Heuristic model and some mathematical formalization on the Austrian School theory of the business cycle

Working Paper
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Cameron M. Weber
New School for Social Research

cameron_weber@hotmail.com
cameroneconomics.com

Draft for comment, thank you.

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I. Introduction

This paper presents a heuristic[1] model of the Austrian School theory of the business cycle based on concepts first developed by Carl Menger, Eugen Bohm-Bawerk[2] and Friedrich Hayek. In summary, the Austrian School theory of the business cycle states that the capital structure of the economy is based on various time-ordered stages of production, from those that take the longest period of time (mining, refining and manufacturing) to those that take the least amount of time (distributing and retailing). This capital structure determines the economic growth of an economy over time, which in turn determines the amount of consumption available to an economy over time. The longer in time the capital structure of an

[1] *The Cambridge Dictionary of Philosophy*, 2nd Edition (1995) describes *heuristics* as, "A rule or solution adopted to reduce the complexity of computational tasks, thereby reducing demands on resources such as time, memory or attention." (379).

[2] The Austrian School is divided on whether or not capital can be aggregated. This paper follows Bohm-Bawerk's notion that aggregating capital to an "average period of production" is a useful idea that helps to explain the theory.

J.M. Keynes stated, "Dr. Hayek complains that I do not myself propound any satisfactory theory of capital and interest and that I do not build on any existing theory. He means by this, I take it, the theory of capital accumulation relatively to the rate of consumption and the factors which determine the natural rate of interest. This is quite true; and I agree with Dr. Hayek that a development of this theory would be highly relevant to my treatment of monetary matters and likely throw light into dark corners. It is very possible that, looking back after a satisfactory theory has been completed, we shall see that the ideas which Bohm-Bawerk was driving at lie at the heart of the problem and that the neglect of him by English pre-war economists was as mistaken as their neglect of Wicksell." (Keynes 395).

It is from Wicksell, amongst others including the classical school from which the concept of a "natural rate" (a key concept used in the Austrian School theory of the business cycle) of interest derives, see footnote 3.

economy, the more robust is the economy; the Austrian School theory behind this notion is the assumption that longer-term investments are more fruitful and productive than are shorter-term investments.[3]

Austrian School capital theory also proposes that real changes in the supply of loanable funds, through increased savings, results in longer-term investment and thus economic growth and increased consumption, whereas money supply manipulations, not resultant from real changes in the psychological disposition of economic actors (such as entrepreneurial disposition or the propensity to save one's income), do not increase growth or consumption, but merely create skewed and counter-productive investment incentives and thus create "bad" investment decisions. Monetary policy manipulations affect the interest rate[4] facing entrepreneurs and thus create changes in the time-structure of capital which are not based on real and fundamental economic changes. These money changes in an economy exacerbate natural business cycles and create unnecessary unemployment as the bad investments work their way through the economic system.

The purpose of this paper is to present and describe a heuristic model of these concepts. Many but not all of the Austrian School concepts shown here are found in Garrison (2001) but the mathematical formalization and approach to quantifying Bohm-Bawerk's average period of production are, I believe, new, and might help provide a basis for further empirical and theoretical research into the Austrian School theory of the business cycle.

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[3] Or, patience is a virtue. For example, the development of the housing mortgage industry, and the increased payback time (from 10 years to 30 years) has allowed more people to own homes. Stock market returns vary widely in the short term but measured in decades return 10% or more. This same logic applies to investment in means of production; a longer payback time may allow for more trial and error leading toward more efficient productive techniques, movement up learning curves, and more time for product and process innovation. Container ships are much more effective than canoes.

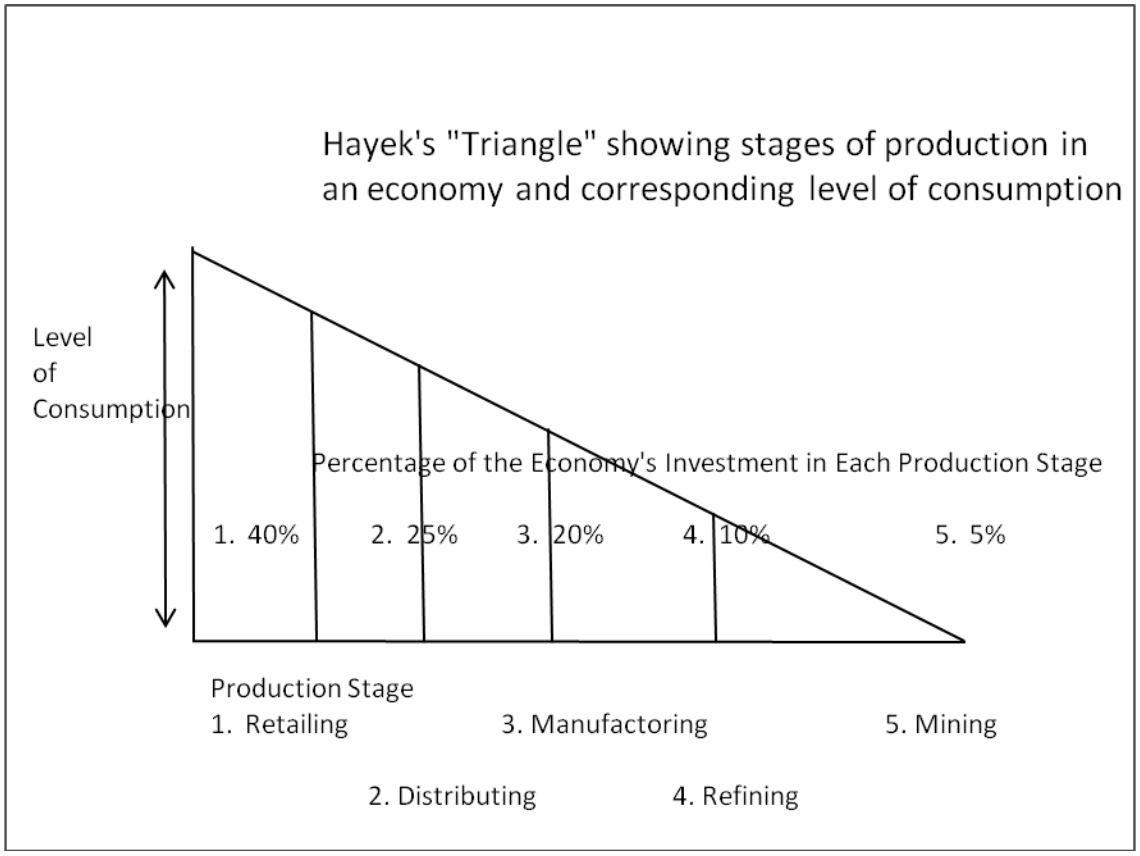
[4] We are using the term "natural rate of interest" in this paper as the interest rate found under the "*normal and ideal* conditions of the economic system" (Kurz 1992, 35, emphasis in the original).

