# An Empirical Illustration of the Austrian Business Cycle Theory: The case of the United States, 1988-2010

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## Abstract

The 2007-2008 financial crisis and subsequent global economic recession have sparked renewed interest in the Austrian business cycle theory. Although for methodological reasons we have found few econometric studies that analyze this theory, in recent years several works have been published to illustrate very relevant aspects of it. The main objective of this article, after reviewing econometric literature on the Austrian cycle, is therefore to analyze the performance of the U.S. economy between 1988 and 2010 in light of the contributions of the endogenous monetary cycle theory.

**Key words:** Austrian business cycle theory, monetary cycles, credit expansion, yield curve, intertemporal structure of the production process, Almon's polynomial.

**JEL Classification:** E32, E44, E52, G21.

## Introduction

The 2007-2008 financial crisis and subsequent global economic recession have renewed interest, in academic circles and online, in the Austrian business cycle theory (ABCT), also known as the endogenous monetary cycle theory. The main conclusions are being increasingly examined by economists, to the degree that Carney (2010) wrote, "We are all Austrians now".

ABCT has a long historical tradition. Based on the natural rate of interest theory of Wicksell 1936 [1898], the British Monetary School and the theory of capital established by Eugen Böhm-Bawerk 1970 [1890] at the end of the nineteenth

century, it was initially formulated by von Mises (1912; 1928) and later developed by von Hayek (1929; 1931) and Rothbard 2000 [1962]. In recent years, Hülsmann (1998), Garrison (2001), and Huerta de Soto (2009) have perfected it.

The Austrian theory explains that boom and bust economic cycles are the result of credit expansion processes implemented by a fractional-reserve banking system. The increase in loanable funds without prior backing from real deposits stimulates investments in projects requiring a production process that is longer than consumers are willing to wait. In other words, an artificial increase in credit, intensified by the laxity inherent in the monetary policy, creates a situation in which intertemporal decisions of producers and consumers become uncoordinated, leading to excess investment in long-term projects that the market will not be able to absorb. As a result, the productive structure is severely distorted and does not respond to the availability of real resources or economic agents' consumption preferences, ultimately requiring readjustment through a painful recession process.

Although, for methodological reasons, few econometric studies have been published that analyze the Austrian business cycle theory, in recent years a number of such works have appeared, making it possible to illustrate important aspects of this approach. This article is based on thorough research of econometric literature on the Austrian cycle and seeks to analyze the performance of the U.S. economy between 1988, the first year of Alan Greenspan's tenure at the Federal Reserve (or the Fed), and 2010, in light of the contributions made by the endogenous monetary cycle theory.

## The Austrian business cycle theory

The ABCT reveals the essential differences between scenarios of sustainable or genuine growth, backed by the prior accumulation of real savings, and episodes of growth that are unsustainable or induced through monetary policy. These discrepancies must be looked for in the differential role played by savers and the monetary authority in each of these scenarios (Garrison, 2001).

Graph 1 shows the economy's response to credit expansion. It is assumed that consumers' preferences remain constant and that monetary supply is controlled by the central bank. Therefore, the offer of loanable funds not only includes previously accumulated savings ($S$), but also the monetary funds supplied by the central bank through the banking system ($\Delta Mc$).

