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Agent-Based Modeling and the Austrian School Theory of the Business Cycle

Research Proposal

Background:

The "Austrian School of Economics" lost its prominence in the 1930s with the rise of Keynesian economics. One of the reasons for this (see Hayek 1995) is that Austrian School capital theory could not be adequately formalized with mathematics, as was done with John Maynard Keynes's ideas from the *General Theory*. When F.A. Hayek won the Nobel Prize in 1973 this created a resurgence of interest in the ideas of the Austrian School. Our proposed research is a further continuation of this resurgence in Austrian School ideas.

The Austrian School business cycle theory (we are using the terms "capital theory" and "business cycle theory" interchangeably in that they are closely related, with the business cycle theory building upon the fundamental capital theory) is based, unlike neo-classical economics, on disaggregated quantities of capital. Capital is invested into various, ordered, processes (stages) of production based upon the time-structure (or "roundaboutness"[1]) of the period of production. The highest order goods (goods produced in an economy requiring the longest period of time before the process pays back the capital and makes a profit for the capitalist[2]) are those resulting from investment in the mining process. The next highest order is refining, followed by manufacturing, distributing, retailing and finally, consumption goods (the latter being the center of analysis of much mainstream economics)[3].

Austrian School business cycle theory is based in large part on the concept that there is a natural rate of interest[4] in an economy which matches the needs of savers (supply of capital) with those of lenders (demand for capital). This supply and demand relationship sets the market rate of interest. This market rate of interest, absence of policy manipulations, is per the Austrian School, the natural rate of interest.

When the natural rate of interest is manipulated it causes a change in the relative amount of investment in each stage of production. This capital structure change is

[1] "Roundaboutness" refers to the length of time the production process takes. The more roundabout the stage of production, the longer is the process and the higher is the degree of entrepreneurial risk required. See Bohm-Bawerk (1891) on the roundaboutness of stages of production.

[2] We are using the term *capitalist* to represent an agent who is investing capital into the production process.

[3] Note that we are using the stages listed by Hayek (1966a), which are based on 'early capitalism,' which do not include the FIRE (finance, insurance and real estate sectors) nor the government sector, e.g. 'modern capitalism'. We will add these sectors later to our model and then test empirically the model with data from 1900 and 2000 to see if the model captures the real data.

[4] See for example the "*normal and ideal* conditions of the economic system" (Kurz 1992, 35, emphasis in the original) for a concept of "natural" in economics, here applied to the interest rate.

skewed from the natural state of the economy, which creates over-, under- and/or mal-investment, changing the economy's natural production of consumption goods and other, higher order, goods (Hayek 1966b). The change from this natural state of the economy then exacerbates natural business cycles, creating unnecessary unemployment.

The Research:

The research proposed will be to apply agent-based modeling to Austrian School business cycle theory. It could be argued that this is a good fit in that Hayek, later in life, denied the mainstream economic approach of General Equilibrium Theory, seeing the economy as an open-ended system (Burzcak 2006). Agent-based modeling too does not use an equilibrium framework for modeling the economy. Therefore we propose that the use of non-equilibrium, "bottom-up", agent-based modeling might provide robust insights into Hayek's and Bohm-Bawerk's theories for capital and would be true to their methodological approaches.

We propose an attempt to model a decentralized, non-equilibrium, economy with varying spacial and temporal elements with agents who are workers, borrowers, lenders, and capitalists and who have individual and varying endowments, risk preferences, and spatial locations. We are also including an endogenous "prosocial" variable to allow the agents to voluntarily redistribute wealth based on spatial relative wealth inequality. The objective function of each agent will be to maximize the relative wealth of each agent.[5] The individual preferences change over time as society and the economy becomes developed and/or experiences technological innovation, transformation growth or undergoes political-institutional change

Investment is determined by the rate of interest and a measure of time-based entrepreneurial risk (risk premium, or, "α") for each stage of production. Production functions are based on capital, labor, natural resources and climate. Ideally we will model an economy with natural business cycles based on

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[5] In later generations of the model we hope to add leisure time as an endogenous preference.

exogenous climate variables or technology shocks, against which we can test manipulation of the interest rate as opposed to real changes in the economy.

