Roundaboutness is not a Mysterious Concept: a Financial Application to Capital-Theory

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ROUNDABOUTNESS IS NOT A MYSTERIOUS CONCEPT
A FINANCIAL APPLICATION TO CAPITAL-THEORY

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Abstract

We apply the EVA® terminology to the concepts of roundaboutness and average period of production in capital theory. By doing this we show that these terms have a clear and well understood financial interpretation. A financial application to capital theory helps to clarify obscure and controversial economic terms. We then extend our financial interpretation of roundaboutness and average period of production to the Austrian business cycle theory and show how this approach can be used to shed light on the subprime crisis.

Keywords: roundaboutness, average period of production, duration, modified duration, Macaulay duration.

Jel codes: B53, E23, E30
1. Introduction

The distinctive aspect of Austrian business-cycle theory is the effect that monetary policy can have on the allocation of capital goods. The Austrian theory of the business-cycle makes use of Wicksell’s natural interest rate analysis and of Böhm-Bawerk’s capital-theory. According to this business-cycle theory, the structure of production is altered when the monetary authority changes the level of interest rates. Succinctly, a monetary policy that reduces interest rates, increases the “average period of production”, or the degree of “roundaboutness,” of the “structure of production,” thus creating unsustainable imbalances in that structure. The increase in “roundaboutness,” followed by its reduction when the monetary authority revises interest rates upward, is what constitutes the boom and bust in the this business-cycle theory. The appeal and credibility of this theory has been limited by its use of terms that are hard to define and operationalize.

Most contemporary empirical studies of the Austrian business-cycle theory focus on the effects produced by monetary policy on the structure of production as presented in the Hayekian triangle, and as embedded in Garrison’s (2001) Model (Lester & Wolff, 2013; Luther & Cohen, 2013; Mulligan, 2002, 2013; Powell, 2002; A. T. Young, 2005).¹ This approach, falls short however, because it has to observe the constraints and simplifications of this model in order to do the empirical research.

¹ Some scholars offer a case study approach (Callahan & Garrison, 2003; Powell, 2002; Ravier & Lewin, 2012; Salerno, 2012). Other econometric studies focus on macroeconomic aggregates rather than in the “structure of production” or Hayekian triangle (Bismans & Mougeot, 2009; Keeler, 2001; Mulligan, 2006). This approach is inadequate in the sense that such aggregation can also be interpreted as empirical evidence of rival business cycle theories. As such, the empirical evidence does not provide distinctive support for the Austrian theory.
In this paper we offer an alternative way of thinking about “roundaboutness” or “average period of production” that has not received the deserved attention. We use the economic value added (EVA®) literature to frame roundaboutness and interest rate sensitivity into financial terminology (Stern, Shiely, & Ross, 2001; Stewart III, 1991; D. S. Young & O’Byrne, 2001).

This paper contributes in two ways to the contemporary literature on this subject. First, it argues that notions of “duration” (as commonly used in the financial literature) offer a more straightforward interpretation of “roundaboutness” or “average period of production” than the one represented in the Hayekian triangle. Even though the concept of duration is well known and its application may seem trivial at first sight, trivial concepts can have non-trivial applications. The connection between “roundaboutness” and duration has not, to the best of our knowledge, been made explicit.

Second, it offers a connection between the EVA® literature (mostly commonly applied in the field of corporate finance) and economics, that remains largely unexplored. As far we can tell, J. C. Cachanosky (1999) and N. Cachanosky (forthcoming-a) are the only studies offering a direct connection between the EVA® literature and Austrian business-cycle theory. Duration and related concepts have wide application to issues in corporate finance and investments. We thus offer a new application to a different context, the context of money-macroeconomic policy. The complications that inhere in the notion of “roundaboutness” at the center of the Austrian theory, and the renewed interest in this theory since the 2008 crisis, makes this new application a value-adding endeavor, one well-suited to illustrate how a financial framing can clarify some difficult concepts in capital-theory as applied to the understanding of business-cycles.

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2 EVA® is a registered trademark of Stern Stewart & Co.

3 Cwik (2008) offers a corporate financial approach to the Mises-Hayek theory but does not rely on the EVA® literature.
In section 2 we discuss the concept of “roundaboutness” and its representation in the Hayekian triangle. In section 3 we introduce the financial interpretation of “average period of production” and “roundaboutness” making use of the EVA® literature. We argue that these terms are not mysterious and do not contain the irresolvable difficulties that characterize the “average period of production” approach. Rather they provide a straightforward value-based interpretation. In section 4 we show how the distinctive features of the Austrian theory of the business-cycle can be captured in the EVA® representation. We also suggest an interpretation of the subprime crisis within the EVA® framework using this theory.