## Graph 1
### *Unsustainable growth: Austrian business cycle*
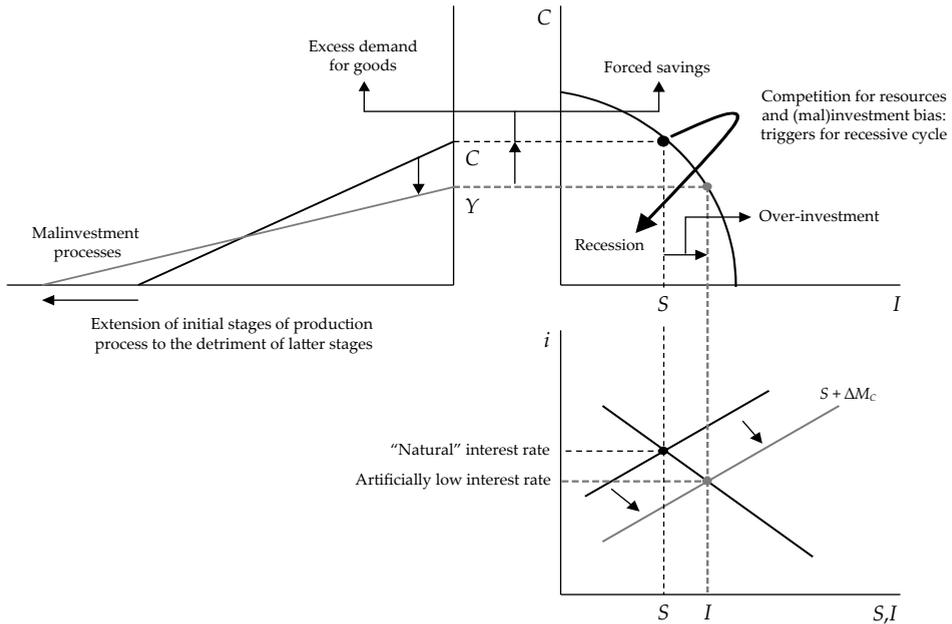


The ABCT shows that episodes of unsustainable growth arise due to artificially low interest rates resulting from the process of banking credit expansion that cannot be attributed to a prior accumulation of real savings. In such a process, the bank's interest rate is below the natural or Wicksellian rate (Wicksell, 1936 [1898]) as a consequence of the 'liquidity effect' (see Garrison, 2011). The natural rate is defined as an intertemporal price that does not depend on monetary factors but is consistent with the companies' real long-term profit rate, capital structure, and the availability of the economy's resources. Furthermore, the price balances the supply of real savings and the investment demand, accurately reflecting the agents' rate of time preference.

Based on this scenario, Hayek argues that production fluctuates because interest rates on bank loans diverge from their natural rates. Credit expansion triggers two major distortions in the operation of capital markets. On the one hand, savers obtain an interest rate that is lower than its corresponding intertemporal discount rate, thus stimulating consumption and discouraging the accumulation of savings. Also, businessmen who finance their projects through debt pay a

lower interest rate on the loans they take out, with an increased investment in long-term projects at the initial stages of the production process (Graph 1), even when they lack enough real resources with which to finance them. Therefore, the injection of money through the market of loanable funds generates a negative differential between saving ($S$) and investment ($I$) levels, which is covered by artificially-created bank money ($\Delta Mc$).

The allocation of productive resources among the various stages that form the economy's capital structure responds to fluctuations in interest rates. Companies react differently to these changes depending on the stage they have reached in the production process. Therefore, their response will be slightly stronger the further away they are from final consumption ($C$) along the horizontal axis of Hayek's triangle, also called the time axis. This is due to the "temporary discount effect": lower interest rates have a greater impact on the current value of investment projects the longer the time required for their completion (Garrison, 2001).

Therefore, an artificial decrease in interest rates linked to credit expansion will cause a deviation of the economy's capital structure toward the initial stages of the production process (capital goods, construction, durable materials,…) to the detriment of the later stages (oriented toward the production of goods for immediate consumption), causing an accumulation of long-term investments that the market will be incapable of absorbing.[1] The result is artificial and unsustainable economic growth. In other words, given that businessmen, induced by the abundance of cheap credit, wish to invest in long-term projects, and consumers prefer to save less, there will be a struggle over real resources that will cause a temporary displacement of the economy beyond its production-possibility frontier (PPF). This struggle over limited resources, which will end up being resolved in favor of demand for investment, will bring about a sharp increase in interest rates, thus raising the costs of financing for businesses.

In this context, many long-term projects, pushed forward during the credit bubble period, will cease to be profitable and numerous companies will face financial difficulties or even bankruptcy. Unemployment will increase, families'

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[1] Garrison argues that the unsustainable growth scenarios imply over-investment and malinvestments in the initial, more time- and capital-intensive stages of the production process. While malinvestments lead to a contraction in economic activity, excessive accumulation of investment will make the subsequent adjustment process slow and painful.

income will fall, and consumption will contract. The economy will enter a recession phase to purge the malinvestments made during the preceding phase of monetary and credit expansion. Economic activity will only return to a path of sustainable growth upon the conclusion of this adjustment.

