definition of capital. Kirzner, for example, although he clearly recognizes Mises’s non-physical definition of capital (Kirzner 1976: 141), seems to see little reason, in his Essay on Capital, to explain why he does not adopt this definition but rather deals with capital-goods, the period of production, and waiting (Kirzner 1966). Also Rothbard (1962: 47 ff.), in his Man, Economy, and State which was thought to follow Mises’s Human Action closely (Hülsmann 2007: 935), does not seem uncomfortable when he identifies capital with capital-goods and thus follows a physical-capital concept. Mises’s definition which clearly aims at a financial-capital concept has not been made much use of by later Austrian economists. Rather Mises is categorized, with some minor qualifications, among other Austrian authors in that he focuses, in his discussion of capital, on the role of the complex of capital-goods in the production process (Endres and Harper 2011: 367 f.).

This being said, and leaving aside the terminological issues, Mises can be shown to hint at what a theory of capital building upon a financial-capital concept would look like. Capital, in Mises’s view, is a basic tool of the economic calculations of entrepreneurs under capitalism. He considers it, in the words of Hodgson (2014), as a historically specific concept:

The concept of capital cannot be separated from the context of monetary calculation and from the social structure of a market economy in which alone monetary calculation is possible. It is a concept which makes no sense outside the conditions of a market economy. It plays a role
exclusively in the plans and records of individuals acting on their own account in such a system of private ownership of the means of production, and it developed with the spread of economic calculation in monetary terms (Mises 1949: 262).

Monetary calculation based on capital is only possible under capitalism. Owing to what Mises calls capital-accounting, entrepreneurs are able to compare the economic significance of their inputs and their outputs even in a complicated and dynamically “changing industrial economy” (Mises 1949: 511). That is what distinguishes capitalism from other economic systems.

[O]nly people who are in a position to resort to monetary calculation can evolve to full clarity the distinction between an economic substance [capital] and the advantages derived from it [income], and can apply it neatly to all classes, kinds, and orders of goods and services (Mises 1949: 261).

Mises’s theory of capital is a theory of the way monetary calculation based on (financial) capital helps entrepreneurs to organize the production process under capitalism. One could also say that his theory of capital is a theory of capitalism, a theory of how entrepreneurial operations are guided by capital accounting.

Although his take on this theory of capital is only rudimentary and needs further elaboration (see e.g. Braun 2015b), it has brought about a significant negative result: Mises’s critique of socialism. Mises (1920: 6) famously argues that without the ability to engage in monetary calculation, it would not be possible to reduce inputs and outputs to a common denominator and an industrial economy would not be sustainable. Hence the impossibility under socialism to economize on resources and to determine where input factors can be employed most economically.

[I]t lies in the very nature of socialist production that the shares of the particular factors of production in the national dividend cannot be ascertained, and that it is impossible in fact to gauge the relationship between expenditure [production effort] and income [production proceeds] (Mises 1920: 2; brackets contain our own translations).

A socialist government would badly need what the capitalist system has, namely the concepts of capital and income to guide its operations. However, without private ownership in the means of production, without markets and prices for such goods, the concepts of capital and income are “mere postulates devoid of any practical application” (Mises 1949: 264).

4. Towards a fuller financial theory of capital

Lacking from the financial approach to capital by Menger and Mises is the monetary counterpart of Böhm-Bawerk’s (physical) concept of roundaboutness. Thinking about capital as a value rather than as physical entities should not involve abandoning the important connection between value and time that is the essence of capital.

Among the Austrians it is most explicitly in the work of Eugen von Böhm-Bawerk, that the role of time in production is manifest (though, of course, Hayek also worked extensively on this, work which culminated in Hayek 1941). Since production takes time, the relationship between value and time must be considered. Time has to be ‘spent’ in order to get results in the form of products that are useful to consumers, that are valued more highly than the combined value of what went into them over time. This suggests that if ‘more’ time is to be taken to produce anything, there must be a reward. This comes
in the form of a higher valued product. In Böhm-Bawerk’s terms, wisely-chosen roundabout production processes are more productive.

But what does it mean to take ‘more’ time? Consideration of this leads one very quickly into difficult territory. To attempt to quantify the time-to-be-taken raises a whole host of well-known difficult questions. When does the ‘time-period’ begin – or end? It is not elapsed time per se that is taken. Rather it is work-time – the application of effort over time by different kinds of resources. So it is input-time that is relevant and must be measured. In what units? And so on. In order to simplify the matter, and hopefully make it tractable, Böhm-Bawerk suggested the concept of the ‘average period of production’ (APP) – a conceptual measure of the ‘average amount of time’ taken in the production of any product.