2. Roundaboutness

The term “roundaboutness” is associated with both (1) a higher “average period of production” and (2) a more capital-intensive method of production. It refers to a method of production that requires more “time” but which is compensated for by higher productivity. The higher productivity results from the use of more (complex) capital goods, hence the notion of more “roundabout” as more “capital intensive” methods of production. An analogy close to the Turnpike Theorem from growth theory can clarify the idea. It is possible to go from one point in a city to the opposite side by the shortest route, a road that goes through the middle of the city, or by taking the turnpike that requires going through a longer route because it borders the city. However, because the turnpike allows faster driving it is possible to reach the opposite side of the city more quickly than by taking the shortest route. The turnpike is a more roundabout, but more productive, way to go from one side of the city to the opposite side. It is important to distinguish between the time that it takes to produce the good or service (crossing the

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4 The Turnpike Theorem argues that sometimes it is better to grow slowly for a while in order to ultimately grow faster – just like it is often worth it to take the turnpike (highway/tollway) even though it may be a longer distance, because you get there more quickly.
city) and the time it takes to set-up the method of production. Once the turnpike is built, it is then faster to go from one point to the opposite of the city, but it takes more time and funding to build the turnpike than it takes to build a road that goes through the middle of the city.^[5]

This idea, which comes originally from Menger (1871), was expanded by Böhm-Bawerk (1884). In an attempt to encapsulate the relationship between time used in production and capital intensity, Böhm-Bawerk proposed the idea of measuring production time in a construct called the “average period of production” which can be written as follows.

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

where $T$ is the average period of production for a production process lasting $n$ calendar periods; $t$, going from 1 to $n$, is an index of each sub-period; $l_t$ is the amount of labor expended in sub-period $t$ and $N = \sum_{t=1}^{n} l_t$ 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 from 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 $N$.^[6] In this way Böhm-Bawerk hoped to have solved the problem of measuring roundaboutness.

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[^5]: See the discussion in Hayek (1941, pp. 77–78).

[^6]: This formulation was the source of an enormous amount of subsequent controversy over a long period of time. Though arguably a deviation of the essential “Mengerian” vision that characterized Böhm-Bawerk’s understanding of capital, it became the focus of much attention and the source of many developments involving the notion of capital, including neoclassical production and growth theory. See Lewin (1999, pp. 63–78).
In the special case where there is an even flow of inputs so that the same amount of
labor-time, \( l_0 \), is applied in each period, \( \sum_{t=1}^{n} (n - t)l_t = \frac{1}{2} n \cdot (n + 1)l_0 \) and \( \sum_{t=1}^{n} l_t = n \cdot l_0 \) and therefore \( T = \frac{n}{2} + \frac{1}{2} \) or simply \( \frac{n}{2} \) (when \( n \) is large enough so that the \( \frac{1}{2} \) can be ignored, or when \( T \) is expressed in continuous time where it is absent). So, when inputs
occur at the same rate over time, each unit is “locked-up” on average for half the length
of the production period. It is this idea which is reflected in Hayek’s later use of a
triangle (for which the average period is found half-way along the base of the triangle)
to represent the idea of roundaboutness.

Hayek (1931, 1941) thus uses a triangle to capture, in a simple manner, the idea of
roundabout methods of production. The triangle depicts a production process divided
into different stages where the output of each stage is sold as input to the next one.
Mining, for instance, precedes refining, which in turn precedes manufacturing, which is
followed by distributing and then retailing as the final stage of production before
reaching the consumer (Figure 1). As production moves forward from stage of
production to stage of production, the vertical axis captures the accumulation of the
value added of each stage.

**Figure 1.** Hayekian triangle

Source: Garrison (2001, p. 47)
Time makes its appearance on the horizontal axis. As production takes place, intermediate goods move from the early or first stages of production (mining) to the later stages of production (retailing.) It is *how much capital is invested in each stage* and *what particular methods of production* are chosen that defines the “structure of production.” Yet, as Garrison (2001, p. 49) points out, the horizontal line does not measure units of time, but a combination of the market value of resources *and* time. Two dollars of resources used for three years in a production process amounts to one dollar worth of resources used for six years (six dollar-years) of production-time. It is the amount of dollars *and* how long they are locked up that constitutes the degree of roundaboutness. It may take one year to produce either the turnpike or the street that crosses the city, but the highway is still more roundabout because it requires a larger amount of capital (input-time). The ambiguity of the term and the difficulty of defining the “average period of production” plus the graphical representation of the Hayekian triangle invite confusion and the appearance of paradoxes like technology reswitching and capital reversing.\(^7\)

It is, however, very intuitive and useful for as an expository device. How many stages of production can be sustained by the market depends on the time-preference of