## A REVIEW OF RECENT EMPIRICAL LITERATURE

Few econometric studies have been published on the Austrian business cycle theory. This is mainly due to the Austrian School's authors' methodological rejection of the use of mathematical economics and econometrics. Austrian economists, who traditionally focus on the use of deductive logic based on self-evident axioms, argue that historical empirical evidence cannot be used to corroborate the universal validity of a theory. In other words, as opposed to the world of physical sciences, where the laws of thermodynamics or quantum mechanics are repeatable under controlled conditions and based on homogenous facts, economic facts are complex, heterogeneous, and unrepeatable; hence they cannot be replicated or used to validate a theory or construct historical laws (Mises, 1966 [1949]).

In the Austrian tradition, a theory's importance is determined by its ability to offer explanations about history that correspond to observable data during a specific period. Therefore, as part of this methodological focus, empirical evidence can only be used to illustrate a theory or characterize concrete historical episodes. Thus, for decades Austrian economists have applied historical techniques to explain the distinctive features of ABCT (Rothbard, 2000 [1962]; Butos, 1993; Hughes, 1997; Powell, 2002; Callahan and Garrison, 2003; Woods, 2009; Bocutoglu and Ekinci, 2010, among other authors). However, in recent years, a number of econometric works have been able to illustrate very important aspects of this theory.

## ECONOMETRIC CONTRIBUTIONS TO THE STUDY OF THE AUSTRIAN CYCLE

In the past few decades, various authors have used econometric methods to analyze the propositions of the Austrian business cycle theory. Wainhouse (1984) wrote one of the first important studies. Examining the ABCT, the author identifies nine hypotheses on the impact of credit expansion on interest rates

and the intertemporal structure of the production process. Subsequently, using monthly data for the period from 1959 to1981, he empirically contrasts six of these proposals by applying the Granger causality test (1969).

Wainhouse makes several important findings. Firstly, he shows that the changes in the supply of voluntary saving are independent from the variations in the supply of bank credit, reflecting that the business cycle responds to credit expansion processes and that money is not neutral. Secondly, he explains that the variations in the supply of credit give rise to interest rate changes (liquidity effect). Furthermore, he offers proof that the changes in the rate at which loans are granted lead to an increase in capital goods output, reflecting the existence of "temporary discount" effects that boost investment in the initial stages of the production process. Finally, he argues that the ratio between the prices of capital goods and those of consumer goods behave according to the ABCT forecasts, showing the existence of "derived demand" effects in the productive structure.

Le Roux and Levin (1998) later reproduced Wainhouse's work using data from the South African economy between 1980 and 1996. In line with the Austrian theory, these authors maintain that the implementation of monetary policy in South Africa had helped credit expansion without a prior accumulation of real saving, creating unsustainable distortions in the structure of the production process and giving rise to "forced saving."

A second group of studies include those by Keeler (2001a; 2001b), Carilli and Dempster (2008), and Bismans and Mougeot (2009). These texts examine the relationship between the behavior of the real gross domestic product (GDP) (and other real variables such as investment and consumption) (Mulligan, 2006) and the temporary structure of interest rates. Therefore, Keeler (2001a) uses quarterly data from the United States for the 1950-1991 period and concludes that the monetary upsets caused cycles that were propagated through interest rate fluctuations. By analyzing cross-correlations, calculated with different lags, between the increase in monetary supply, the slope of the yield curve, and the adjustments of output (measured in terms of deviations of the real GDP compared to its trend) and of the capacity utilization (calculated as the ratio between the capacity utilization ratio in primary and advanced production processes), this author finds a positive contemporary ratio between the processes of monetary expansion and the slope of the yield curve, continuing until the second quarter. He also shows that the aggregate production and the capacity

utilization respond positively and significantly —albeit with a lag of three or four months— to an increased slope of the yield curve. This last result is in line with the idea that a fall in short-term interest rates causes resources to be reallocated toward more capital-intensive production processes. Nevertheless, although this effect continues for twelve quarters, its intensity gradually drops off before disappearing completely.

