HAYEKIAN TRIANGLES: AN APPLICATION TO FINANCIAL ASSETS

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Resumen: Los triángulos Hayekianos son una herramienta utilizada por la escuela de economía austriaca, especialmente en la teoría del ciclo económico. El objetivo de este trabajo es mostrar cómo también pueden ser empleados para analizar las fluctuaciones de los mercados de valores, añadiendo los activos financieros al modelo.

Abstract: Hayekian trinagles are a device used by the Austrian school of economics, especially in the Austrian Business Cycle Theory (ABCT). The purpose of this paper is to show how they can also be used to analyze the fluctuation of the securities market, by adding financial assets to the model.

Keywords: Austrian Economics, business cycle theory, financial assets, Hayekian triangles.

Classification JEL: E14, E32, E51, G01.

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I
INTRODUCTION

Hayekian triangles are named after F.A. Hayek who used them in 1931[1] to explain the productive structure of a simple economy and how it is affected by changes in the interest rate. Therefore, they can analyze the consequences of modifications in the individuals' time preference, and of credit expansions (Hayek 2008, pp. 237-245) which are the main cause of the Austrian Business Cycle Theory (ABCT). The ABCT was first developed by Mises ([1912] 1981) and has been updated by authors such as Huerta de Soto (2009); this last version will be the one followed throughout this paper.

I will argue that triangles can also describe the price performance of the hypothetical financial assets employed to finance the productive structure. However, in order to get this result, we must accept all the assumptions needed to construct Hayekian triangles and their attached shortcomings.

The paper is divided as follows: in section II, I will introduce Hayekian triangles, highlight some of their limitations and include financial assets in the analysis, starting with the example used by Huerta de Soto (2009). In section III, the case of a voluntary increase of savings will be examined, specifically the impact on financial assets. Sections IV and V are dedicated to the boom and crisis phases of the ABCT. Finally, section VI concludes.

II
ADDING FINANCIAL ASSETS INTO HAYEKIAN TRIANGLES

Before using Hayekian triangles, it is necessary to understand the assumptions on which they stand. First of all, they need to use *descriptively false* simplifications of the reality, making them unsuitable to prove (or falsify) economic laws (García Iborra 2015); there-

[1] First edition of Prices and Production (Hayek 2008). Jevons ([1871] 1998, pp. 228-229) already used a similar diagram sixty years earlier. For more historical references see Huerta de Soto (2009, pp. 233-234).

fore, they can only be used to *illustrate* theories that have been *previously* accepted following scientific criteria. Basically, triangles try to capture the operation of a complex system during a period of change, and in order to get a simplified picture of the process it is necessary to:

(1) Rule out the existence of durable consumer goods.
(2) Exclude the employment of fixed capital.
(3) Aggregate all productive processes and divide them in different stages of production (Barnet II and Block 2006, pp. 50-53).
(4) Assume an arbitrary monetary base, composed of monetary units that do not represent the liabilities of any agent. Therefore, triangles cannot capture the creation and destruction of credit; it has to be assumed exogenously.
(5) Restrict the role of money to the function of means of payment and unit of account leaving its use as store of value aside (money cannot be hoarded): thus, triangles are also unable to capture the value of money[2]. The employment of monetary units to measure the value of each stage, and its components, implies that *we cannot compare different triangles*, neither in physical units nor in utility terms.
(6) Assume that all stages take the same time for their completion and that all payments and exchanges are made at the same time[3]. We will use an annual basis.
(7) Assume the interest rate used for each stage; normally it is assumed to be unique and the same for all stages (Barnet II and Block 2006, pp. 43). However, it is important to highlight this is not a necessary assumption for equilibrium: we can also assume that agents assign different levels of risk to each produc-

[2] As Cannan (1921, pp. 454) explains, the demand as means of payment is at the same time its offer, so the value of money comes from the service it provides as a store of value. Money cannot have *value* in Hayekian triangles and therefore any «token money» is acceptable.

[3] This does not mean their *liquidity* is the same. Although they are all negotiable, their liquidity is different according to how distant they are from consumption (García Iborra 2014).

tive stage and, therefore, require a higher nominal ROA to the riskier ones[4].