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\(^7\) For discussion on the terminological ambiguities in the initial development of capital-theory see Lewin (1999, pp. 63–73). For an account on the related capital controversies see Cohen and Harcourt (2003), Cohen (2008), Kirzner (2010), Machlup (1935) and Yeager (1976). Among the many problems with the idea of “average period of production” is that it is a conception of production occurring in a static environment in which technology is applied by identifiable, measurable resources over time to produce identifiable products in a known and unchanging manner with clearly identifiable starting and ending points. As such, it can be viewed as an unambiguous measure of the “size” of the production process, in terms of “resource-time-taken” or “quantity of capital” that can be viewed looking forward or looking backward. This equilibrium construct, in which all values are known and revealed, allows for a fallacious “cost of production” interpretation of the value of capital (of which the labor-theory of value is one example.) Moving from a quantitative physical input conception to a forward looking value conception, such as is implied by the use of the concept of *duration* to be discussed below, allows us to avoid these serious drawbacks with the original conception of roundaboutness.
consumers. For instance, a reduction in time-preference increases the supply of loanable funds and reduces the interest rate in the market, other things constant. This increase in savings allows for extending the triangle by augmenting the financial capital needed to add stages of production. Namely, an increase in savings allows for the financing of a more capital-intensive structure of production. The interest rate, then, is (1) the slope of the Hayekian triangle and (2) the opportunity cost or minimum value added required by each stage of production to be profitable.

The Hayekian triangle offers a simplification of capital-theory in order to emphasize particular features like the effects of market interest rates on how long production takes in the economy. But this simplification imposes important challenges for empirical research based on the Hayekian triangle approach. The notion of stages of production is a mental construct to enable the study of the production structure in the economy, it is not an objective demarcation that can be observed in the market. For the same objective reality, the Hayekian triangle in Figure 1 could depict a different number of separations between the different stages of production, and could also show more or less stages of production than five. In other words, empirical research inspired by the Hayekian triangle calls for a subjective judgment on how to separate and order the stages of production. Plausible assumptions might be available in a simple world, but the complexity of the real-world market economy makes this a non-trivial problem. The problems that arise from this are significant. For instance, the same economic activity can appear in different stages; electricity can be used to power early stages of production and also be a consumer service for households. This requires a decision on how to weight the participation of each industry at the different stages. It can also be the case that different stages of production sell their input to each other, making it unclear what the order should be – a phenomenon known as “looping”. The car industry can sell vehicles to the steel industry, and the steel industry sell steel to the car industry.
In addition, it is possible that an industry moves from early (late) stages of production to late (early) stages of production in time or as a result of the monetary policy being studied. Finally, it is also possible that stages of production can grow not only vertically (increase the value added) but also horizontally (increase in the dollar-time). Luther and Cohen (2013) argue that this effect can significantly change how empirical results can be interpreted and produce misleading conclusions.

In addition, the wording of “average period of production” plus the graphical representation of the Hayekian triangle may bias the interpretation of “roundaboutness” as a backward-looking concept rather than a forward-looking investment decisions. It is how monetary policy affects forward-looking marginal investment decisions that should be the focus of attention.

Most of the contemporary empirical research on the Austrian business-cycle theory follows the Hayekian triangle. This work locates different industries in different stages of production of what would be the Hayekian triangle of the economy (Lester & Wolff, 2013; Luther & Cohen, 2013; Mulligan, 2002; Powell, 2002; A. T. Young, 2005). The Austrian business-cycle theory is then empirically tested against this classification according to the effects described in Garrison’s model. According to this model, during an expansionary monetary policy the early and later stages of production should grow vertically with respect to medium stages of production. As discussed above, this approach confronts serious problems that undermine the strength and persuasiveness of the empirical results.

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8 A. T. Young (2012) finds empirical evidence that suggest that this effect was present during the 2002-2007 period.

A few scholars take a different approach. Instead of locating industrial data in different stages of production, A. T. Young (2012) estimates the size (roundaboutness) of what would be the Triangle of different industries. Young, however, does not make a reference to interest rate sensitivity and focuses on the behavior of the “aggregate roundaboutness” rather than on “stages of production.” N. Cachanosky (forthcoming-b) separates economic activities at the industrial level in three groups with different degrees of roundaboutness for two Latin American countries with different exchange rate regime and finds that in both countries the output of the more roundabout industries are more sensitive to changes in the U. S. Federal Reserve Funds rate than the output of less roundabout activities. This is a similar approach to the one taken by Robbins’s (1934) study of the Great Depression. We turn now to an exposition of roundaboutness in terms of Macaulay duration.

3. Roundaboutness as Macaulay Duration.

Let $ROIC$ be the (expected) return on invested capital, $WACC$ the weighted average opportunity cost of capital, and $K$ be the financial capital invested. Then, the economic value added in any given period $t$ is the excess of $ROIC$ over $WACC$ times the amount of financial capital invested ($K$). Economic value added is just another term for economic profits, which is the spread between the rate of return and the opportunity cost of capital times the capital invested, as follows,

$$EVA_t = (ROIC_t - WACC_t) \cdot K_t$$

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10 A current example of a similar analysis can be found in N. Cachanosky and Salter (2013), N. Cachanosky (forthcoming-b) and Koppl (2014); all authors who talk about interest rate sensitive sectors rather than stages of production.
The expected market value added (MVA) of a given project is the present value of the expected future EVAs discounted by the opportunity cost of capital.\textsuperscript{11}

\[ MVA = \sum_{t=1}^{T} \frac{(ROIC_t - WACC_t) \cdot K_t}{(1 + WACC_t)^t} = \sum_{t=1}^{T} \frac{EVA_t}{(1 + WACC)^t} \]