Although these results are consistent with ABCT, Keeler maintains that other explanations, such as Friedman's cycle theory, cannot be ruled out. However, a key difference between the Austrian approach and this theory or other similar contributions is its proposal for an *endogenous cycle* theory based on the hypothesis that the variations induced in relative prices and in the use of resources are a mechanism of essential propagation of cyclical fluctuations. Thus, a monetary interest rate that falls below its natural level can only have positive temporary effects: the distortions induced in the capital structure and the shortage of productive resources will cause the initial expansion to transform endogenously into a recession. In this sense, Keeler shows that the pattern of correlations —initially positive and then negative— observed between the deviations of real GDP and the ratio of capacity utilization confirms the influence of resource allocation processes in the economy's performance.

Along the same lines as the aforementioned work, Keeler (2001b) proposes the vector autoregression (VAR) method, which considers the cyclical performance of aggregate production, includes the existence of monetary shocks, and analyzes the responses of prices relative to interest rate fluctuations as a propagation mechanism for the cycle. This method estimates the existence of a significant liquidity effect as a result of an exogenous monetary shock. The resulting alteration to the slope of the yield curve stimulates a pattern of relative price changes, resource allocation, and economic activity, which is consistent with ABCT. In particular, the microeconomic alterations of capital structure transfer the initial monetary shock to production, creating permanent real effects that refute the hypothesis of money's neutrality.

Carilli and Dempster (2008), meanwhile, seek to support Keeler (2001a) showing the existence of endogenous inflection points in the effect of interest rate differential of real GDP. Based on quarterly data on the United States for the 1959-2007 period and using Granger causality contrasts and VAR methods, these authors illustrate the existence of two essential causal relationships in the Austrian theory, namely: 1) variations in reserves induced by the central bank

cause a divergence between the natural interest rate and the monetary interest rate, and 2) this divergence gives rise to an expansive-recessive economic cycle. Later, using a polynomial distributed lag model (Almon, 1965), the authors show as positive the initial impact of an interest rate differential increase on real GDP, but this situation tends to be reverted as the market identifies the malinvestment.

Similarly, Bismans and Maugeot (2009) broaden Keeler's analysis (2001a) based on aggregate data from four countries (Germany, the United States, the United Kingdom and France) during the 1980-2006 period, to study the existing relationship between the cyclical deviations from real GDP (measured in terms of deviations from its tendencies) and the slope of the yield curve, the components of aggregate expenditure (*C/I*), and relative prices. Based on a model of panel data with fixed effects, these authors conclude that an increase in the slope of the yield curve implies an acceleration of real GDP to reach its trend level. Nevertheless, this effect abates as the short-term interest rate begins to converge toward its *natural* or long-term level.

Finally, Mulligan (2006) illustrates the experience of cointegrating relationships between consumption spending in the United States and the slope of the yield curve between 1959 and 2003. Mulligan indicates that the structure of prevailing interest rates affects the allocation of resources among the various stages of the production process, approximated by the changes observed in consumer and investment behavior. Furthermore, he shows that a drop in short-term interest rates gives rise to a more complex capital structure and a decreased production of immediate consumption goods.

On the whole, these studies' main limitation is that they continue using excessively aggregated production data, which obscures the differential behavior of capital's intertemporal structure in the economic cycle's expansive and recessive phases. However, the Austrian theory chooses to focus, as a factor of the cycle's essential propagation, on microeconomic distortions to the production structure as a result of monetary and credit-induced inflationary processes. Aware of this limitation, Cotter (2010) applies Almon's model to determine the existence of endogenous inflection points in the effect of the interest rate's fluctuating differentials on various production sectors that make up the capital structure of the U.S. economy.

As with the ABCT, Cotter shows that an increase in the interest rate differential has a positive initial effect on all segments of the production process.

However, over time, the impact tends to be reverted. Also, the initial expansive effect tends to become diluted earlier in consumer goods production industries than in the initial stages of production. He concludes that the induced expansion is greater in sectors that produce capital goods than in those that produce consumer goods.[2]

Mulligan (2002; 2006) and Young (2005) represent a third group making a contribution to econometric studies on the Austrian cycle. These authors argue that interest rates indicate which capital structures are profitable, and that therefore they induce a reallocation of factors among the various stages of the production process. Although production processes have hard-to-measure heterogeneous capital structures, the changes in them begin with the reallocation of the labor factor that accompanies capital movements. Therefore, Garrison (2001: 53) maintains that changes to interest rates cause an increase in the demand for labor in some stages of the production process to the detriment of others. These shifts in employment will drive forward capital's new structure.