The proposed output of the model will be the measurement of relative wealth per person and employment levels based on business cycles. One of the key elements of the model is the use of a "Capital Index"[6], based on Bohm-Bawerk's concept of an average production stage for the economy. In our model, it is when this Capital Index changes from its natural level from monetary not real economy changes that business cycles are exacerbated.

As time continues the stages of production increase in roundaboutness as the society becomes more developed and new technology evolves. The risk preferences of each agent then determine the riskiness of the agent's investments (each agent has her or his own time-based entrepreneurial proclivities, e.g. his or her own "α,", with the longer the time-preference, the larger the "α")[7] and how this investments are made in the evolving capital structure. The "α" can also serve as a 'cultural proxy' where institutional change in a society effects individual risk-perception and time-preference.

Additionally, if possible, we hope to show temporally, analogically and graphically the concept of "Hayek's triangles" as they equate the interest rate with the production processes. We also hope to tie Garrison's loanable funds supply and demand curves with the Hayekian triangles in the analogical model (Garrison

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[6] The "Capital Index":
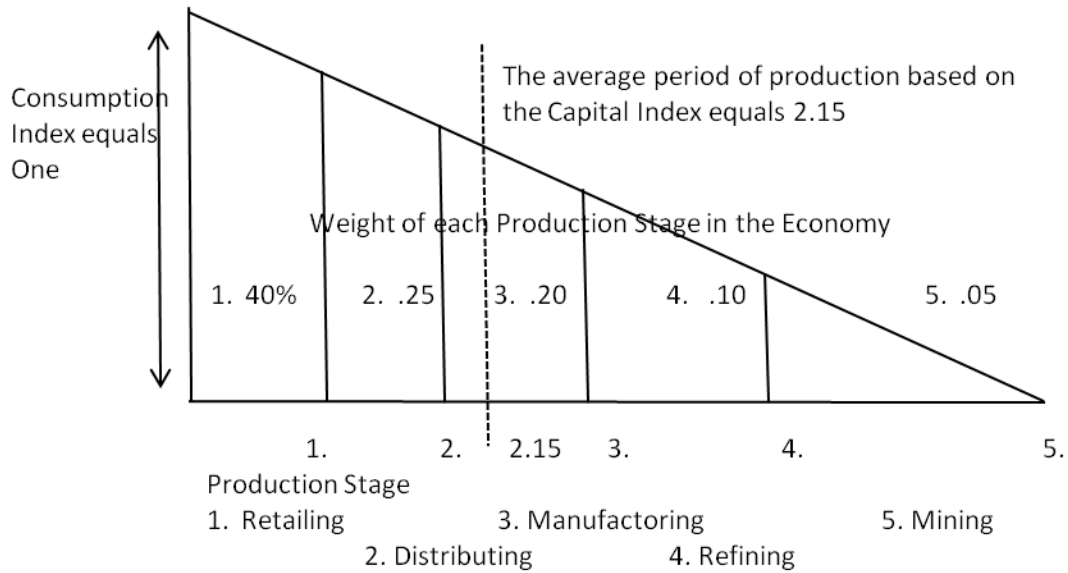
$$\sum_{i=1}^{k} x_i \, w_i$$

Where i = (1, 2, ..., 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,
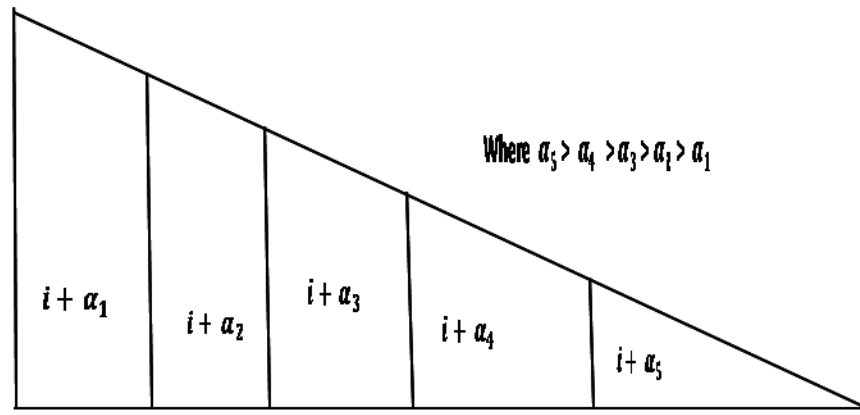
$$\sum w_i = 1$$
.