(8) Assume the temporal distribution of savings. As Fillieule (2007, pp. 195) states: «... a structure is entirely determined by the three parameters, *C*, *i* and *a*, where *C* is the annual aggregate spending on consumer goods, *i* the annual originary rate of interest, and *a* the ratio of originary factors to investment at each stage». Thus, those three parameters have to be *independent*. Following a similar reasoning, Hülsmann (2011, pp. 16) affirms that any interest rate can be found along with any amount of savings.

In other words, *the amount of savings does not determinate the interest rate*, they are *independent* factors, and we need to assume both. For these reasons, not only total savings are relevant but also their temporal profile (Jevons [1871] 1998, pp. 227-228).

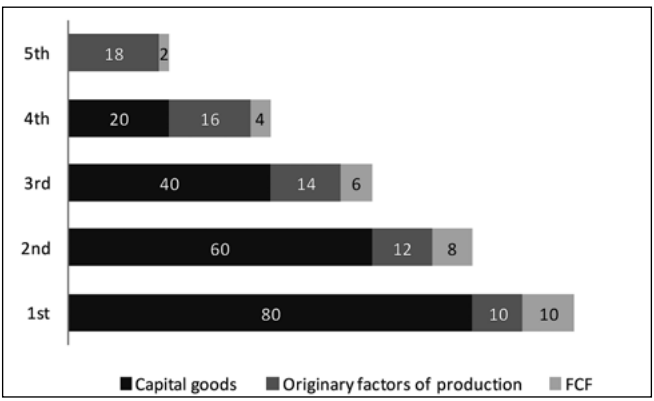
(9) The economy is assumed to be in equilibrium.

All these assumptions (and their shortcomings) will also be used when adding financial assets into the picture. In addition, as we will explain below, further assumptions will be needed.

Now, let us start with the example of a productive structure that can be found in Huerta de Soto (2009, pp. 234) and that is shown in FIGURE 1:

[4] In the context of an Evenly Rotating Economy (ERE) all ROAs would be equal. However, it is not necessary to restrict the analysis to all the assumptions of the ERE.

FIGURE 1
EXAMPLE OF A PRODUCTIVE STRUCTURE



The economy is divided in five different stages: the first one is where consumer goods are produced, while the fifth represents the production of those capital goods that are farthest away from consumption. The vertical axis of the graph represents the distance to the act of consumption, while the horizontal measures the *monetary* value of all the resources assigned to each stage. This monetary value is divided into three different parts according to what type of agent is receiving it:

(i) Payments to owners of capital goods: reflecting the monetary value of the capital goods for each stage; thus, they also represent the value of the previous stage (this is why the fifth stage has no payment of this kind).
(ii) Payments to originary factors of production, which are assumed to be non-specific.
(iii) Payments to capitalists that have saved and invested to finance the previous two concepts. This third factor is equivalent to the concept of Free Cash Flow (FCF), as it includes all the monetary income received by all suppliers of savings. In addition, the ratio of FCF to the sum of (i) plus (ii) is equivalent to the Return On Assets (ROA).

We will assume, for the sake of simplicity, that these «investors» hold their investments through a single type of asset: a perpetuity.

There are as many perpetuities as stages, and each of them gives the right to collect all the Free Cash Flow generated by the particular stage they finance. Therefore, these perpetuities have no maturity and provide the right to collect all payments to capitalists *during all future periods, not only the one that is represented by the current productive structure* and which is assumed to be one year[5].

These assumptions will allow us to use a simple mathematical formula to calculate the price for each perpetuity:

$$Price\ of\ the\ perpetuity\ of\ stage\ i = \frac{Cash\ flow_i}{Discount\ rate_i}$$

Going back to FIGURE 1 we can see there are 300 monetary units in the economy: the monetary value of consumption goods is 100 m.u., equivalent to the monetary value of the first stage and to the total net income (Huerta de Soto 2009, pp. 306). Knowing that each stage lasts one year, the annual ROA of all stages is 11,11% regardless of its proximity to consumption.

With the information provided in the example, we can proceed to calculate the monetary value of the financial assets that represent the funding source of each stage: we have the *annual* cash flow provided by each stage, represented by the FCF, and we only need a *discount rate* to obtain the present monetary value of all perpetuities. Here is where we need to make a new assumption on top of those previously stated, there are two options:

1. Use the annual ROA of the example. Thus, we would be implicitly assuming that time preference is linear (i.e. annual time preference from now till next year is the same as the one starting in ten years from now, for a period of one additional year); and that agents assign the same level of risk to each annual period regardless of how far it is from the present. This assumption is incompatible with the existence of uncertainty and the creative aspect of human action.