The Oxford Dictionary of Economics, 2nd Edition (2002) defines natural rate of interest as, "the rate of interest which would be compatible with a constant price level. Attenpts to set a market rate of interest below the natural rate lead to expansion of real activity above the level consistent with stable prices, and in the longer run to inflationary rises in prices and monetary wages." (316).

II. The Basic Model: Hayek's "Triangles"

In this basic model, following Hayek's original construct, we find that there are five stages of production; retailing, distributing, manufacturing, refining and mining[5]. Mining takes the longest amount of time, retailing the least. The underlying capital structure depicted by the length of the triangle allows, corresponds to, the level of consumption shown by the height of the triangle. The capital structure, the length of the triangle, is given by the percentage of the economy's investment in each stage of production.

Illustration One



[5] There are of course many more possible stages of production in an economy than Hayek's original five, not least of those excluded are the agriculture, housing and commercial real-estate sectors as well as the information technology base of the modern economy.

In Illustration Two we find the notion of Bohm-Bawerk's "average period of production." This average is calculated by taking the weight of each production stage and multiplying it by the number of the production stage.[6] In our model the average period of production (K = 2.15) corresponds to the capital structure which occurs in the economy at the natural rate of interest. This natural rate of interest is determined when the market is allowed to set the interest rate through the interaction of the savers (supply) and borrowers (demand) for loanable funds. This natural rate of interest creates a natural set of investment incentives which then determines how much capital gets invested into each stage of production.[7] It is at

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[6] Formally, the average period of production is given by the Capital Index (K),

$$\sum_{i=1}^{k} x_i \; w_i$$

Where $i = (1, 2, \ldots, k)$, k is equal to the number of the highest stage of production in the economy (in our model $k = 5$, where five represents the mining stage of production); x is each stage of production, and w is the weight of the production stage's quantity of capital in relation to the quantity of capital in the economy as a whole,

$$\sum w_i = 1.$$

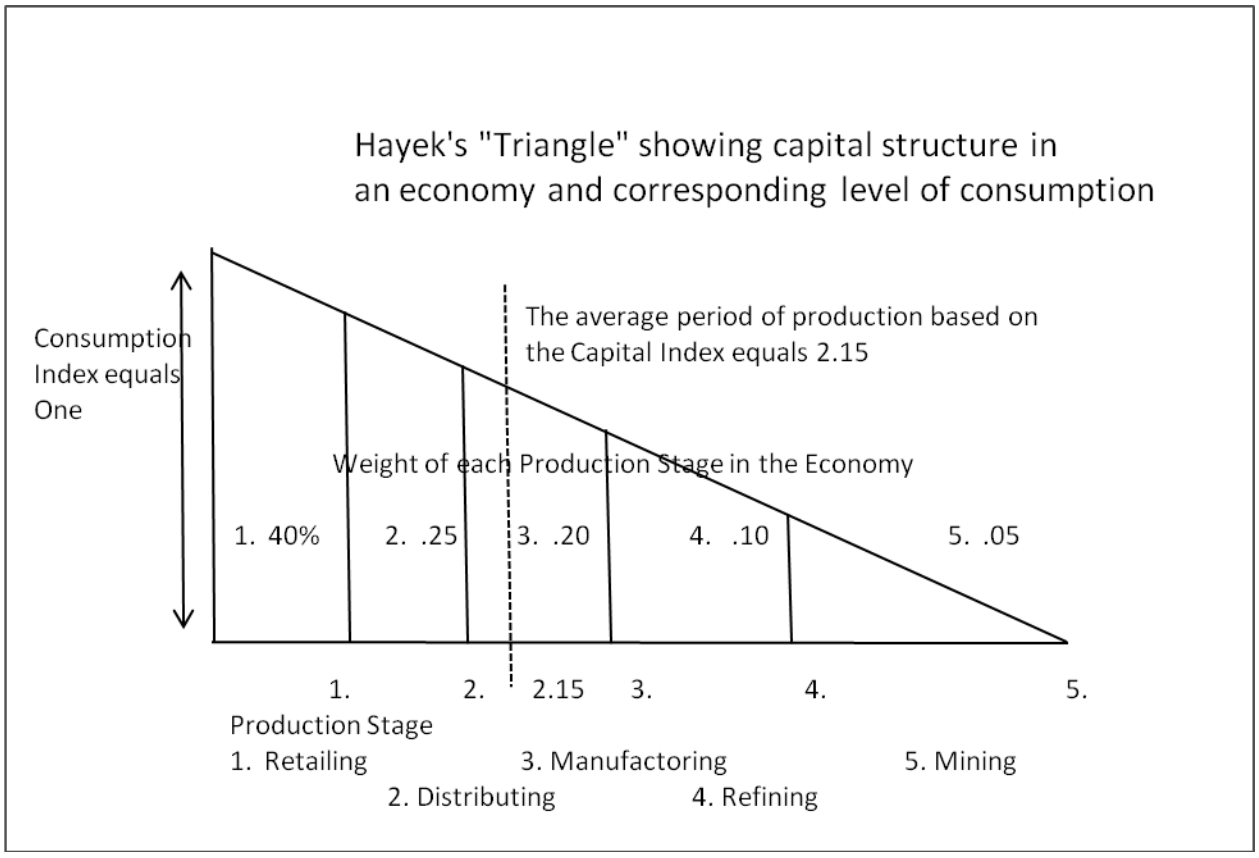
[7] Investment incentives are determined by what is known as the 'investment hurdle'. The longer a period of production the more risk (uncertainty) is involved. This means that the interest rate must be lower in order for the investor to invest in longer period projects in order to compensate for the increased risk. When the interest rate is at a natural level there will be the natural level of investment in longer term, more risky, stages of production. However, if the interest rate is artificially decreased through monetary policy manipulation then there will be more than the natural level of investment in longer term projects, which means that, due to the economic trade-offs inherent in scarce economic resources, there will be less capital available for consumption.