[7] Note that "α" can also be used as a proxy for the culture and institutions economy-wide, which effects the endogenous risk preferences of each individual agent in society.

2001), in order to show dynamically the effect of a change in the money supply, and real changes in the economy such as capital accumulation, on the capital structure in an economy.

Hayek's "Triangle" showing capital structure in
an economy and corresponding level of consumption

Consumption
Index equals
One

The average period of production based on
the Capital Index equals 2.15

Weight of each Production Stage in the Economy

1. 40%   2. .25   3. .20   4. .10   5. .05

1.   2.   2.15   3.   4.   5.
Production Stage
1. Retailing   3. Manufactoring   5. Mining
        2. Distributing   4. Refining

Hayek "Triangle" showing stages of production in an economy and corresponding investment hurdle, where i is loanable funds interest rate and alpha is risk proxy

Where $\alpha_5 > \alpha_4 > \alpha_3 > \alpha_2 > \alpha_1$

$i + \alpha_1$

$i + \alpha_2$

$i + \alpha_3$

$i + \alpha_4$

$i + \alpha_5$

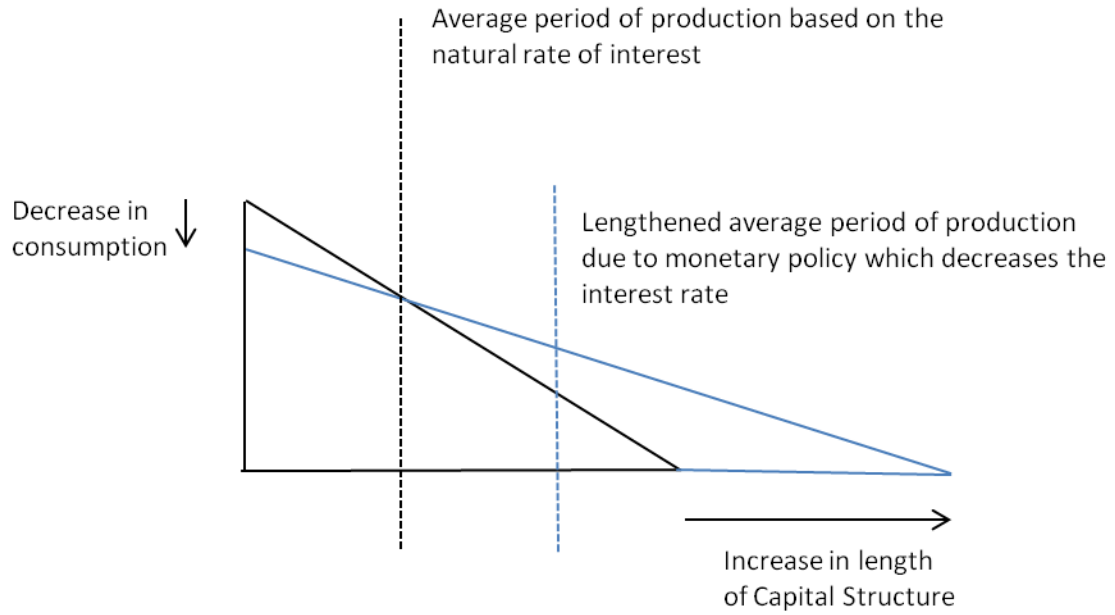Production Stage

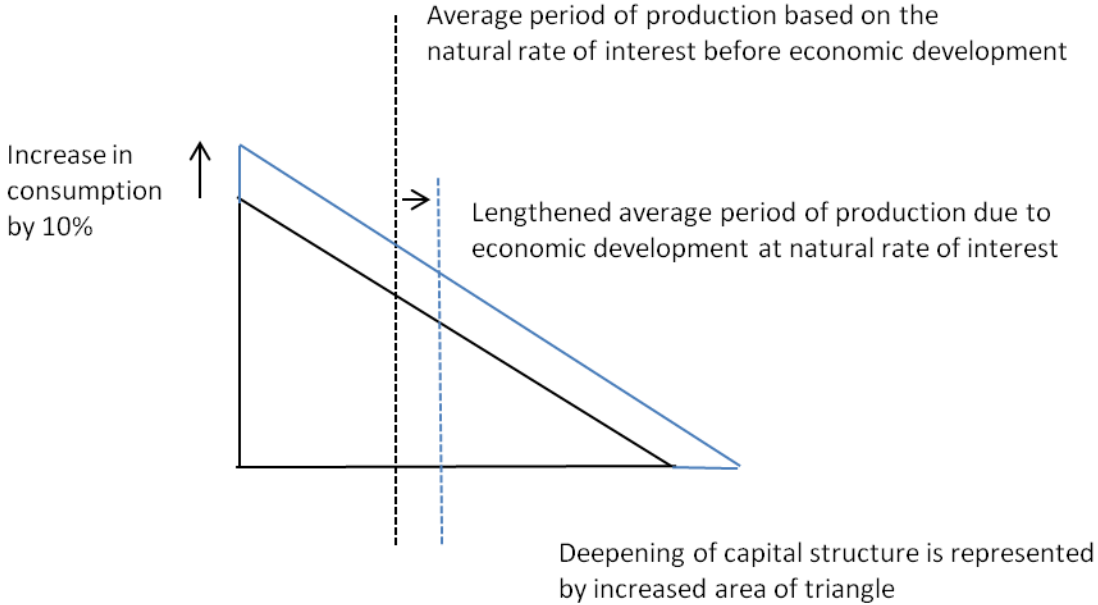1. Retailing   3. Manufactoring   5. Mining

2. Distributing   4. Refining