The EVA® representation is a rearrangement of the free-cash-flow approach (FCF). The present value of future FCFs or the addition of invested $K$ and the present value of future EVAs (MVA) yield the same mathematical result.\textsuperscript{12} The advantage of the EVA® literature is that it offers a clearer representation of economic profits by separating investment decisions from business operation results. If, for instance, there is an investment outflow of a higher amount than the NOPAT, then the FCF will show a negative result for the given period even if EVA is positive for the same period. The EVA® literature also has the advantage of explicitly showing a variable for financial capital.

Note that the MVA representation captures the desired characteristics of capital-theory; (1) it is forward looking, (2) it focuses on the length of the EVA cash-flow, and (3) it captures the notion of capital-intensity. An interpretation of “average period of production” or “roundaboutness” can be given a straightforward financial interpretation as the Macaulay duration ($D$) of the project, where

\[ D = \frac{\sum_{t=1}^{T} \frac{EVA_t \cdot t}{(1 + WACC_t)^t}}{\sum_{t=1}^{T} \frac{EVA_t}{(1 + WACC_t)^t}} = \frac{\sum_{t=1}^{T} \frac{EVA_t \cdot t}{(1 + WACC)^t}}{MVA} \]

\textsuperscript{11} \textit{ROIC} can also be expressed as net operating profits after taxes (NOPAT) over capital invested; ROIC = \frac{\text{NOPAT}}{K}. Then, EVA equals the difference between the NOPAT and the opportunity cost of the capital invested: \( EVA_t = NOPAT_t - WACC_t \cdot K_t \)

\textsuperscript{12} The value of a firm using EVA® is Firm value = $K + \sum_{t=1}^{n} \frac{EVA_t}{(1 + WACC)^t} = K + MVA$ which equals the present value of future FCFs. We use MVA because we are looking at the value of the marginal investment, not the value of the firm.
D has the interpretation “the amount of time on average for which one expects to have to wait to earn a dollar from the project.” It is in units of time, constructed as the weighted average of each unit of time, where the weights are the importance of the EVA in the project as a whole, or the ratios EVA\(_t\)/MVA, for all \(t = 1 \ldots T\).\(^{13}\)

This interpretation keeps the spirit of the concept but does away with the problems that arise in the traditional Hayek-Böhm-Bawerk approach discussed above. The latter was a vain attempt to approximate a purely physical measure of “time-taken” or “quantity of capital invested,” for example as the amount of homogeneous labor-time applied. By contrast, Macaulay duration is a forward-looking value construct. From the producer’s point of view, the weighted average time until the future EVA cash-flows are received is the average period of production of the project. Because D weights the periods by the present-value of each period, this measure captures the dollar-time dimension mentioned above and thus avoids any necessity to directly measure physical quantities.

Recalling the earlier discussion of Böhm-Bawerk’s “average period of production” formula as depicting the average amount of time for which a unit of labor-time is “locked-up” in the production process, D, by contrast, depicts the average amount of time for which one dollar is “locked-up” in the production process. As long as we are talking about the appraised value of a forward-looking investment no ambiguity or incommensurability of units attaches to this formulation. A dollar is a dollar, whereas, a unit of labor-time is fraught with conceptual problems.

It should be noted that the MVA of a project is not a measure of its roundaboutness, D. The time pattern of earnings, of the EVAs, can produce differences in numerous ways in D for projects that appear to last the same time. For example, two projects that have a

\(^{13}\) The Fisher-Weil duration allows for a term structure of discount rates (a zero coupon curve.) Though this is a more precise calculation than the Macaulay duration, the idea on the latter is precise enough for the purpose of this paper. But see the discussion of changing expectations below.
different time horizon and the same value of $K$ can only have a same $MVA$ if the longer project has lower $EVA$ cash-flows. For simplicity let us assume that the values of $K$ and $ROIC$ (and thus $EVA$) of each project are the same for each period $t$ and that both projects have the same constant $WACC=c$ for all $t$; then,

5)  \[ MVA_{HR} = \sum_{t=1}^{T_{HR}} \frac{EVA_{t,HR}}{(1 + c)^t} \]

6)  \[ MVA_{LR} = \sum_{t=1}^{T_{LR}} \frac{EVA_{t,LR}}{(1 + c)^t} \]

where subscripts $HR$ and $LR$ denote high-roundabout and low-roundabout respectively. If $MVA_{HR} = MVA_{LR} = MVA$ with the same pattern of discount rates, and $T_{HR} > T_{LR}$, then $EVA_{HR} < EVA_{LR}$. This gives the $HR$ project a higher $D$ than the $LR$ project. Therefore, two projects with the same capital-intensity, as defined by $K$, can have a different $D$. From equation 4 it follows that $D_{HR} > D_{LR}$,\(^4\) that is:

7)  \[ \frac{\sum_{t=1}^{T_{HR}} \frac{EVA_{t,HR} \cdot t}{(1 + c)^t}}{MVA} > \frac{\sum_{t=1}^{T_{LR}} \frac{EVA_{t,LR} \cdot t}{(1 + c)^t}}{MVA} \]

### 3.1. Wicksell Effects and Modified Duration

The value of a combination of heterogeneous capital-goods is the present value of their future cash-flows from their employment in production. This means that the prices of capital goods vary inversely with the discount rate. According to Wicksell, there is a natural rate of interest that equilibrates the supply of and demand for loanable-funds

\(^4\)For a simple proof see the appendix to this paper.
under full employment.\(^{15}\) The natural rate of interest depends on the time-preference of economic agents. In a competitive market in equilibrium there are no economic profits, therefore \(ROI_C = WACC\) and \(MVA = 0\). But if the real interest rate deviates downward, all else constant, then the \(MVA\) rises signaling the opportunity to earn economic profits. The increase in the demand for capital goods to invest in projects that promise a positive \(MVA\) pushes the price of capital goods upward. This is the Wicksell effect.

Succinctly, at a lower real interest rate, the value of capital goods is higher because the present value of their output is discounted at a lower opportunity cost. The increase in the cost of production due to higher prices of capital and intermediate goods is captured as a decrease in net operating profits (after tax) or \(NOPAT\).

Note that in this treatment, the discount or interest rate is not the price of loans (financial-capital), but rather a representation of the opportunity cost of waiting, namely, the subjective time-preference of economic agents. This approach, therefore, does not only help to clarify the controversies around “average period of production” and “roundaboutness”, but also helps to clarify that defining the price of capital goods in terms of the rate of return and having the rate of return dependent on the price of the capital goods as assumed in the “Cambridge-Cambridge” controversy over in capital-theory does not present a dilemma to Austrian capital-theory. That the discount rate of a cash-flow is a representation of an economic agent’s time-preference (plus risk aversion, etc.) is not at odds with the financial literature. As market interest rates change, the marginal rate of time preference may be assumed to change accordingly.\(^{16}\)

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\(^{15}\) Even though this is the most common representation of Wicksell’s natural rate of interest, its specific definition is model-dependent. For a discussion of Wicksell’s natural rate see Anderson (2005), Borio and Disyatat (2011, sec. appendix).

\(^{16}\) For a discussion of pure time-preferente theories of interest rates see Kirzner (2010) and Lewin (1999, Chapter 7).
It follows from the EVA cash-flow valuation (discussed above) that those projects that are either more forward-looking ($T_{HR} > T_{LR}$) or more financial capital intensive ($K_{HR} > K_{LR}$) are more sensitive to changes in the value of WACC (other things constant). While $D$ captures the financial interpretation of “roundaboutness” or “average period of production,” the concept of “modified duration” ($MD$) captures Böhm-Bawerk’s argument that more roundabout projects are more sensitive to changes in interest rates. Modified duration measures the sensitivity of the value of the product to changes in the discount rate, where the yield to maturity (the internal rate of return) is used as the discount rate. It is the semi-elasticity of $MVA$ with respect to yield of the project.

8) \[
MD = \frac{\partial \log MVA}{\partial YTM} = \frac{D}{1 + YTM}
\]

where $YTM$ is the yield to maturity, paid (compounded) once per period.

The application of this to Wicksell and Böhm-Bawerk’s argument has a straightforward financial interpretation. $MD$ measures the percentage change in $MVA$ of a project for a change of 1 percentage point in the discount rate. As market interest rates change, changes in the market prices (values) of durable assets will change inversely in a manner indicated by $MD$.

Consider the case where two projects that have the same $MVA$ and time horizon ($T_{HR} = T_{LR}$) but different amount of invested capital. The project that is more financial capital intensive is more sensitive to changes in the interest rate even if both projects have the same $D$. EVA can be written as the difference between the NOPAT and the cost of opportunity of the capital invested, $EVA_t = NOPAT_t - WACC_t \cdot K_t$, where NOPAT is the net operating profit after taxes. Assume that for each project, $WACC (=c)$ and NOPAT is the same for every period.
If $MVA_{HR} = MVA_{LT}$ and $K_{HR} > K_{LR}$, then either $NOPAT_{HR} > NOPAT_{LR}$ or $WACC_{HR} > WACC_{LR}$. In this case, all else equal, a similar fall in the $WACC$ increases $MVA_{HR}$ more than $MVA_{LR}$ because $K_{HR} > K_{LR}$. Namely, the more finance capital intensive project has a larger convexity, meaning that the capital intensive project’s $MVA$ is more sensitive to changes in the discount rate. The two conflated terms, “average period of production” and “capital intensity” can be separated thanks to how EVA® separates the cash-flow components. Note that this particular case of two projects with equal $MVA$ and $D$ but different convexity when $K$ is different can easily be shown using EVA® but remains concealed in the traditional $FCF$ approach because this methodology does not explicitly show the value of $K$ in the cash-flows.