For example, let's assume that the incremental relative risk (risk premium) for each stage of production increases by 100 basis points (1%). If the natural rate of interest is 3% then an investment in retailing would need to return 4% in order to attract investment, distribution would need to return 5%, manufacturing 6%, refining 7%, and mining 8%. If the interest rate is lowered by 100 basis points (1%) investment would shift to higher stages of production accordingly. The investment hurdle for each stage would be lowered, shifting capital investment to higher stages of production from the lower stages.

Of course, there is neither immediate nor complete shifting of capital as the interest rate changes. Investment changes (the movement of capital from one investment to another), despite the traditional, classical and neo-classical economic assumptions, is not completely frictionless. In Keynesian terminology, investment is "sticky." There are costs associated with disinvesting in one sector and moving to another. There are both transactional and informational costs which are not accounted for in the traditional models. However, the Austrian School theory and the Hayekian triangles capture the risk premia and interest rate relationships involved and help to explain, in this case analogically, an economy's capital structure.

this natural capital structure of the economy that consumption is also at its natural rate, or, that which corresponds to a Consumption Index of One[8].

Illustration Two



[8] The Consumption Index is equal to 1 when the Capital Index is that which is determined by the natural rate of interest. The Consumption Index deviates from its natural level of 1 when the Capital Index deviates from its natural level due to monetary policy manipulation of the interest rate.

In Illustration Two the average period of production based on the Capital Index calculation is,

$\sum_{i=1}^{k} x_i \, w_i$, or, K = .40(1) + .25(2) + .2(3) + .10(4) + .05(5) = 2.15.

III. Monetary Policy Manipulation Lowering the Interest Rate

Illustration Three shows the analogy in the triangles of what happens when the interest rate is lowered from the natural rate by monetary policy manipulations[9]. When the interest rate is lowered investors have the incentive to invest in longer term projects because the 'investment hurdle' has been lowered (see footnote 2). The capital (money resources) which was previously used for consumption and retailing has now shifted to higher order goods and investment in higher stages of production, lengthening the economy's capital structure and reducing the level of consumption from its natural level. Illustration Three shows that when the average period of production is increased due to monetary policy manipulation, there is a decrease in consumption.

[9] The central bank authorities use monetary policy to manipulate the interest rate through two main tools. The first is a direct lowering of the interest rate charged to banks borrowing from the central bank (this is known as the discount rate). The second is to print more money (or buy more bonds), this then increases the money supply which means then more supply and thus a lower price, e.g., a lower interest rate. Neither of these policy tools represent real economic or behavioral changes in the economics system, and only represent a change in the value of the medium of exchange.