The APP may succinctly express as follows:

1) \[ T = \frac{\sum_{t=0}^{n}(n - t)l_t}{\sum_{t=0}^{n} l_t} = n - \frac{\sum_{t=0}^{n} t \cdot l_t}{N} \]

where \( T \) is the APP for a production process lasting \( n \) calendar periods; \( t \), going from 0 to \( n \), is an index of each sub-period. Variable \( l \) is the amount of labor expended in sub-period \( t \), and \( N = \sum_{t=0}^{n} l_t \) is the unweighted labor sum (the total amount of labor-time expended). Thus \( T \) is a weighted average that measures the time on average that a unit of labor \( l \) is ‘locked up’ in the production process. The weights \( n-t \) are the distances in time from the emergence of the final output. \( T \) depends positively on \( n \), the calendar length of the project, and on the relation of the time pattern of labor applied (the points in time \( t \) at which labor inputs occur) to the total amount of labor invested \( N \).

Although Böhm-Bawerk’s APP, a concept designed to capture the role of time in production, is very limited in its applicability to real-world processes, the essential idea is important and is a precursor to much work on the nature of production in the modern world. Böhm-Bawerk tried to capture in quantitative terms the average amount of time taken in any production project – a purely physical measure of physical-capital. As can be easily shown, except for the most simple of cases, this is not possible. As soon as one considers the relationship between capital and time, value enters the analysis and a purely physical (quantitative) measure is impossible. Böhm-Bawerk’s essential error lies not in his attempt to take account of time considerations in the mind of the investor/entrepreneur as expressed in some simple formulation, but, rather, in his attempt to do so by confining his attention to a strictly physical measure.

In contrast to Menger (1888) and Mises (1949), who do not delve into this problem of time, value, and production in their discussions of the financial-capital concept, the modern theory of finance has much to say on this that is very useful to this discussion. We consider this in this section and the next.

Modern financial theory, though adhering to the financial capital definition, has carefully considered the role of time in production and investment. For investment decisions in a monetary economy we express the time-value of money in a familiar way.

2) \[ CV = \frac{CF_1}{(1 + d)^2} + \frac{CF_2}{(1 + d)^3} + \cdots + \frac{CF_n}{(1 + d)^n} = \sum_{t=1}^{n} \frac{CF_t}{(1 + d)^t} = \sum_{t=1}^{n} f_t CF_t \]
Where:

- $CV$ = the capital-value of the investment, being the net present-value (NPV) of the investment. In some contexts it is the original financial-capital outlay. For a bond traded in a competitive financial market it is the market price of the bond.
- $CF_t$ = the money-valued cash-flow expected from the investment in period $t$ ($t = 1, \ldots, n$) - which is the net-value of earnings and outlays in that period and can be positive, negative or zero.
- $n$ = the time-horizon of the investment or the number of periods for which the investor is planning from now until the investment is considered to end. It is the planning period of the investor. For a fixed income investment like a bond it is called the term to maturity.
- $d$ = the rate of discount applied to any future-value to reduce it to present-value. As explained below, depending on the context, $d$, can be considered to be the rate of time-preference of the investor, or it can be a market interest-rate that determines the market price of the investment (as in the case of a bond), or something similar. We will refer to it as the discount rate.
- $f_t = \frac{1}{(1+d)^t}$ which we shall refer to as the discount-factor.

This equation expresses a universal arithmetic relating value and time as perceived by human actors. There are a large number of potential unknowns. For the equation to be of practical use information must be supplied for all but one of the unknowns. So, for example, in the case of a fixed-coupon bond everything except $d$ is known. Barring default the bond-holder knows what the bond will pay per period and at the end of the investment period, $n$. The price to purchase the bond is thus given in the market. $d$ is calculated given this information. It is that number that solves the equation, making the present-value of the stream of payments equal to the price. This procedure is used wherever financial assets are traded many times every day.

Other special cases, like premium bonds, discount bonds and perpetuities, are well known and need not be repeated here. The essential take-away point is the significance of $d$ in connecting values over time. An investor purchasing the bond knows that each dollar of investment of $P$ dollars will be marked-up by $d$ percent in each sub-period of the investment period (Osborne, 2014). It is the essence of what is known as the time-value-of-money.