[5] Thus, they are analogous to shares in a 100% equity-financed corporation, i.e. one which has no debt on its balance sheet. We stick to the concept of «perpetuity», instead of using «share», to highlight the fact that they would represent the payments to both stock and bondholders, were the stages financed by a mix of equity and debt.

2. Use a different discount rate from the annual ROA employed for the current productive structure. In this case, we could take into account all those factors mentioned above. However, we would also need to make a new set of arbitrary assumptions to model the temporal distribution of the time preference and risk that agents subjectively assign to each time horizon[6].

Knowing that Hayekian triangles already stand on assumptions that does not allow them to falsify scientific laws, and for the sake of simplicity, I will use the annual ROA to discount the FCF of each stage[7]. Now, we can calculate the price of the perpetuity that receives the FCF generated by each productive stage; the following results are obtained (TABLE 1):

TABLE 1
PRICE OF THE PERPETUITIES

Stage	FCF (m.u.)	Price of the perpetuity (m.u.)
5th	2	18
4th	4	36
3rd	6	54
2nd	8	72
1st	10	90

These results add little value to the analysis, as Hayekian triangles do, if not applied to the study of *changes* in the productive structure. The next sections will be dedicated to that.

[6] This would also include the risk of changes in the purchasing power of the money; this factor would affect, in the same way, all financial assets regardless of the stage they finance.

[7] A consequence of this decision is that the monetary value of all perpetuities will be equal to the value of the spending on originary factors and capital goods for each stage. This is because we are discounting all the «future» triangles at the same rate as the «present» one. Had we used a higher ROA (to reflect an increasing time preference or the higher level of risk attached to longer horizons), the price for the perpetuities would have been lower.

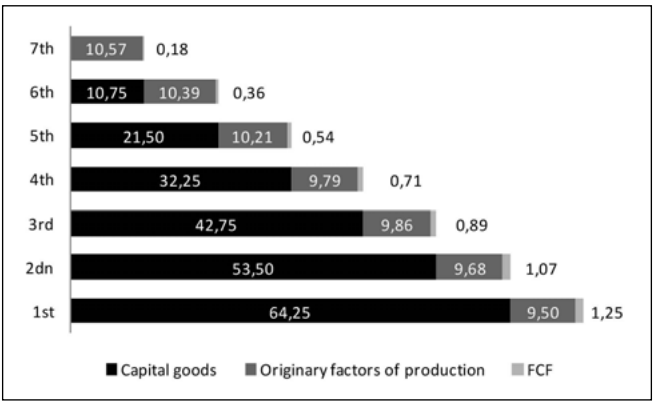
III
VOLUNTARY INCREASE OF SAVINGS

Let us look at the case in which agents lower their time preference and increase their savings. Following Huerta de Soto (2009, pp. 249-272), this act brings about three effects that will affect the productive structure:

1. Changes in the relative profitability of the stages: the higher stages show higher profitability rates than the lower, so that the latter reduce their demand of originary factors of production, that are absorbed by the increased demand of the former.
2. Changes in the prices for capital goods: the lower time preference implies a higher valuation of future income relative to present one, this will push up the prices for capital goods that are distant from consumption.
3. Ricardo effect: labor (one of the originary factors) becomes more expensive in real terms versus capital goods, if wages do not react automatically to the lower valuation of consumption goods.

Looking at the example provided by Huerta de Soto (2009, pp. 266) for a Hayekian triangle, consumption is reduced by 25 m.u. from 100 to 75 monetary units and, after a process of change that takes time, we reach a new equilibrium (FIGURE 2):

FIGURE 2
NEW PRODUCTIVE STRUCTURE
WITH A LOWER TIME PREFERENCE



The new productive structure is longer: we have now seven stages instead of five; and wider, as the monetary value of the stages that do not represent consumption goods is now 225 m.u. (vs. 200 previously) following the higher saving rate. The net income decreases to 75 m.u. and the ROA is now 1,69% and again equal for all of stages.