On this basis, Mulligan (2002) uses the Hayekian triangle model to determine how fluctuating interest rates affect capital structure. However, this author contrasts Hayek's model by using the labor factor as a more heterogeneous and difficult-to-measure proxy variable of capital.

Mulligan maintains that Hayek's triangle offers an *a priori* explanation of how capital structure should behave in an economy responding to interest rate changes. Therefore, an inverse (direct) relationship should be observed between the use of the initial (final) stages in the production process —which are more (less) capital intensive— and the market's interest rate.[3] Using unbundled employment data on the nine industrial sectors of the U.S. economy between 1959 and 2000, and with five series of different maturity interest rates, this author applies cointegration techniques and error correction models to corroborate that the Hayekian triangle can explain the pattern of resource allocation observed in the United States during the period analyzed.

Young (2005) proposes a similar exercise with the use of quarterly reallocation data of industrial employment and the interest rate of federal funds as

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[2] Huerta de Soto (2009: 391) refers to other studies (Kretzmer, 1989; Thorbecke, 1995) that also show the non-neutral aspect of monetary growth and how it has a relatively larger effect in more capital-intensive industries.

[3] In other words, employment should be procyclical (countercyclical) in the initial (final) stages of production.

an indicator of monetary policy between 1972 and 1993.[4] On the basis of a dynamic panel data model with fixed effects, Young corroborates the existence of a "Hayekian channel" of employment reallocation in response to changes in monetary policy. However, although the result is statistically significant, the economic effect turns out to be very slight, and therefore he concludes that ABCT only provides a minor explanation for reallocated industrial jobs observed in the United States between 1972 and 1993.

I will conclude this section by referring to Young (2011). In his recent and relatively innovative publication, the author describes the United States' production structure between 2002 and 2009, applying input-output accounts at an industrial level, published by the Bureau of Economic Analysis. After using the so-called 'total industry output requirement' (TIOR)[5] to measure the level of complexity of the U.S. economy's capital structure, Young's results are consistent with the Austrian cycle theory; he concludes that the U.S. output increased with the monetary expansion initiated in 2002, only to contract afterwards during the 2007-2009 recession.

## The Austrian cycle theory applied to the U.S. economy, 1988-2010

After the 1998 Russian crisis, and its role in causing the bankruptcy of the Long-Term Capital Management hedge fund in August that same year, between 1998 and the end of 1999, the Federal Reserve System began to aggressively expand monetary supply, reaching annual growth rates of the Money Zero Maturity (MZM) of over 10 percent. Soon afterwards, with the collapse of the dot-com bubble and the 2001 recession, the target interest rate of federal funds dropped from 6.25 percent in 2001 to 1 percent between 2003 and 2004 (reaching negative real values for two and a half years), and the growth of monetary supply exceeded 15 percent, going as high as 20 percent after the 9/11 attacks.

In this context, the concomitant processes of monetary and credit expansion found their outlet in the real-estate market. Therefore, while commercial and industrial loans increased by 23.21 percent (from US$1.055 trillion up to US$1.3 trillion) between 2000 and 2007, real-estate loans rose by 119.48 percent (from

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[4]  The concept of "reallocation" is defined as the sum of jobs created and destroyed in an industry.

[5]  TIOR is defined as the required direct or indirect output for each industrial sector to provide one dollar of final product required of this sector to the end user.

US$1.576 to US$3.459 trillion). As a result, between 2000 and 2003 mortgage rates fell to their lowest levels in 30 years.

The sudden increase in mortgage financing and the concomitant "Cantillon effects" —the price of housing increased by 103 percent between 2001 and 2006, according to the S&P/Case-Shiller 20 index— caused a disproportionate and artificial boom in the construction sector. However, this changed definitively after 2004, the year in which the Fed began to raise the federal funds target rate, alarmed by a possible growth of inflationary tendencies. The intervention rate rose from 1 to 5.25 percent between 2004 and 2007, and home prices began to fall in 2006, dropping by more than 50 percent by 2011.