In a more general context, encompassing any kind of multi-period investment, the value of $d$ that reduces the NPV to zero is known as the internal-rate-of-return, $i$ (or IRR) – it is that rate that reduces the expected income stream of the investment to its current cost – the current financial-capital outlay. At this rate-of-return, the cost of the project is equal to its present-value. Thus, $i$ can be compared to current market interest-rates (yields) to see if the investment per dollar covers its opportunity cost.²

Because of positive marginal time-preferences (including impatience and risk-uncertainty-aversion), investments will be made only if they promise to pay a premium. In a growing economy this implies creating value. Resources are marshalled and combined in ways that promise to produce outcomes that consumers value enough to cover the costs of doing so. In common terms, the transformation of resources into more valuable uses is known as production, and the more value added the more productive this process is considered to be. It seems obvious that modern financial theory clearly

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² It is well known that the IRR criterion is inferior to using the magnitude of NPV (net present-value) when deciding among exclusive investment projects and that there are instances when the two criteria give different rankings. Among available investments that cover the (the opportunity) cost of capital the investor should choose the one with the highest NPV at that cost. This does not affect our discussion.
echoes important elements of Böhm-Bawerk’s approach to time and value as the essential features of capital.

But modern finance theory even uses a concept that captures the idea of Böhm-Bawerk’s APP. Already John Hicks (1939: 186) pointed out as early as 1939 that a valid form of the APP does exist – he called it the average period (AP). It is exactly that same construct developed by Frederick Macaulay (1938)\(^3\) that is known as ‘duration’. Duration \((D)\) is most easily understood as ‘the average amount of time for which one has to wait for \$1’ in any investment. It is a measure of the ‘length’ of the project – or, at least, some significant aspect of the length. It captures an important aspect of what is in the investor’s mind as he contemplates his investment.

Specifically,

\[D = \sum_{t=1}^{n} \left( \frac{f_tCF_t}{CV} \right) t\]

where the terms are as previously defined. Note \(D\) is a weighted average of the time-units involved in the project, starting from 1, the earliest, to \(n\), the last, where the weights are the proportions of the present value of the investment received (or paid) in the time period \((f_tCF_t/CV)\). It is the (present-) value-weighted amount of time involved in the investment. As such it is a money-value of time measure.

The logic is simple. The economic significance of the time involved in the investment, the amount of time for which one has to wait for payments to be made or received, is dependent on the relative size of payments in each of the periods involved. The simple size of the calendar time, \(n\), is not very informative. The same \(n\) can have very different significance to the investor depending on whether the payments occur sooner or later and in what proportions. The value-significance of the time involved must be considered. Given time-preference, other things constant, a longer average period (duration) should carry a higher markup.

This concept captures the money-value of time. The amount of time involved in any investment is valued according to the influence of value on time.

5. **Discount rate changes and time**

It is well known in the financial literature that \(D\) also has a use different from the one of measuring the time-intensity of the invested dollars, namely as a measure of the interest-elasticity of NPV (or CV) of the investment. This dual aspect of \(D\) is significant. Using equation 1, the sensitivity of the \(CV\) to changes in interest-rates (more specifically to the rate of discount applied to the investment) is a key factor in investment appraisal. And financial specialists have long worked to develop tools to mitigate, if not completely immunize, investments from this risk.

It turns out, as first indicated by Hicks (1939) that \(D\) is also a measure of the elasticity of the (present) value of the project with respect to the discount factor \(f_t\). It measures how any estimate of net present value changes with a change in the discount factor, for small changes.

\(^3\) See also Lewin and Cachanosky, 2014, 2016 for a fuller discussion.
Hicks’s formulation (1939 [1947]: 186) proceeds as follows: The capital-value \(CV\) of any stream of \(n\) payments (cash-flows) is given as before by

\[
2) \quad CV = \sum_{t=1}^{n} \frac{CF_t}{(1 + d)^t} = \sum_{t=1}^{T} f_t CF_t
\]

We may calculate the elasticity of this \(CV\) with respect to the \(f_t\)’s, as

\[
4) \quad E_{CV,f_t} = \frac{E(CV)}{E(f_t)} = \frac{1}{CV} \left[1 \cdot f_1 CF_1 + 2 \cdot f_2 CF_2 + \cdots + n \cdot f_T CF_T\right]
\]

or

\[
3') \quad E_{CV,f_t} = \sum_{t=1}^{n} \left(\frac{f_t CF_t}{CV}\right)
\]

where \(E\) is the elasticity (or \(d \log\)) operator. This follows from the rule that the elasticity of a sum is the weighted average of the elasticities of its parts.