As we said earlier, only by knowing that agents have saved 25 monetary units more we cannot determine how they will distribute them among the different stages, we have to *assume* it (assumption 8). In our example, there is no fixed relationship between the spending on originary factors and total investment (the *a* parameter for Fillieule (2007) is not the same for all stages), so we also need to assume the proportion invested in capital goods for each stage (except the last one). We may conclude that, for Hayekian triangles, the decrease of consumption determines the increase of the investment, but it is the combination of (a) the new ROA and (b) the share of total investment dedicated to capital goods the factors what will determine how the additional savings are *distributed* (Machaj 2015)[8].

[8] Howden (2016) shows the relevance of providing a *causal* explanation to changes in these variables.

From the initial situation to the new equilibrium, we see that the monetary base has remained unchanged at 300 m.u. even though the economy has gone through a significant process of change to reach the new situation; in any real situation, this should also affect the value of money and the monetary base.

Although the *monetary* value of the consumption stage has decreased from 100 m.u. to 75, this does not imply the physical production of consumption goods, or the utility they provide, is lower. On the contrary, it can be argued that productivity must be higher in the new equilibrium given that the economy is now more capitalized: the monetary base may have not changed but its *value* (in terms of consumption goods) has (Huerta de Soto 2009, pp. 267)[9].

Let us now analyze these changes from the perspective of financial assets: we can see how FCFs have changed in TABLE 2:

TABLE 2
CHANGES IN FCF FOLLOWING A LOWER TIME PREFERENCE

Stage	Initial FCF (m.u.)	Final FCF (m.u.)	Change (m.u.)
7th	0	0,18	+0,18
8th	0	0,36	+0,36
5th	2	0,54	-1,46
4th	4	0,71	-3,29
3rd	6	0,89	-5,11
2nd	8	1,07	-6,93
1st	10	1,25	-8,75

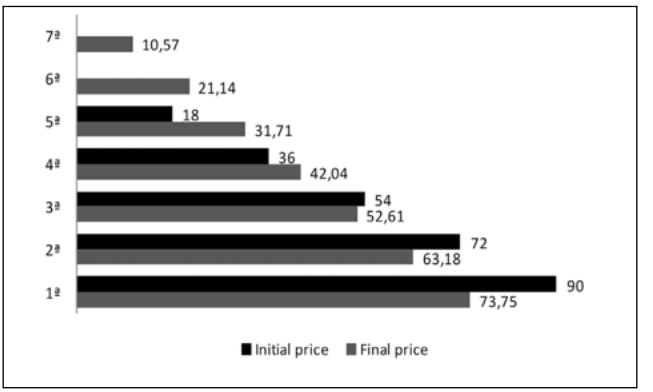
The FCF has increased for the sixth and seventh stages but for the rest we get lower values. However, this does not imply the *monetary value* of those perpetuities that finance the first five stages has decreased, we need to take into account the new discount rate: 1,69%. Applying the new ROA we get the results shown in TABLE 3:

[9] Again, this has to be proved by economic laws, not by Hayekian triangles.

TABLE 3
CHANGES IN THE PRICES OF PERPETUITIES FOLLOWING A LOWER TIME PREFERENCE

Stage	Initial price	Final price	Change	% Change
7th	0	10,57	+10,57	-
6th	0	21,14	+21,14	-
5th	18	31,71	+13,71	+76%
4th	36	42,04	+6,04	+17%
3rd	54	52,61	-1,39	-3%
2nd	72	63,18	-8,82	-12%
1st	90	73,75	-16,25	-18%

FIGURE 3
CHANGES IN THE PRICES OF PERPETUITIES FOLLOWING A LOWER TIME PREFERENCE



The lower ROA is the reason why, despite the lower FCF generated, the prices for the perpetuities of the fourth and fifth stages are higher than in the initial situation. However, the decrease of the discount rate is not enough to offset the lower FCF obtained in the stages closest to consumption[10]. Again, it is important not to

[10] Using the vocabulary of the equity market, we can divide the change of the price for each perpetuity in two: (1) the change of expected profits (FCF in our example) and

forget that a lower monetary value does not imply a lower value in terms of consumption goods.

So far, we have assumed that each stage is exclusively financed by one asset that receives all the FCF generated. However, it is theoretically possible to include in the analysis different assets with different rights over the FCF produced by each stage, for example a combination of equity and debt. This would significantly increase the number of assumptions, and the overall complexity of the model, starting with the need to introduce two additional discount rates: one for stocks and another one for debts, to reflect their different risk and temporal profiles.