### Initial hypotheses:
### The cycle's impulse and propagation mechanisms

The analysis of U.S. expansive/recessive business cycles between 1988 and 2010 requires the initial hypotheses to be split into two blocks that take into account the separation between the business cycle's impulse and propagation mechanisms. With regard to the impulse mechanisms, an ABCT model would need to show that:[6]

1) Credit and monetary expansion processes ($\Delta M^s$) orchestrated by central banks cause a divergence between the natural interest rate ($i_n$) and the current interest rate in the credit market ($i_m$) as a result of the 'liquidity effect'.
2) This interest rate differential causes, with a certain lag, an artificial alteration of capital structure and is beneficial for investment in the initial, more time- and capital-intensive stages of the production process (capital goods, construction, durable materials,…) to the detriment of the latter stages near to the final consumption.
3) Finally, as a result of the above, we must observe a change in the ratio between the Industrial Production Index (IPI) and its trend level.

The second group of hypotheses involves the propagation mechanisms of the expansive-recessive cycle that also affects in its amplitude —or volatility of the observed cyclical variations— and persistence or the autocorrelation in the cyclical deviations calculated with regard to its long-term trend.[7] The endogenous monetary cycle theory emphasizes that:

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[6] See Wainhouse (1984), Le Roux and Levin (1998), and Bjerkenes, Kiil, and Anker-Nielsen (2010).

[7] The persistence speaks to the length of the cycle: in other words, how long a variable is kept above its long-term trend before this situation is reverted.

4) The initial increase in the interest rate differential, approximated by the slope of the yield curve, will tend to be reverted in line with the new restrictions on resources linked to the original expansive monetary cycle. Therefore, whereas during the initial phases of the economic cycle the variations in the monetary supply would be positively related to the slope of the yield curve, this relation would tend to be reverted and become negative over time.

5) The induced alterations in the capital's intertemporal structure characterize the pattern of the business cycle's evolution. Given that the use of productive resources essentially responds to the variations in the slope of the yield curve, the production ratio between the initial and final stages in the production process should be expected to increase at the outset of the expansive cycle, but diminish as the market begins to discover the malinvestment induced by the abundance of cheap credit.

6) Finally, as a result of the foregoing points, an endogenous reversion should be observed, along with a strong deterioration in the ratio between the IPI and its trend level.

## Data

To contrast the hypotheses on the cycle's impulse and propagation mechanisms, we will examine quarterly data on money, interest rates, and industrial production for various sectors of the U.S. economy between 1988 and 2010. All the series come from the Federal Reserve Bank of St. Louis's FRED database,[8] except for the construction figures, which are taken from the Board of Governors of the Federal Reserve System.[9] The variables analyzed, except for the interest rates, are measured in deviations from their trend (calculated using Hodrick and Prescott's filter) to ensure stationarity.[10]

*Money*

The MZM (MZMSL) cyclical performance, measured in terms of deviations from its trend, is used as an indicator of the orientation and laxity of the Federal Reserve's monetary policy. The MZM's cyclical deviations are obtained from the expression $\Delta MZM_t = \ln(MZM_t/trendMZM_t)$.

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[8] Available at: <http://research.stlouisfed.org>.

[9] Available at: <http://www.federalreserve.gov>.

[10] The Hodrick and Prescott (1997) filter makes it possible to divide a temporary series into two components: a determinist long-term trend and a short-term stationary cycle.

*The yield curve slope*

Economists from the Austrian School argue that monetary and credit expansion processes place monetary interest rates below their natural or Wicksellian levels, creating expansive-recessive business cycles. However, given that the natural interest rate cannot be measured directly, we must estimate it instead. Three options can be observed in academic literature:

   *a)* On the one hand, mainstream literature usually takes the economy's real growth rate as a proxy for the natural interest rate (Laubach and Williams 2003). However, proponents of the Austrian theory reject this option because they consider that the economy's growth rate is affected by the orientation of monetary policy (Carilli and Dempster, 2008).
   *b)* Alternatively, based on contributions by Rothbard (2000 [1962]), Austrian economists prefer to think of the natural interest rate as a reflection of agents' intertemporal preferences (Carilli and Dempster 2008; Cotter 2010). Therefore, they use the savings-consumption ratio as an approximation of the Wicksellian interest rate.
   *c)* Finally, authors such as Keeler (2001a), Mulligan (2002; 2006), Bismans and Mougeot (2009), and Bocutoglu and Ekinci (2010) use the long-term interest rate as an estimation of the natural interest rate. In particular, they consider the slope of the yield curve as an approximation to the differential between the natural interest rate, defined as a long-term variable that does not depend on monetary factors and that is consistent with companies' real profit rate, and the interest rate of the short-term credit market.