A simple numerical example can illustrate this effect. Assume two projects that produce a positive $EVA$ for ten periods, after which no more economic profits are earned - $EVA$ is 0 after period 10. Assume also that $K_{HR} = 400 > K_{LR} = 100$; that $WACC_{HR} = WACC_{LR} = 10\%$. Then, it follows that with $ROIC_{HR} = 12.5\%$ and $ROIC_{LR} = 20\%$ both projects have the same $MVA$ of $61$. Figure 2 shows a reduction in $WACC$ (going from right to left on the horizontal axis) that results in $MVA_{HR}$ growing faster than $MVA_{LR}$.$^{17}$

$^{17}$See the appendix to this paper for the the data used to construct this graph.
3.2. Capital goods versus capital value

It should be clear from this that capital value and capital goods, as usually understood, refer to different phenomena. Capital goods refer to durable production items of many shapes and varieties. What makes them valuable are the valuable uses to which they can be put. In an important sense they represent a kind of embodied production “knowledge” (Baetjer, 2000; Lewin & Baetjer, 2011). When used appropriately in combination they facilitate the transformation of inputs into valuable outputs for sale. In an intuitive sense they represent roundabout production in that they are produced means of production and lengthen the supply chain. But, by themselves, they do not represent an indication of the time taken until the emergence of the product. To try and capture this Böhm-Bawerk (and later Hayek) used a device of imagining the application of resources per-period of time and then tried to reduce the magnitude of time involved.
to amounts of resource units – like labor-hours – required to produce the product, including those necessary to produce the produced means of production. As discussed, this approach contains irresolvable problems, and, more important, does not allow one to capture the idea of “capital-intensity” relevant to the interest rate sensitivity of different project projects.

In this context, the idea of capital is about the relationship between value and time regardless of the physical form of the resources embodied in any project. Indeed, human-capital value is on a par with physical capital. A project that uses $100 to acquire only capital goods and a project that uses $100 to acquire $50 in capital goods and $50 in labor have the same “capital value” of $100. In financial terms, both projects have the same financial capital-intensity as would appear in the EVA® representation. Time and capital intensity are related insofar as the different projects with the same financial capital and market value of a project may have different durations – implying that said capital values will respond different to changes in interest rates. Projects that receive their returns “later” rather than “earlier” will be more sensitive, and, in this sense are more capital intensive – their value accumulates over a “longer” period of time.

4. Monetary Policy and business-cycles

The subprime crisis has brought a renewed interest in the Austrian theory as a plausible explanation of what went wrong (Borio & Disyatat, 2011; Calvo, 2013; Diamond & Rajan, 2009a; Hume & Sentance, 2009). This literature, however, does not deal in detail with the problem of “roundaboutness.” This may be considered an inadequacy because the use of roundaboutness is what distinguishes the Austrian theory from

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18 For a literature review see N. Cachanosky and Salter (2013). Caballero (2010) offers a critique of macroeconomics with "Hayekian" points of view. Other research that offers very compatible points of view to those of the Mises-Hayek theory but do not mention the connection are Diamond and Rajan (2009b), McKinnon (2010), Meltzer (2009), Schwartz (2009) and Taylor (2009).
alternative business-cycle theories.\(^{19}\) The interpretation of “roundaboutness” we present here offers an easy way to fill this gap.

The concept of roundaboutness that is most relevant is one that puts the entrepreneur at its center. Any potential investment project (to add to productive capacity) is based, explicitly or implicitly, on the logic of the present-value of expected future earnings from the project. Anything that systematically affects these expectations, or the rate at which they are discounted, will affect the appraisal of categories of projects with similar characteristics. \(MD\) captures the most relevant characteristic.

If it is the case that investments projects under consideration across different industries have a different \(MD\) as assessed by marginal entrepreneur-investors, then it follows that a monetary policy that \textit{is successful} in affecting the discount rate used by these investors will produce uneven effects on the economy as marginal investments take place. For equal reductions in the relevant discount rate, the \(MVA\) of a \(HR\) project will increase proportionally more than the \(MVA\) of a \(LR\) project. Because the ratio \(\frac{MVA_{HR}}{MVA_{LR}}\) increases, the \(HR\) investors are in a position to outbid investors who want to stay on \(LR\) projects in the market for factors of production. Therefore the allocation of capital to \(HR\) projects will increase relative to capital allocated to \(LR\) activities. A monetary policy that lowers the discount rate used in the market increases the \(K_{HR}K_{LR}\) ratio.\(^{20}\)

Unless the monetary authority can keep the level of interest rate below equilibrium indefinitely, the moment will come when the discount rate increases.\(^{21}\) Now the effect is

\(^{19}\) For a comparison between the Mises-Hayek business cycle theory and other theories see Prychitko (2010), Sechrest (1997) and Shah (1997).