To conclude this section, we can see that the observed changes of prices for perpetuities in TABLE 3 support the statement made by Huerta de Soto (2009, pp. 261): following a reduction in the time preference, stock prices for companies producing capital goods will rise, while those of the consumption sector will decrease (assuming companies with no debt). Now it is time to analyze the business cycle.

IV
THE BOOM

Let us start again with the initial situation of FIGURE 1 and now assume the central bank (or any other agent controlled by the State) initiates a credit expansion channeled by the banking sector into the economy. The lower price of credit transmits the same information via the price system as a decrease of the time preference, and private agents start investing in more capitalized processes that, although more productive, take more time. However, the time preference has not changed; thus, the economic system is entering a state of discoordination.

Following Huerta de Soto (2009, pp. 283), we assume the credit expansion increases the monetary base by 100 m.u. leaving the productive structure as described in FIGURE 4:

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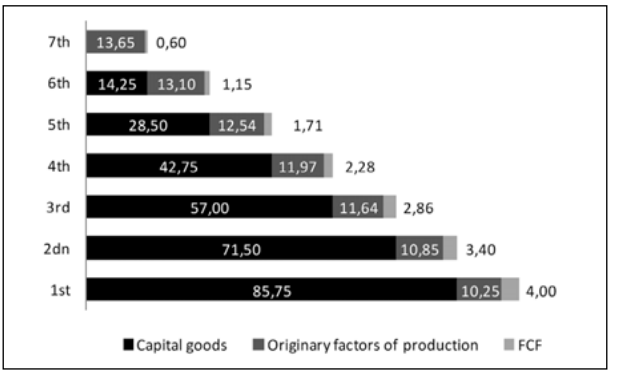
(2) the change of the Price-to-Earnings Ratio (PER) equivalent to the change in the discount rate (the inverse of the PER can be interpreted as a discount rate for stocks).

FIGURE 4
NEW PRODUCTIVE STRUCTURE IN THE BOOM



We see two new distant stages appearing again: the sixth and the seventh, yet the monetary value of the first one is unchanged.

TABLE 4
CHANGES IN THE MONETARY VALUE
OF THE DIFFERENT STAGES IN THE BOOM

Stage	Initial value (m.u.)	Final value (m.u.)	Change (m.u.)
7th	0	14,25	+14,25
8th	0	28,50	+28,50
5th	20	42,75	+22,75
4th	40	57,00	+17,00
3rd	60	71,50	+11,50
2nd	80	85,75	+5,75
1st	100	100	0

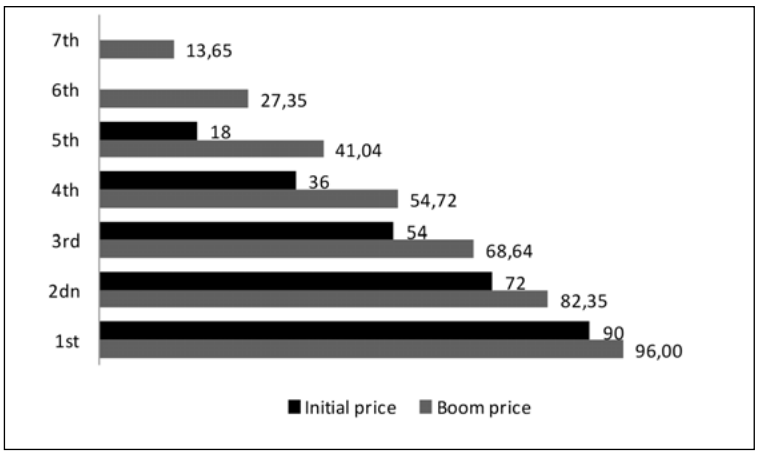
The monetary expansion has also affected the ROA of the economy which is now lower; in this example, a new rate of approximately 4,2% is assumed. This change has been caused not by a lower time preference, nor by a lower level of expected risk, but by the new credit that does not come from a new set of individual preferences, only from the action of the central bank. We proceed

to obtain the perpetuities' new monetary value with the current data (TABLE 5 and FIGURE 5):

TABLE 5
CHANGES IN THE PRICES OF PERPETUITIES IN THE BOOM

Stage	Initial price	Boom price	Change	% Change
7th	0	13,65	+13,65	-
8th	0	27,35	+27,35	-
5th	18	41,04	+23,04	+128%
4th	36	54,72	+18,72	+52%
3rd	54	68,64	+14,64	+27%
2nd	72	82,35	+10,35	+14%
1st	90	96,00	+6,00	+7%

FIGURE 5
CHANGES IN THE PRICES OF PERPETUITIES IN THE BOOM



All prices have increased (the new ROA is lower enough to more than offset the decreased FCF of the first five stages) although the ones for the more distant stages have done so relatively more; we can say that we are entering a time of financial euphoria. However, this price increase is as unsustainable as the underlying productive structure: it is a financial bubble.