Note that equation 3’ is identical to equation 3. Importantly, \(E_{CV,f_t}\) provides a measure of the sensitivity of the value of the project (investment) to changes in the rate of discount, or (inversely) in the discount factor. So, anything that affects the discount rate applied to investments will affect their relative valuations. The perceived values of investment projects that constitute the components of the structure of production will be unevenly affected by monetary policy that systematically affects discount rates. Those components of existing production processes that have a higher \(E_{CV,f_t} (=D)\) will be relatively more affected – for example, a fall in the discount rate (perhaps provoked by a fall in the federal-funds and other interest-rates) will produce a rise in the value of high-\(E_{CV,f_t}\) (=D) projects relative to those with lower ones. \(D\) thus serves the dual purpose of measuring both ‘roundaboutness’ and the sensitivity of capital-value to changes in the discount rate (discount factor). A comparison of the two approaches to roundaboutness appears below in Table 1.

**Table 1. Time in production/investment, alternative measures**

<table>
<thead>
<tr>
<th>Böhm-Bawerk – a physical capital concept</th>
<th>Hicks and Macaulay – a financial capital concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ APP = n - \sum_{t=0}^{n} t \cdot I_t ]</td>
<td>[ AP = \sum_{t=1}^{n} \left( \frac{f_t CF_t}{CV}\right) t ]</td>
</tr>
<tr>
<td>Labor-weighted average amount of time in production</td>
<td>Value-weighted average amount of time in investment and the discount-factor elasticity of capital-value</td>
</tr>
</tbody>
</table>

Using the financial framework outlined above, with capital understood as the market value of physical capital, adds to the applicability and plausibility of Austrian business-cycle theory (ABCT) which depends on a coherent understanding of the role of time in production and investment. Unsustainable investments in ‘longer-term’ investments, at the expense of ‘shorter-term’ investments are at the root of the cycle. It is a matter of malinvestment. Yet the theory has been hampered, both theoretically and, moreso, empirically, by the impossibility of defining ‘longer’ or ‘shorter’ term. This ambiguity is the result of a neglect of the financial dimensions of capital. The concept of duration gives a precise meaning to this and suggests different possible theoretical and empirical approaches to the ABCT, approaches based on financial measures of the length of production (investment).
6. Conclusions - implications

As our discussion suggests, Mises’s understanding of capital and its role is wholly compatible with these observations.

Capital-accounting is possible only in a monetary economy. To the notable feature of money that it separates the acts of purchase and sale, thus allowing for a high degree of specialization, we should add that money allows for the separation of the acts of saving and investment, thus both facilitating and evaluating specialized investments. This is at the heart of a comparison between different economic systems.

As our discussion of duration has shown, a theoretically unambiguous meaning of the investment-period can be given in financial terms. Where there is a cash-flow and a discount-rate there is a duration that measures the ‘time involved’ in the investment and this precisely captures the mental process of appraisal in the minds of investors as they contemplate (even if tacitly) the values of alternative investment prospects. Value and time weigh in their considerations and changes in the discount rates they use will influence these appraisals in predictable ways, in line with the claims of ABCT (see for example Cachanosky and Lewin 2014, Lewin and Cachanosky 2014, 2016).

References


Appendix:
Why capital should not be seen as a factor of production – two examples
Introduction

Besides the implications for Austrian economics, the financial view of capital offered here has implications for economics generally, including for the history of economics. For the interested reader here are two examples of how a confounding of the value and physical conceptions of economics has created needless confusion. Both have to do with the familiar neoclassical production function. The first example, involves the interpretation of the aggregate production function routinely estimated from data – using (deflated) money values to make inferences about physical quantities. The second example is the Cambridge-Cambridge controversy in capital theory in which matters were confused by both sides working within a framework that presumed that ‘capital’ must refer to a physical factor of production.

Apples and oranges

Consider the standard production-function. The simplest form will suffice to make the necessary points.

1) \[ Q = Af(K, L) \]

a special case of which is the popular and convenient Cobb-Douglas form

2) \[ Q = AL^\alpha K^\beta \]

Where this is of any practical use, however, is another matter and depends on how much is known, or can be known, about the specific form of the function and whether or not it is a ‘complete’ production-function. In many situations there are likely to be many unknowns and unknowables that characterize the production process. A large number of categories or subcategories of inputs, for example, would add layers of formidable complexity. The higher the level of aggregation that this equation is meant to depict the less useful it is likely to be.

\(Q\), \(K\), and \(L\) are meant to be physical quantities, measurable by counting up the number of homogeneous units. \(Q\) is a particular identifiable product. \(L\) is the number of labor-hours of a particular kind of labor employed. And \(K\) is the number of units of a particular kind of physical input-service. Consideration of even the simplest kind of product suggests that matters can become complicated very quickly.