Illustration Three

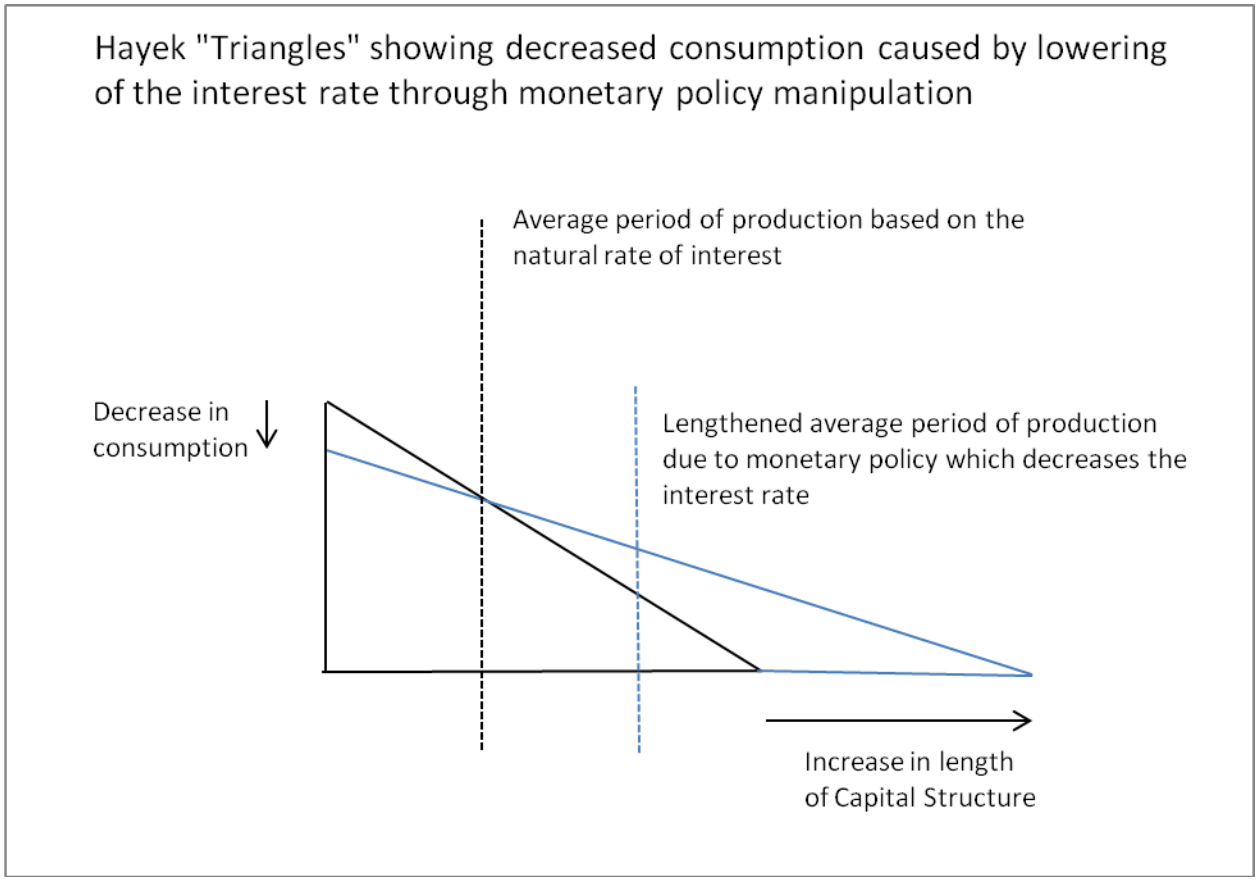


Illustration Four quantifies the changes we show in Illustration Three about what happens in an Austrian School economy when the monetary authority lowers the interest rate. The Capital Index (average period of production) increases from K = 2.15 to K = 2.50 as the lower interest rate creates incentives for longer period (higher stage) production.[10] This in turn decreases the Consumption Index from the natural rate of C = 1 to a lower C = .85.

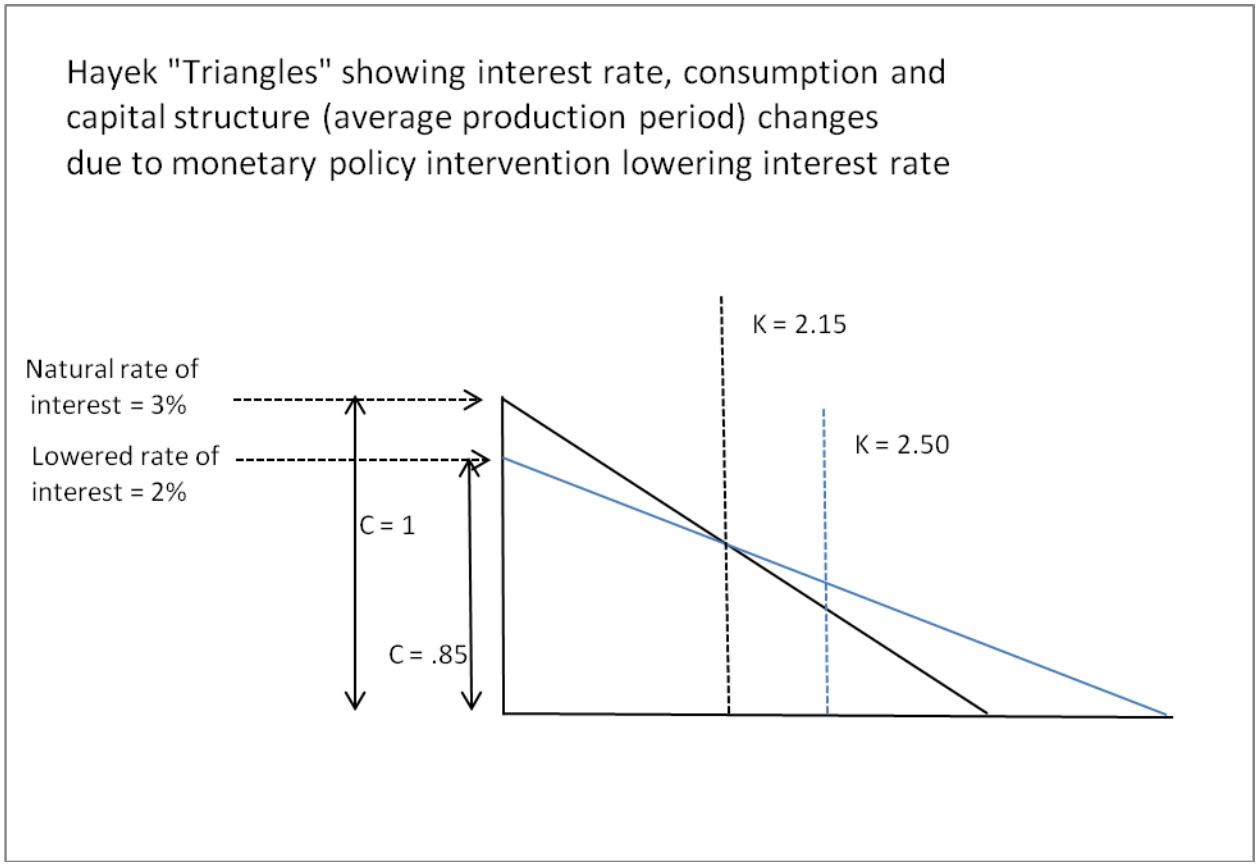
[10] In Illustration Four we are using a natural rate of interest of 3% and assuming the monetary authorities decrease the interest rate by 100 basis points (1%). This then increases the average period of production based on the increased weighting of the economy's investment in longer periods of production and decreased investment in less lengthy periods of production. The Capital Index for the natural rate and lowered rates of interest is constructed from the following:

Production Stage	Weight of Stage at Natural rate of Interest (i^n) = 3%	Weight of Stage at Lowered rate of Interest (i') = 2%
1.	.40	.30
2.	.25	.25
3.	.20	.20
4.	.10	.15
5.	.05	.10
Average Period Of Production (K)	2.15	2.50

We are assuming that the change in consumption, ΔC, is equal to the change in the Capital Index, ΔK, but in the opposite direction (as the average stage of production increases consumption decreases due to the opportunity costs for capital). In this case,

ΔK = (2.50 – 2.15)/2.15 ≈ 15%. Thus, the change in consumption is -15%. Or, after the change in the economy's capital structure due to the interest rate manipulation, the new level of consumption is, C = 1- .15 = .85, with 1 being the natural level of consumption.

Illustration Four



IV. Capital Accumulation and Economic Growth

As capital accumulates and an economy grows[11] this leads to a "deepening" of an economy's capital structure (e.g., capital becomes more patient) and improved standards of living (increased consumption). This can be seen in Illustration Five where we show analogically an economy which has developed economically, leading to increased consumption and an increased average period of production.[12] Note that this increased lengthened capital structure, which is based on economic development, can be contrasted with the increased average period of production that shown in Illustration Four, which illustrates not a capital deepening and economic growth, rather the malinvestment of existing resources based on interest rate manipulations. We are assuming in Illustration Five that accumulation has increased 10% which in turn has meant a capital deepening of 10%, with correspondingly increased consumption of 10%.

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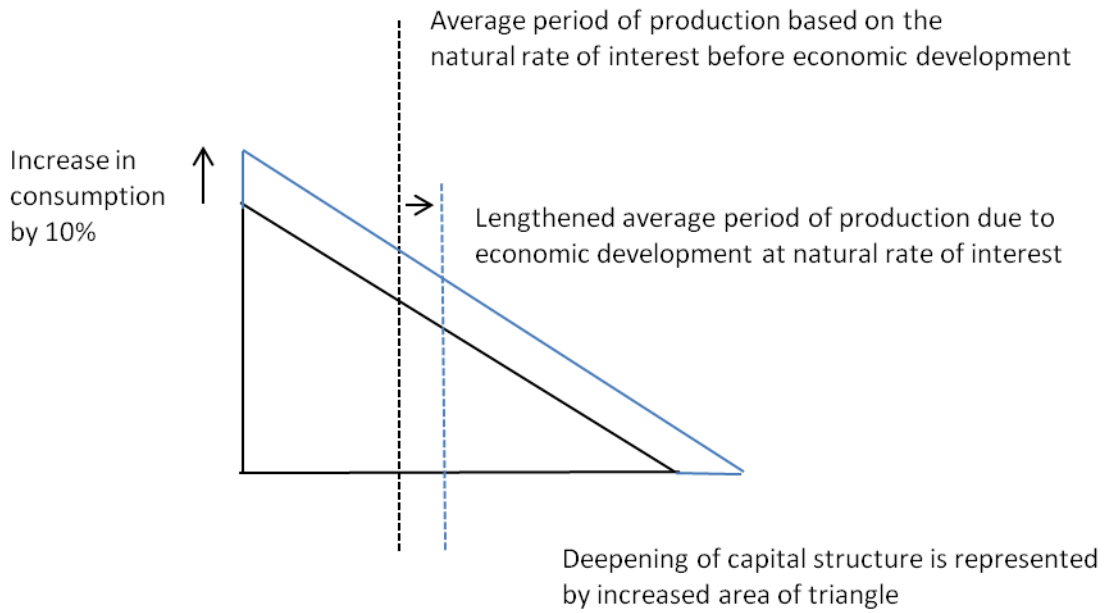
[11] Economic growth and capital accumulation can be described as "economic development". However, as is well known, economic development has taken on another meaning which is the transfer of funds from 'developed' countries to 'developing' countries through the assorted institutions specifically created for this purpose after the Second World War, expanded during the Cold War, and continuing hence. In this working paper we use 'economic development' to mean economic growth and capital accumulation, not the process of taxpayer resource transfers between donors and recipients.

It might be said that one important aspect of economic development is cultural, legal, governmental and social change which motivates lengthened time-spans for decision-making and risk/return trade-offs. This includes, of course, the notion of 'patient capital' which requires trust in local institutions - also necessary to build wealth through small-scale entrepreneurial capital.

[12] Note that economic development and capital deepening can include new, longer, stages of production. For example in industrial countries this could mean increased investment in basic research, and/or research and development. In agricultural-based economies this could mean, of course, increased investment in manufacturing. We are not adding a new, longer, stage of production in this working paper analogy in order to maintain Hayek's original five stages. See footnote 4. for more on stages of production.

Illustration Five

Hayek "Triangle" showing economic development, e.g., economic growth, increased consumption, and capital deepening. We are assuming a 10% level of capital accumulation for analogical purposes.