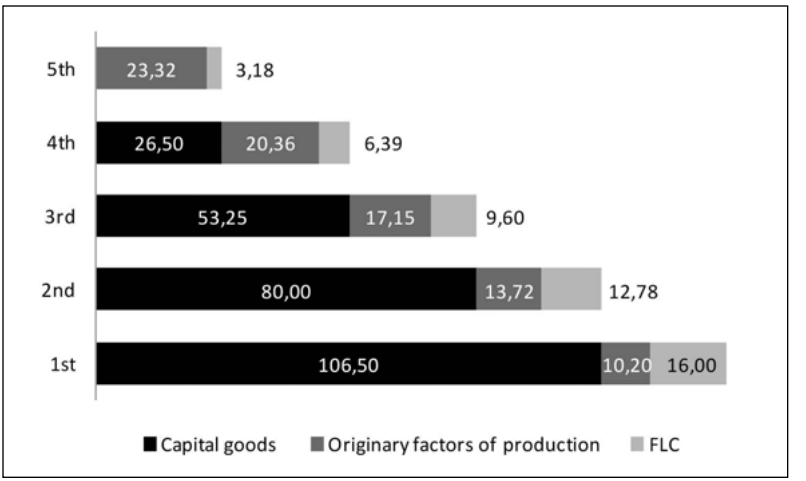
V
THE CRISIS

The productive structure is unsustainable because it does not follow the agents' preferences. The necessary correction will be caused by six microeconomic effects (Huerta de Soto 2009, pp. 289-305):

1. The price increase for the originary factors that, contrary to the case of a lower time preference, have not been transferred from the lower stages to be employed by the higher ones.
2. The price increase of consumption goods, brought about by the higher demand of those agents receiving a higher monetary income and that have not reduced their time preference.
3. Relative increase of the FCF generated by the lower stages in relation to the higher ones.
4. The Ricardo effect that makes labor cheaper in real terms versus capital goods.
5. The rise of nominal ROAs that go back to the original level, or even higher, as there is (i) a higher demand of funds by the entrepreneurs trying to finalize the excessively capitalized productive process initiated during the boom and (ii) the lower purchasing power of money in terms of consumption goods after the monetary expansion.
6. The appearance of losses in the higher stages as a result of the previous five effects.

Huerta de Soto (2009, pp. 301) continues his example with the following productive structure reflecting the new equilibrium that follows after the crisis has taken place (FIGURE 6):

FIGURE 6
NEW PRODUCTIVE STRUCTURE AFTER THE CRISIS



The monetary base is broadly unchanged from its peak at the boom (399 m.u.) but its distribution has changed significantly: the sixth and seventh stages have disappeared leaving again five stages in total. In addition, the ROA has increased to approximately 13,6%, higher than the initial level because of the *lower purchasing power of money* in terms of consumption goods.

Although the monetary value of consumption goods is higher (132,70 m.u. vs. the initial 100 m.u.) this does not mean there are more physical units of consumption goods (nor that they are more valuable). Actually, and given that the boom has created malinvestments, it is likely that the output of consumption goods will be lower than in the initial situation (Huerta de Soto 2009, pp. 303)[11].

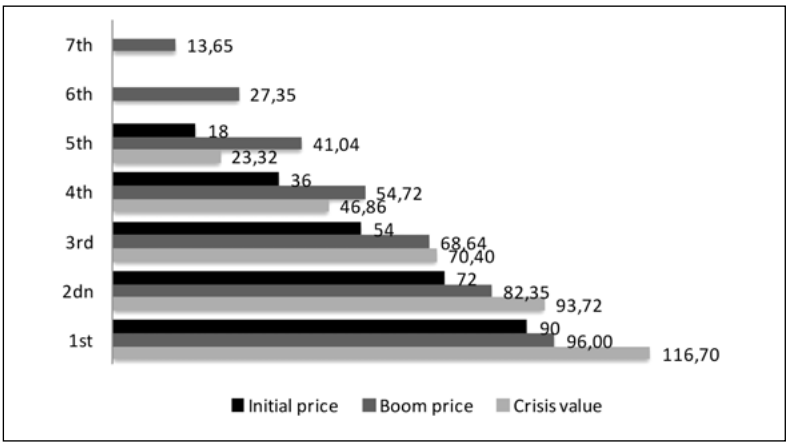
Using the new FCFs and ROA, we obtain the following prices for perpetuities (TABLE 6 and FIGURE 7):