Heterogeneity of all of the inputs and the output complicate the notion of the production function as a relationship between physical entities. Multiple product types may be produced. This means that the inputs may be involved in producing a set of heterogeneous products, and there is no obvious way to

\[ Q = Af(K_i, L_j) \]

where \(i = 1, ..., n\) and \(j = 1, ..., m\) are sets of different kinds of capital-goods and labor respectively. They could be very large sets, the higher the level of aggregation the larger the sets. Though the elements within each set can be counted they cannot be added together across sets. This is the phenomenon of heterogeneity to be discussed below.
separate out production-functions for each type of product. Also different kinds of labor may be
involved in the production process. Our focus here, however, is on capital. When it comes to capital as
a category in the production function, the whole notion of \( K \), as a factor of production, has been called
into question. In this section we consider two specific arguments against the use of \( K \) and of production
functions, the argument that estimated production functions are a statistical artifact devoid of
economic meaning, and that, therefore, the theory of the distribution of earnings by economic
function is invalid; and, secondly, that using \( K \) and \( L \) to characterize production techniques results in
unteivable paradoxes. The first argument appears to us to be correct, but it does not imply the invalidity
of the explaining earnings by economic function. The second appears to us to be without merit.

The distribution of earnings, factor shares
It is not suggested anywhere that sufficient knowledge of the production-function can be used as a
tool for detailed management, production and employment decisions, however reflection suggests
that managers must use some kind of abstract production-function reasoning when making many of
their decisions. For example, it is pretty–much a tautology to say that an employer will hire a worker
for an hour of work only if that hour is expected to add to revenue at least as much as it adds to cost
(the benefit-inclusive hourly wage); an employer will hire labor-hours up to the point that \( VMP_L = w \),
that is, up to the point where the expected value of the marginal product of the labor employed equals
the wage rate. This ‘logic of choice’ is familiar and certainly useful in understanding basic principles of
economics, of ‘economizing’. But this logic in no way depends on a complete and accurate knowledge
of the production-function as a stable relationship between physical inputs and outputs. Entrepreneurial judgment is called for when deciding on the employment and combination of all kinds
of inputs, and such judgement cannot avoid making use of the logic of choice – of the necessity to
compare the cost of inputs with the value of projected outputs. In the aggregate these judgements
interact to determine the earnings of all input-owners.

Having said this, it may be doubted that the production-function is useful as a description of the
economy as whole, considering \( K \) and \( L \) as aggregate categories of inputs, in which the ‘factor-shares’
are determined. It is probably more accurate to say that the prior designation of the categories of
inputs whose shares are the object of investigation determines the kind of production-function that
appears to ‘fit’ the data rather than that the production-function really determines factor-shares. The
aggregate production-function, that captures a stable technical relationship between identifiable
aggregate outputs and inputs, is just not something that exists in the real world.

The conditions under which one can aggregate different heterogeneous outputs and factors
of production and sum across different micro-production-functions to give an aggregate
production-function are so stringent as to make it difficult to believe that such a function can
exist in reality (Felipe and McCombie 2014, p. 61, see also Fisher 1993).

As Felipe and McCombie (2014, p. 60) point out “the existence of an underlying accounting identity
can explain [favorable] regression results even if the aggregate production-function does not exist.”
This is true even as economists continue to use the aggregate production-function to explain factor-shares (Piketty 2014). This may be seen as an instance of circular reasoning.

Consider the aggregate accounting identity (available from aggregate data like national accounting
data)

3) \[ Q = wL + rK \]

Where \( Q \) is the value of final output (like GDP adjusted for inflation), \( L \) is the constant-price-index
aggregate of Labor, \( K \) is the constant-price-index aggregate of Capital, \( w \) is the average wage of a unit
of \( L \) and \( r \) is the average rental-rate of a unit of \( K \).
Totally differentiate this identity as follows.

4) \[ \text{d} \log Q = \left( \frac{wL}{Q} \right) \text{d} \log L + \left( \frac{rK}{Q} \right) \text{d} \log K = \alpha \text{d} \log L + (1-\alpha) \text{d} \log K \]

Where \( \alpha \) is the *share of L* and \( 1-\alpha \) is the *share of K*, since the shares must add to one. Integrating this equation gives,

5) \[ Q = AL^\alpha K^{1-\alpha} \]

identical to equation 2 with \( \beta = 1-\alpha \) (constant returns to scale), where \( A \) is the constant of integration. It should be emphasized that \( Q = AL^\alpha K^{1-\alpha} \) is not an approximation to \( Q = wL + rK \); it is an *exact transformation*. Thus, it is not surprising that the Cobb-Douglas form of production-function estimation gives a relatively good ‘fit’, much more so in cross-section than time-series estimations (see Felipe and McCombie 2014, pp. 68-69 for more detailed discussion). The production-function thus specified does not so much ‘explain’ factor-shares as express them in a different but equivalent way. A good fit does nothing to solve the heterogeneity problem or the ambiguities that attach to the categories of physically heterogeneous inputs and their earnings.\(^5\)