V. Further Research

This paper represents a very preliminary set of explorations on Austrian School capital and business cycle theory and was prepared as background material for a New School for Social Research seminar on evolutionary – institutional economics and agent-based modeling.[13] Further research along the lines presented in this paper might be as follows:

1). This paper uses "guesstimates" to show analogically how an economy's capital structure can be disaggregated into stages of production based on the ratio (percentage) of each stage of production in relation to an economy's capital structure as a whole. Input-output and other macro-economic data of real economies can be used as a basis for empirically-testing the analogies presented here. For example;

a) In this paper we are assuming that mining is 5%, (refining is 10%, etc.) of our economy. What are these sector shares in actuality? How have these investment shares changed with interest rate and policy changes over-time and/or with macroeconomic shocks?

b) In our analogy we are assuming that the incremental risk premia for each successive (higher order) stage of production is 100 basis points (1%). What are these premia in actuality, and how do the risk premia differ as the stages of production increase in length? How does monetary policy, or capital (factor) mobility policy affect investment hurdles, investment, capital structure, growth and consumption?

c) We are assuming Hayek's original five stages of production. How can this be expanded to empirically measure an entire economy of interest? Austrian School capital theory (beginning with Menger 1871) describes that the more developed an economy becomes the more patient the capital, or, the longer the stages of production. Is this borne-out empirically? How

[13] See Weber and Sum (2007) for a research proposal on Austrian School business cycle theory using agent-based modeling. It is proposed that agent-based modeling (or bottom-up, non-equilibrium, economic modeling) might be true to Austrian School methodological approaches despite the necessary aggregation inherent in any modeling.

have the stages of production changed over the history of capitalist modes of production?

d) How can the notion of a natural rate of interest, and thus a natural capital structure and natural consumption level be used as tools for social analysis?

2). Garrison (2001) uses graphical analogies to show the effects of many different variables (including changes in propensity to save, technological advancement, movements along a production possible frontier with trade-offs between investment and consumption) on the capital structure, and hence consumption and growth, of an economy. How can the quantitative measures presented in this paper be expanded to include analysis of these additional macroeconomic phenomena?

3). Garrison (2007) shows graphical analogies of a monetary expansion triggering economic booms and busts. Whether monetary policy is a trigger for economic cycles, or a catalyst, or neither, is a matter of debate. The catalyst assumption revolves around, as stated earlier in this paper, whether or not monetary expansions resulting from monetary policy interventions exacerbate economic downturns, as is *a priori* (logically) assumed under the Austrian School.[14]

Austrian School and Schumpeterian theoreticians in general do agree that business cycles are natural phenomenon based on psychological (subjective) factors affecting investment and savings decisions and entrepreneurial risk-taking. One of the Austrian School tenets is that manipulation of the interest rate sends investment incentive signals which are not sustainable (e.g. are unnatural) which in turn trigger "mal-investment."[15]

This bad investment may sustain an unnatural growth-run of the economy. However in the end, once an upward cycle has played itself out, this bad investment needs to be worked out of the system, much as a bacteria needs to be worked out of a biological organism, through time, healthy resources and natural antibodies. The working-out of this bad investment can create

[14] See Mulligan (2006) for empirical analysis on the Austrian School theory of the business cycle.

[15] Malinvestment (bad investment) can include over-investment in bad sectors, under-investment in good sectors, and mistimed investment due to bad, unnatural, policy signals.

unnecessary unemployment during downturns just as it created unnatural, unsustainable, employment during policy-induced growth. It follows then, under the Austrian School theories, that a more natural economy, one without policy intervention is more sustainable, robust and healthy.

The concept of a natural economy, with a natural capital structure, might also be used to evaluate Schumpeter's notion of *creative destruction*, where innovation and technological change interrupts an economy.[16] In Schumpeter's concept, short-term disruption can lead to longer-term progress.

Austrian School theory then proposes that malinvestment can make the "creative" (upside potential) portion of creative destruction less invigorating than it could be and "destruction" (short-term disruption) worse than it should be under natural rates of interest and policy regimes due to "sticky" malinvestment. The model of disaggregated capital, stages of production, and time- and risk-based investment functions presented in this paper might be used to evaluate the *quality of investment* in a specific sector (stage of production) and effect of a "creative destruction" shock on that sector. Schumpeterian empirical analysis might also include evaluation of inter-sectoral investment changes as part of specific examples of creative destruction, economic disruption, and longer-term investments in technological advancement.

5) Another concept of Austrian School capital theory is the understanding and analysis of the redistributive effects of monetary policy changes. Money supply increases can mean price increases, but these prices increases do not affect everyone in the economy equally. Those that "touch" the new money before the price increases make their way through the entire economy are better off than those that touch the new money only after the price increases. This in effect is a wealth transfer from those further down the monetary food-chain to those higher-up on the food-chain, or, in other words, expansionist monetary policy can be regressive.

[16] Schumpeter (1950).

This line of reasoning and its implications have not been adequately addressed in mainstream economic research.[17] Perhaps the concept of theoretically and empirically (and then indexing an aggregate to allow comparative analysis) disaggregating capital and stages of production (from consumption goods to higher-order goods) can provide insight into a research approach for analyzing the under-appreciated re-distributionally regressive effects of monetary policy.

V. Note on the Debate in Economics over Capital Theory

It is beyond the scope of this paper to locate the Austrian School business cycle theory in the debate over capital theory.[18] However it should be stated that in certain ways the concepts presented in this paper are only peripherally related to the historical debate over capital theory. The major deviations are:

1) Both "sides" of the capital controversy (the *classical economists* and the *neo-classical economists*) assume that capital moves costlessly and immediately to its most profitable use, this then means that there are no extra-normal economic profits because competition drives the profit rate down to one uniform level. Austrian School capital theory (and our heuristic model) does not assume this complete mobility of capital but states more realistically that investment decisions are bounded by limited knowledge and "sticky" investment. In turn this means differing rates of profit for differing capitals and, more explicitly, in this paper we assume

[17] Ludwig von Mises, another seminal Austrian School economist writes, "The oversimple formula both of the old quantity theory and of contemporary mathematical economists according to which prices, that is all prices, rise or fall in proportion of the increase or decrease in the quantity of money, is disproved…let us look at the case of inflation only. The additional quantity of money does not find its way at first into the pockets of all individuals, not every individual of those benefited first gets the same amount and not every individual reacts to the same additional quantity in the same way. Those first benefited are in the position to offer more money on the market for the goods and services they wish to buy….It takes time until the additional quantity of money has exhausted all its price changing possibilities, the process of progressive depreciation [inflation] has changed the income and the wealth of the different social groups" (Mises, 72-73).