[11] Another example of the impossibility to compare different triangles due to the fact that they cannot measure the value of money.

TABLE 6
CHANGES IN THE PRICES OF PERPETUITIES
AFTER THE CRISIS

Stage	Boom price	Crisis price	Change	% Change
7th	13,65	0	-13,65	-100%
8th	27,35	0	-27,35	-100%
5th	41,04	23,32	-17,72	-43%
4th	54,72	46,86	-7,86	-14%
3rd	68,64	70,40	+1,76	+3%
2nd	82,35	93,72	+11,37	+14%
1st	96,00	116,70	+20,70	+22%

FIGURE 7
CHANGES IN THE PRICES
OF PERPETUITIES AFTER THE CRISIS



The perpetuities of the higher stages have suffered significant losses (the investments in the sixth and seventh have lost their full value). The *monetary* value of the perpetuities financing the lower stages has increased but, as it was mentioned before, their *real value* is likely to be lower, following the capital destruction created by the malinvestments carried out during the boom.

The price action of the perpetuities shows a good example of a stagflation: the economic activity has decreased (the disappearance of the higher stages implies that some productive projects have been stopped; and that capital goods have been transferred to less capitalized projects, for which they were not designed, generating losses to their owners). At the same time, the purchasing power of money is lower, which is why the price for the outstanding perpetuities is higher than in the initial situation[12]. Anyway, Hayekian triangles may also illustrate the case of a deflationary crisis, if the monetary base is decreased from the highs at the boom, reflecting the destruction of private credit that takes place during the crisis.

VI
CONCLUSIONS

Because of their reliance on descriptively false (and some arbitrary) assumptions, Hayekian triangles are unsuitable to elaborate or test economic theories. In addition, they are unable to take into account changes in the value of money, thus not allowing for comparisons between different triangles or between the same triangle in different periods. These analyses can only be carried out with the support of a sound economic theory based on scientific grounds.

However, and despite their shortcomings, Hayekian triangles remain a useful tool to illustrate the effects, in the productive structure, either of changes in the agents' set of preferences or of changes in the interest rates determined by central banks, the main cause of business cycles.

I have tried to show how they can also be employed as a teaching tool for financial assets. With only a few additional assump-

[12] One anonymous referee compared the price performance of the perpetuity financing the first stage to the stock price of a consumer company (Unilever) during the period between 2007 and 2009, in which it fell by about 40%. Apart from some factors triangles cannot account for (such as changes in competitive advantages within the same stage, or different levels of corporate leverage and its impact on stock prices), the difference may be explained by changes in the purchasing power of money: the 2005-2010 cycle was deflationary while our example assumes stagflation.

tions (selecting the discount rate being the most relevant), Hayekian triangles can also generate the present value of the future stream of cash flows produced by each productive stage, and describe how it is affected by changes in the same factors usually employed in the analysis of the productive structure. Therefore, we can also represent how prices of financial assets change during business cycles.

In this paper, I have followed the example provided by Huerta de Soto (2009) which shows a boom followed by a stagflationary crisis in which the purchasing power of money is significantly decreased. In this specific case, the financial market exhibits a speculative bubble in the first place followed by a crisis in which some assets lose up to 100% of their value, specifically those that were financing the stages that appeared on the back of the monetary expansion. At the same time, the prices for the ones financing the «consumer sector» have risen significantly, but only because of the lower value of money. Had we followed an example of a deflationary crisis, the results would have been different: future research could address this case and model the financial cycle that took place during 2005–2010 with the hereby-proposed financial application of Hayekian triangles.

Anyhow, I hope I have proved that Hayekian triangles can also be used to describe some financial aspects of business cycles and provide a new link between the traditional ABCT and financial markets.

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