This type of argument has been used to suggest that the neoclassical theory of the functional distribution of earnings is invalid – that wages and rents of capital and land cannot be explained in terms of their earnings in production, because, in particular, the category \( K \) is meaningless and corresponds to no real-world physical factor of production. Rather the earnings of the different factor groups are explained by the interaction between the various ‘social classes’ – workers, capitalists, and landowners. The marginal productivity theory of distribution is bankrupt if the marginal product of \( K \) cannot be defined. Production-function exercises are beside the point.

**Production paradoxes**

So much is the thrust of the so-called reswitching debate mentioned above that also involved a challenge to the concept of capital as a factor of production that earns a marginal product. Consideration of the relationship between capital-value and the discount-rate is key in this challenge. This was the so-called ‘Cambridge capital controversy’ between MIT (Cambridge U.S.) and Cambridge University (U.K.)

In support of their case, the neo-Ricardians mounted an attack on neoclassical production theory based on the identification of certain theoretical ‘paradoxes’. These paradoxes consist of cases in which it is alleged, for example, that a fall in the interest-rate (equated to the ‘rate of profit’ earned by ‘capital’ or the ‘price’ of the services of capital-goods) which, according to neoclassical production theory is expected to bring about an increase in the demand for capital in production, can lead to the exact opposite at some interest-rates. More specifically, a fall in the interest-rate may first lead to the adoption a more ‘capital-intensive’ productive technique, and then switch, paradoxically, to a less ‘capital-intensive’ technique, and then switch back again as the interest-rate continues to fall. Among many alternative techniques, characterized by physical capital-labor ratios, there may occur switches, re-switches and reversals (moving between 3 or more techniques in paradoxical fashion). In short, there is no monotonic relationship between capital and its price, the rate-of-interest.

\(^5\) As a relationship between monetary (albeit inflation adjusted) aggregates it does suggest a particular ‘production function’ logic, but only when the monetary values are reflective of ‘correct’ – aka equilibrium – underlying production prospects.
These anomalies are taken to be devastating to the entire neoclassical edifice, based on a quantity of capital earning a marginal product. And, as in the argument in the subsection above, the whole notion of a ‘production-function’ is rendered by this account meaningless.

Though the neoclassicals (Cambridge U.S.) conceded the logic of the neo-Ricardian (Cambridge U.K.) critique, they doubted its relevance and have continued to use the neoclassical framework undeterred. The neo-Ricardians thus continue to criticize this, to this day, indignant at the intransigence of the neoclassicals in refusing not only to abandon the neoclassical framework but also at the refusal to embrace the neo-Ricardian alternative.

A simple illustrative example
To illustrate the implications of this physical-units-approach to capital we borrow the example used by Roger Garrison (2006, pp, 190-196). This example is similar to the one used by Yeager (1976), which he in turn adapted from a seminal article by Samuelson (1966).

The neo-Ricardians refer to a ‘technique’ of production as a method of producing a particular output of a given product with given amounts of labor-input in specific time-periods. Any non-labor inputs are implicit in the analysis. The techniques are fixed, and the output they produce is fixed (Yeager refers to bottles of Champagne), and no reference is made to either the prices of the inputs or the outputs which, presumably, are also fixed (unchanging). Two such techniques are given in table 1 below.

Table 1: Labor Requirement by Technique.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Technique A</th>
<th>Technique B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>210</td>
</tr>
<tr>
<td>2</td>
<td>110.16</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>210.16</td>
<td>210</td>
</tr>
</tbody>
</table>

The two techniques are distinguished mainly by the timing of their (original) labor inputs (units of labor-service), and only minimally by the amount of labor required. Technique B is identified as the more ‘capital-intensive’ because it requires less labor to produce the same output. 'Capital-intensity' is a purely physical matter. If we now consider the cost of financing each technique we get a paradoxical result. 'Capital-intensity' here corresponds to what Böhm-Bawerk referred to as more 'roundabout', that is, involving the uses of labor in more indirect, time-consuming ways (of which more below).

Imagine each unit of labor costs $1, then the cost of financing each technique at a 5% interest-rate is given in table 2.