[18] For an excellent and concise summary of the capital theory debate and the Austrian School's place in this debate see Kurz (1990).

a risk premia for each stage of production, which by definition means non-uniform rates of profit for different stages of production.

The non-deterministic approach to modeling the economy found in the Austrian School, an economy which is based on heterogeneous agents - with every individual carrying unique risk, consumption and time preferences - can add another dimension to social analysis, one which is not an "us versus them" class structure approach. [19]

2) The "long-period" in classical economics conflates the rate of interest and the rate of profit to one level of interest/profit. The Austrian School (and our heuristics) explicitly denotes that the rate of interest and the rate of profit are different, differing by the level of risk (risk premia) of each production stage as subjectively viewed by each individual agent. It could be stated that the assumption of loanable funds being a commodity, tending toward one price (the interest rate based on market forces matching savers and borrowers at one rate of interest) in our model is the same as that of the classical school, but this assumption is for loanable funds only, not investment capital. Investment capital itself is not a commodity and does not tend toward one price (one rate of profit), but varies according to time and risk.[20]

[19] Classical economics uses class structure as an analytical tool, for example in assuming that there is a fixed social surplus which gets divided between capitalists and workers (between profit and wages). In our model we are not assuming this trade-off and are assuming that differing stages of production offer differing wage rates and differing profit rates, without connoting a necessary trade-off between the two. It should be noted that any class struggle in the Austrian School would be between taxpayers and tax consumers, i.e., those benefiting from the tax system are exploiting those that pay taxes, see Hoppe (93-110).

[20] See the Appendix to this working paper for more on heterogeneous capital, e.g., simultaneous differing capitals in an economy based on differing technologies, and on differing time- and risk-preferences of entrepreneurial capital.

Appendix: Hayek Triangles and Heterogeneous Capital

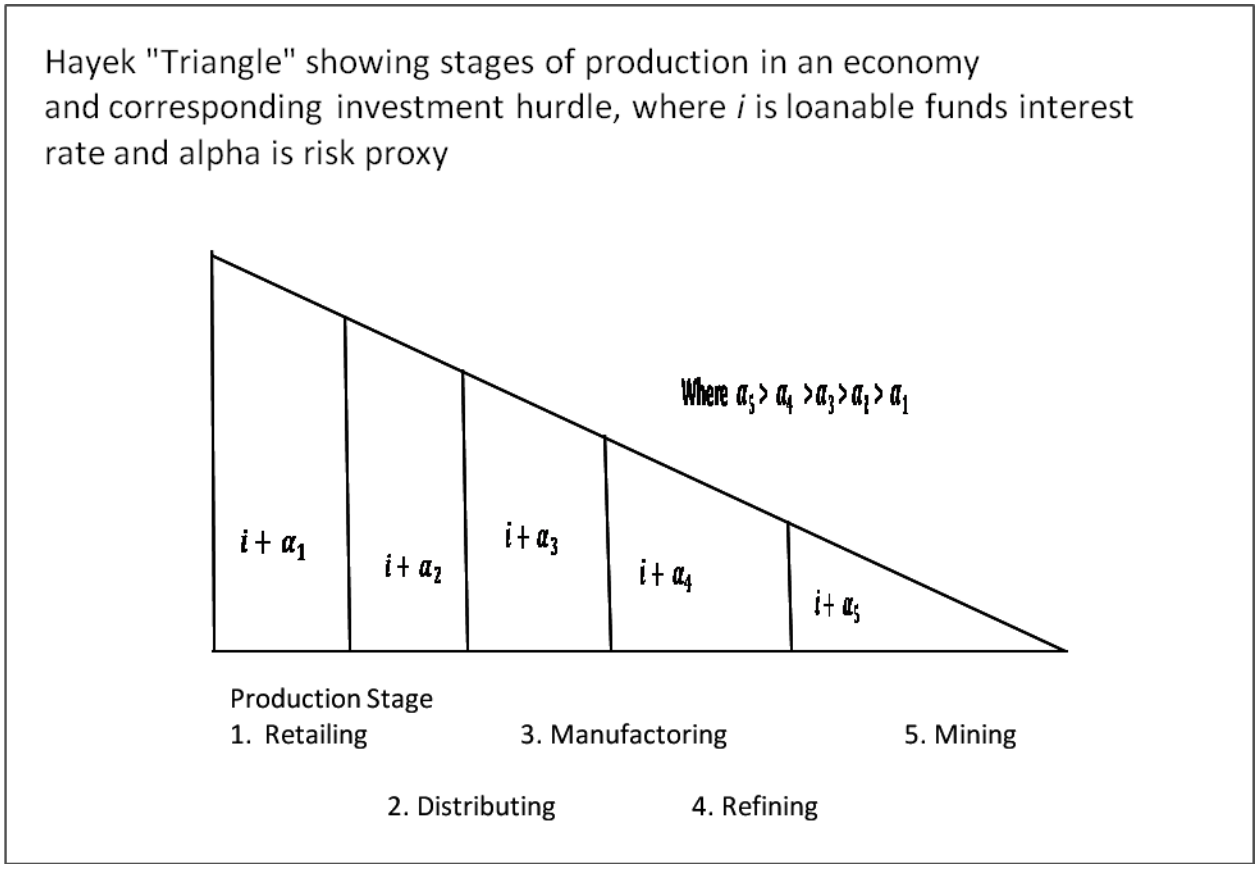
In Illustration Six we show our Hayekian triangle with its five stages of production, in chronological order from the least lengthy (retailing) on the left and the most lengthy (mining) on the right. Each stage of production has an associated level of "risk", α_i, where alpha (α) represents the risk for stage of production, *i*, and where *i* = 1 to 5, e.g. one unique alpha for each stage of production.