Hayek "Triangles" showing decreased consumption caused by lowering
of the interest rate through monetary policy manipulation

Average period of production based on the
natural rate of interest

Decrease in
consumption

Lengthened average period of production
due to monetary policy which decreases the
interest rate

Increase in length
of Capital Structure

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.

Average period of production based on the
natural rate of interest before economic development

Increase in
consumption
by 10%

Lengthened average period of production due to
economic development at natural rate of interest

Deepening of capital structure is represented
by increased area of triangle

Hayek "Triangle" showing "creative destruction" due to technology shock

To illustrate a technology shock in the economy, let's assume that "Alpha 3" experiences a fundamental change due to innovation. How does this effect capital structure and employment economy-wide?

$i + \alpha_1$

$i + \alpha_2$

$i + \alpha_3$

$i + \alpha_4$

$i + \alpha_5$

Production Stage
1. Retailing

2. Distributing

3. Manufactoring

4. Refining

5. Mining
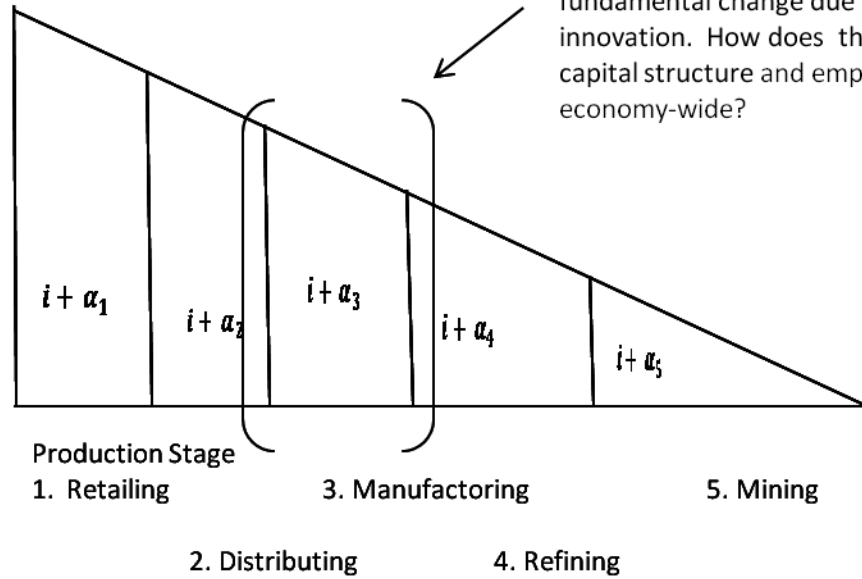
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