6 The neo-Ricardians identify all ‘capital’ as intermediate goods, like machines, tools, or raw-materials. They are goods-in-process from the original labor that constructed them, to the emergence of the final consumer good. So all capital-goods are reduced to dated-labor which is, by implication, homogeneous. In this way, we apparently get a purely physical measure of ‘capital’, one that, by construction, does not vary with the interest-rate. But this appearance is an illusion because capital is defined simply and residually as non-labor inputs. Further reflection reveals that it cannot be a physical measure unless all capital goods are homogenous. ‘Capital’ is understood as the total of non-labor inputs. In this way it is maintained that ‘capital-intensity’ is fixed because labor-intensity is fixed and capital is defined residually. However, heterogeneous capital-goods (and for that matter labor-services) cannot simply be added together quantitatively, a relative-value metric must be found for this purpose, making the result a value; and the value of both the labor and non-labor inputs is not fixed. So understanding capital in value terms allows capital-intensity to vary in a predictable way, even as the physical properties of the productive techniques remain fixed. We discuss this further in the below.
Table 2: Cost by Technique (interest-rate = 5%)

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Technique A</th>
<th>Technique B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$100.00</td>
<td>$205.88</td>
</tr>
<tr>
<td>2</td>
<td>$105.00</td>
<td>$210.00</td>
</tr>
<tr>
<td>3</td>
<td>$220.41</td>
<td>$220.50</td>
</tr>
</tbody>
</table>

The general expression is in table 2A, where \( d \) is the rate-of-interest (discount) used to compound labor inputs. Note, although, for concreteness, we are using money values (dollars) to value the labor inputs by assuming each unit to be worth $1, this assumption is unnecessary. The analysis applies whatever metric is used to value the labor inputs as long as it is constant. The analysis would work even if we used elementary labor-units and count the interest-rate as the mechanism by which such labor is augmented. Metaphorically the interest-rate ‘grows’ the labor inputs in the production process.

Table 2A: Cost by Technique for interest-rate \( d \)

<table>
<thead>
<tr>
<th>Time period</th>
<th>Technique A</th>
<th>Technique B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$100.00</td>
<td>( \frac{210}{1+d} )</td>
</tr>
<tr>
<td>2</td>
<td>$100.00(1+d)</td>
<td>$210.00</td>
</tr>
<tr>
<td>3</td>
<td>$100(1+d)^2+110.16</td>
<td>( \frac{210}{1+d} )</td>
</tr>
</tbody>
</table>

At 5% technique A is the cheaper to finance, hence the one that will be chosen. But, this is not true for all interest-rates as can be shown by repeating the process for various interest-rates according to the information in table 2A. Techniques A and B can be described by the expressions \( 100(1+d)^2 + 110.16 \) and \( \frac{210}{1+d} \), respectively. Calculating their NPVs (net present values) at various interest-rates yields table 3. The output produced by both techniques is identical and invariant and thus can be ignored in this analysis.

Table 3: NPV by technique

<table>
<thead>
<tr>
<th>Interest-rate</th>
<th>NPV (A)</th>
<th>NPV (B)</th>
<th>NPV (A)/ NPV (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>210.16</td>
<td>210.00</td>
<td>1.00080</td>
</tr>
<tr>
<td>1%</td>
<td>212.17</td>
<td>212.1</td>
<td>1.00030</td>
</tr>
<tr>
<td>2%</td>
<td>214.20</td>
<td>214.2</td>
<td>1.00000</td>
</tr>
<tr>
<td>3%</td>
<td>216.25</td>
<td>216.3</td>
<td>0.99977</td>
</tr>
<tr>
<td>4%</td>
<td>218.32</td>
<td>218.4</td>
<td>0.99963</td>
</tr>
<tr>
<td>5%</td>
<td>220.41</td>
<td>220.5</td>
<td>0.99959</td>
</tr>
<tr>
<td>6%</td>
<td>222.52</td>
<td>222.6</td>
<td>0.99964</td>
</tr>
<tr>
<td>7%</td>
<td>224.65</td>
<td>224.7</td>
<td>0.99978</td>
</tr>
<tr>
<td>8%</td>
<td>226.80</td>
<td>226.8</td>
<td>1.00000</td>
</tr>
<tr>
<td>9%</td>
<td>228.97</td>
<td>228.9</td>
<td>1.00031</td>
</tr>
<tr>
<td>10%</td>
<td>231.16</td>
<td>231.0</td>
<td>1.00069</td>
</tr>
</tbody>
</table>

At interest-rates below 2% technique B is adopted. Between interest-rates of 2% and 8% technique A is adopted but a reswitch occurs at interest-rates higher than 8%, where, paradoxically, the more ‘capital-intensive’ technique B is chosen. See figure 1. This example reveals the essence of the neo-Ricardian case.
Another way to tell the story is to consider techniques A and B as aspects of a single decision, with the option not-chosen seen as the opportunity cost of the decision. In this way we can combine the two configurations to yield the equation, for the rate-of-return of the project,

\[ 100(1+d)^2 - 210(1+d) + 110.16 = 0 \]

This is a second-order polynomial which has two roots, \((1+d) = 1.02\) and \((1+d) = 1.08\), and these roots correspond to the fact that there are two internal rates of return in this combined project. There is no paradox in the occurrence of multiple rates of return in the evaluation of investment projects.