It should be noted that this unique alpha represents more than the level of risk for the stage of production, for the investment.[21] The alpha value is a proxy for the market uncertainty, the technology, the regulatory environment, the labor pool, the climate and/or resource dependency, the competitive factors and the 'rational expectations' based on limited information and local knowledge surrounding the investment in the stage of production for the entrepreneur, and, therefore, of course, varies with the subjective knowledge of each entrepreneur.

The purpose of this working paper on the analogical-graphical model presented here (and based on the Austrian School) is to capture this subjective, entrepreneur-based economy into a model which is generalized to facilitate deeper analysis of the capital structures of an economy than is possible with the mainstream classical and neo-classical models. This Austrian School allows, explicitly, varying rates of return based on varying investment risks (varying alphas). This is easy to visualize with time-based periods of production. The further out into the future an event, the less is known about that event; e.g., the less one can control the circumstances surrounding the event. This means of course that the expected return to an investment which pays its return further out into the future must be larger than the return to an investment which will have its payout nearer in time, *ceteris paribus*. This reasoning alone shows the validity of the Austrian School concept on heterogeneous capital returns, and, of our approach to increasing alphas as the stage of production increases.

[21] See footnote 6, for more on the concept of investment hurdle.

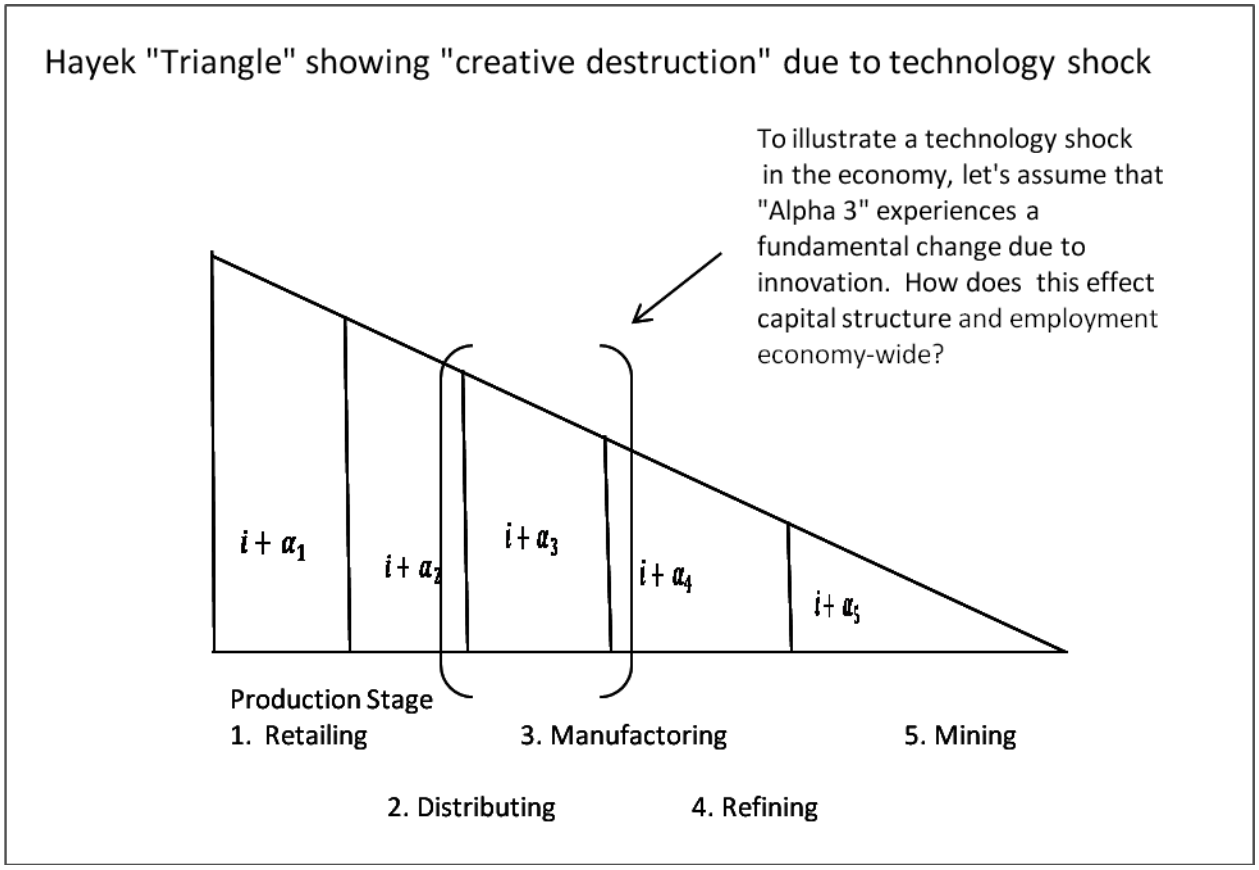
Illustration Six



We use Illustration Seven to show the concept of heterogeneous capital and creative distruction. A techonology shock can effect the means of production in just one sector.[22] How the economy responds to this shock depends on its capital structure (investment is 'sticky' and sticky malinvestment can decrease an economy's ability to quickly adapt change) and the ability for resources to flow between stages of production. Visualizing the disaggregated capital structureof an economy can provide insight into the analysis of creative destruction.

[22] Of course technology or other shocks can be economy-wide or across sectors, such as the internet, transportation technology advancements, and just-in-time inventories. An example of a specific stage of production shock might be the advent of a new chemical processing technique or discovery of previously unknown natural resources.

Illustration Seven



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