\(^{20}\) This would be the analogous effect captured in the Hayekian triangle when in Garrison’s model resources are moved from middle to early and later stages of production.

\(^{21}\) The Austrian Business Cycle Theory was originally developed in the context of gold standard, where the lose of reserves by the central bank eventually forces the bank to revise its monetary policy (or
the opposite. *HR* projects see their *MVA* decrease more than *LR* projects and the process of resource allocation needs to move in the other direction. There are two possible cases. The *HR* projects loose profitability but continue operations with a lower rate of return than expected. This is the case, for example, when the construction and deployment of some durable capital goods has become a sunk-cost and the completion of other components of the project are now profitable to complete at a higher discount rate (Hayek, 1937; Lewin, 2013). In effect, these cases represent an enduring distortion in the capital structure. But is also the case that some *HR* investments are profitable only at the lower discount rate. These projects now have a negative *MVA* and have to be discontinued to cut the loss of aggregated *MVA*. In a nutshell, it is the uneven effects on investment produced by the oscillation of discount rates what constitutes the Austrian story of business-cycles. *LR* and *HR* projects are ranked differently at different moments of the cycle. All else constant, industries with a higher *MD* are affected more than industries with a lower *MD*. This is the financial interpretation of the term “roundaboutness” in the Mises-Hayek theory.

This is portrayed graphically in Figure 3. *MVA* for *HR* and *LR* investments over an Austrian business-cycle which is a simple simulation comparing the *MVA* for *HR* and *LR* projects at different discount rates which vary to simulate an ideal-type cyclical path. The graph shows the case where at $T = 1$ both projects have the same *MVA* of $38$. There is a monetary policy that succeeds in reducing the discount rate *WACC* used by investors from period 2 to 20, after which the *WACC* starts to return to its original value. Even though is not depicted in the graph, it is easy to see that (1) the *HR* project can start with a lower *MVA* than the *LR* project but become more valuable during the boom and suspend incovertibility of banknotes). For a discussion of the Austrian Business Cycle Theory in the context of fiat money see White and Selgin (2010).
(2) that is also possible for the HR project to start with a negative MVA value in period 1 and also become more valuable than the LR project during the boom.  

Figure 3. MVA for HR and LR investments over an Austrian business-cycle

![Graph showing MVA for HR and LR investments over an Austrian business-cycle.]

The above discussion assumes that the expected future values are not affected by changes in the discount rate. In principle, if the EVA, and thus the MVA, of the project vary with the discount rate, the range of possibilities increases unmanageably, unless one has reason to believe that such a connection were systematic. Indeed, we do have such reason. In fact, when interest rates are artificially low (below equilibrium), expectations are likely to be overly optimistic, buoyed by the momentum of the boom, while the downside of the cycle is likely to produce overly pessimistic expectations (N. Cachanosky, forthcoming-a; Callahan & Horwitz, 2010; Evans & Baxendale, 2008; Mises, 1949, Chapter XX.7; Mueller, 2014). This phenomenon adds to the plausibility of the

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22 See the appendix for the table with the data shown in the graph.
scenario depicted above, causing $HR$ project to rise and fall even more relative to $LR$ projects.

We cannot here offer a thorough empirical assessment of the subprime crisis. Nevertheless it can be shown that the approach we offer in this paper allows for a better theoretical fit to the subprime crisis for the Austrian business-cycle theory.\textsuperscript{23} A. T. Young (2013) argues that the canonical version of the ABCT does not fit the events of the subprime crisis very well. Housing, at the center of the 2008 crisis, can hardly be considered among the “most roundabout” industries. Young’s argument is that the Austrian theory needs to work on exploring the role of risk. The subprime crisis, however, did not occur solely because of an expansionary monetary policy with all else equal.\textsuperscript{24} Specific market regulations and the participation of government sponsored entities like Freddie Mac and Fannie Mae played a central role in channeling mortgages to the housing market. This policy resulted in an increase in house prices (as captured in the Case-Schiller index) that increased the $NOPAT$, and therefore in the $EVA$ and $MVA$, specific to the housing market. This occurred besides any downward movement on the discount rates in the economy in general. Even if discount rates do not change, the relative $MVA$ of competing projects can be affected as a result of the monetary policy and regulations in place. It can be plausibly argued, then, that the $MVA$ of a $LR$ project increases more than the $MVA$ of a $HR$ project if the policy effect on the $NOPAT$ of the $LR$ project is big enough to more than compensate for the lower $D$ of the $LR$ project. Figure 4. GDP Deflator and Case-Shiller 20-City Home Price Index shows the change in the GDP Deflator and in the Case-Shiller 20-City Home Price Index (December 2010 = 100.) It is the change in price of housing relative to the rest of the economy that is captured.