**Evaluation**

In this stark form, and given the number of restrictive assumptions, including the lack of substitutability within techniques, and the invariance of all relative-prices, it may seem as if the paradoxes identified are merely theoretical curiosities without much practical significance. This may be true. However, the discussion does raise interesting issues concerning the interpretation of economic categories.

The neo-Ricardian paradoxes occur because of the perception, encouraged by the neoclassical (Cambridge U.S.) use of the production function, that ‘capital’, to be a useful category, must be physically measurable, on a par with physical labor. And much discussion has shown is that a purely physical measure of capital *qua* capital-goods is impossible where capital is heterogeneous. Indeed, this has been well-known at least since pointed out by Wicksell ([1911] 1934). Any attempt to ‘count’ the ‘amount’ of capital units encounters the interest-rate, which is a price that introduces value into the exercise and contaminates its pure physical-ness. Therefore, according to the neo-Ricardians, capital should not be considered as a factor of production exhibiting scarcity, having a price and a demand curve. And this is so much the worse for all neoclassical constructs that depend on it, most notably the aggregate production-function that is used to explain the earnings of ‘labor’ and ‘capital’.
The fallacies in this criticism are in its understanding of capital. The collection of things that we, perhaps unfortunately, call capital-goods should not be considered the economy’s capital. Rather, capital refers to the value of any such collection (in terms of its potential to produce useful things). There is, moreover, no categorical difference between the capital-value of labor employed and the capital-value of the capital-goods employed. The fact that capital-goods can conceptually be traced back all the way to the input of ‘pure’ labor (and nature) is entirely irrelevant for investment decisions in a market economy, which are, as are all such decisions, necessarily forward-looking. An investor contemplating the financing of any given project, for example as described by techniques A and B considered above, cares only about their relative capital-values (net present-values). And these capital-values will often vary in different ways as the rate of interest (discount) changes. There is no reason to expect capital-value to be an invariant property of any technique – even though the physical capital requirements may remain invariant. There is no paradox.

The neo-Ricardians identify the price of capital as the rate-of-interest which they regard as synonymous with the rate of profit. We think neither is correct. The market interest-rate is, indeed, the price of capital as we understand it in this paper. It is the cost of borrowing ‘capital’ to employ any valuable resource. It is the price of credit and is determined by the time-preferences of borrowers and lenders and the production possibilities available to borrowers. However, the interest-rate is not the price paid for the services of capital-goods, and it is not the rate of profit. The price of the services of capital-goods is a rental-rate on capital-goods. It is well-understood, for example, that a firm renting a copy-machine, pays a monthly fee for its services. If it owns the copy-machine, sound accounting dictates that it must charge itself something like the rental-rate for its services – which may be the basis of a depreciation fund. It is dimensionally equivalent to labor, conceived as human-capital services. Labor services cannot be alienated from its owner (in the absence of slavery), so they must be rented. The rental-rate on labor (human-capital) is what we call wages. And, profits are the residual value left over after interest and all factor-costs (wages and the rents of capital-goods) are paid. Profits are the reward for being right in an uncertain world. This conceptual distinction still holds when the economy is assumed to be in equilibrium.

The functional distribution of earnings remains intact. At any moment in time there exists a set of technical possibilities for the production of useful things. We can call these mini-production-functions. The inputs into these production-functions are the homogeneous productive resources, of whatever kind, that are available. Because resources as a whole are very heterogeneous in nature there will be very many categories of inputs. But for each kind, there will be a price and a demand-curve implicit from the production-function. There is no reswitching in terms of homogeneous physical inputs. To be sure, in a general-equilibrium setting, factor-prices may appear to act perversely, because of complicated complementary relationships ("jointness") in production, but this is hardly news. There is an elementary distinction between demand-curve shifts and movements along them.

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7 The neo-Ricardians have no discussion of what determines interest-rates.
8 We should remind ourselves also that the neo-Ricardian argument is confined to comparative-static equilibrium analysis and arguably has little relevance to real-world disequilibrium situations.