\textsuperscript{23} For a more detailed study see Callahan and Garrison (2003), Ravier and Lewin (2012) and White (2008). \textsuperscript{24} With different methodologies, Selgin, Beckworth and Bahadir (2011) and Taylor (2009) conclude that the Federal Reserve’s monetary policy prior to the subprime crisis was loose.
Though often not mentioned, the Austrian theory of the business cycle applies just as much to distortions in the risk structure of interest rates as it does to levels of interest rates. Long-standing accumulative housing policy significantly reduced the perceived risk of investing in housing. For the same discount rate the relative risk in a housing investment appeared substantially reduced as a result of these policies. This assertion rests, of course, on the assumption that investors regarded the housing policy as enduring, as something they could rely on in forming their expectations of EVA and hence MVA. Admittedly, empirical observation of these effects on the MVA of competing projects is quite challenging. The expectations upon which investment decisions are based are observable neither before nor after the occurrence of the crisis. However, the framing we present in this paper, in terms of interest rate sensitivity, allows for a
variation on the Austrian theme that tells a story that is economically easier to follow than the one involving “average periods of production” and “roundaboutness.”

5. Concluding remarks

The evolution of capital-theory has been plagued by obscure terminology and intense controversy. Business-cycle theories, like the Austrian theory, that make use of capital-theory, have also seemed obscure and controversial. Despite these terminological shortcomings, different scholars have found in the Austrian theory a value-added explanation of business cycles and certainly of the two largest crises of the last hundred years, the Great Depression and the Great Recession. This paper contributes to a needed clarification of key concepts of capital-theory (roundaboutness and average period of production) in the context of the Austrian business-cycle theory.

The different notions of duration, explained in this paper, shed light on these concepts. Menger’s and Böhm-Bawerk’s insights into capital-theory and the Mises-Hayek business-cycle theory that builds on it can be interpreted using well-known financial principles. Put differently, the replacement of “roundaboutness” for MD neither adds to nor subtracts anything from the substance of the Mises-Hayek business-cycle theory, but adds to its plausibility. Certainly, the significance of a clear representation of aspects of capital-theory goes beyond this particular business-cycle theory. The approach we offer in this paper opens the door to further research. How does risk play a role in this framework and what role does it plays in the allocation of resources under different monetary policies? Even if expectations are not observable, what can empirical research show about monetary policy affecting activities with different interest rate sensitivity? And, even if the Menger-Böhm-Bawerk-Hayek representation of roundaboutness was developed before the notions of financial duration, one may wonder why this connection has not been noticed earlier?
6. Appendix

6.1. Macaulay duration derivation for two projects with equal MVA but different $T$.

It can be shown that if two projects have the same $MVA$, the same $K$, and the same $WACC_t = c, \forall t$, the project with the longer time horizon (higher roundaboutness, $HR$ - compared with the one with lower roundaboutness - $LR$) has the higher Macaulay duration $D$.

We assume that $MVA_{HR} = MVA_{LR} = MVA$ and that,

$$EVA_{HR,t} = EVA_{HR}, \forall t; EVA_{LR,t} = EVA_{LR}, \forall t.$$ 

This implies $EVA_{HR} < EVA_{LR}$

Consider the relationship between $D$ for the $HR$ project, $D_{HR}$, and $D$ for the $LR$ project, $D_{LR}$.

$$A1)\quad D_{HR} = \frac{\sum_{t=1}^{T_{HR}} EVA_{HR} \cdot t}{\sum_{t=1}^{T_{HR}} EVA_{HR} \cdot t} \quad \text{and} \quad D_{LR} = \frac{\sum_{t=1}^{T_{LR}} EVA_{LR} \cdot t}{\sum_{t=1}^{T_{LR}} EVA_{LR} \cdot t}$$

Let $d_t = \frac{1}{(1 + c)^t}$

then

$$A2)\quad D_{HR} = \frac{EVA_{HR}}{EVA_{HR}} \cdot \frac{\sum_{t=1}^{T_{HR}} t}{\sum_{t=1}^{T_{HR}} (1 + c)^t} = \frac{\sum_{t=1}^{T_{HR}} t \cdot d_t}{\sum_{t=1}^{T_{HR}} d_t}$$

$$A2')\quad D_{LR} = \frac{EVA_{LR}}{EVA_{LR}} \cdot \frac{\sum_{t=1}^{T_{LR}} t}{\sum_{t=1}^{T_{LR}} (1 + c)^t} = \frac{\sum_{t=1}^{T_{LR}} t \cdot d_t}{\sum_{t=1}^{T_{LR}} d_t}$$
A3) \[
D_{HR} = D_{LR} + \frac{\sum_{t=T_{LR}+1}^{T_{HR}} t \cdot d_t}{\sum_{t=T_{LR}+1}^{T_{HR}} d_t} > D_{LR} = \frac{\sum_{t=1}^{T_{LR}} t \cdot d_t}{\sum_{t=1}^{T_{LR}} d_t}
\]
6.2. MVA sensitivity of two projects with different financial capital intensity

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### 6.3. MVA for HR and LR investments over an Austrian business-cycle

This table is built with a different pattern of values for WACC for the same assumptions as used in Table 1.

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