Keeler (2001a) shows that the short-term interest rate variations are temporary and volatile, being particularly dominated by the tone of monetary policy. On the other hand, changes in long-term interest rates are slow, long-lasting, and less volatile; therefore, their performance could well be compared to the marginal output of capital. Equally, and taking into account the length of the lifespan of capital goods, their financing would be produced in long-term credit markets at rates consistent with the natural interest rate. In this regard, Williams (2003) maintains that long-term interest rates would tend to converge on some sort of natural or balanced level, on the margin of the behavior of monetary variables.

   On the basis of studies by Keeler (2001a), Bismans and Mougeot (2009), and Bocutoglu and Ekinci (2010), this study examines the differential between the 10-year bond rate (DGS10) and the three-month bond rate (GS3M) as an approximation to the differential between the natural interest rate and the current rate in the short-term credit market. This differential is calculated by the expression: $DIF_t = \ln[(1 + i_{10a})_t/(1 + i_{3m})t]$.

*Structure of the productive process and fluctuations
in economic activity*

The ABCT establishes that in the initial stages of the expansive monetary cycle a relative increase should be observed in the output of those sectors which, being more time- and capital-intensive, are more sensitive to variations in the slope of the yield curve: capital goods, durable consumer goods such as construction, or durable materials. A boom in these sectors could be created to the detriment of other sectors that produce goods for immediate consumption. Nevertheless, this ratio between the initial and final stages in the production process would tend to deteriorate over time.

While the fluctuations of aggregate production are measured on the basis of deviations of the Industrial Production Index (INDPRO) in terms of its trend ($\Delta IPI_t$), cyclical oscillations in the productive structure are estimated using the following ratios:

$$\Delta K_{1t} = \ln\left[\frac{(capital\ goods\,/\,consumer\ goods)_t}{trend(capital\ goods\,/\,consumer\ goods)_t}\right]$$

$$\Delta K_{2t} = \ln\left[\frac{(durable\ consumer\ goods\,/\,consumer\ goods)_t}{trend(durable\ consumer\ goods\,/\,consumer\ goods)_t}\right]$$

$$\Delta K_{3t} = \ln\left[\frac{(construction\,/\,consumer\ goods)_t}{trend(construction\,/\,consumer\ goods)_t}\right]$$

$$\Delta K_{4t} = \ln\left[\frac{(durable\ materials\,/\,consumer\ goods)_t}{trend(durable\ materials\,/\,consumer\ goods)_t}\right]$$

where the index of capital goods (IPBUSEQ), durable consumer goods (IPDCONGD), construction (B54100), and durable materials (IPDMAT), illustrate the most distant stages of the production process, while the production index for durable consumer goods (IPCONGD) represents the stages closest to final consumption (see Cotter, 2010).

On the other hand, it is assumed that the variations in the slope of the yield curve should have a statistically significant effect on the $\Delta K_{5t}$ ratios (durable/

nondurable materials), $\Delta K_{6t}$ (durable/nondurable manufactured goods) and $\Delta K_{7t}$ (durable/nondurable consumer goods). In other words, since companies producing durable goods in each sector (materials, manufactured and consumer goods) supposedly require more time and capital than companies producing nondurable goods, an increase in the slope of the yield curve should have a positive initial effect on ratios:

$$\Delta K_{5t} = \ln\left[\frac{(durable\ materials\,/\,nondurable\ materials)_t}{trend(durable\ materials\,/\,nondurable\ materials)_t}\right]$$

$$\Delta K_{6t} = \ln\left[\frac{(durable\ manufactured\ goods\,/\,nondurable\ manufactured\ goods)_t}{trend(durable\ manufactured\ goods\,/\,nondurable\ manufactured\ goods)_t}\right]$$

$$\Delta K_{7t} = \ln\left[\frac{(durable\ consumer\ goods\,/\,nondurable\ consumer\ goods)_t}{trend(durable\ consumer\ goods\,/\,nondurable\ consumer\ goods)_t}\right]$$

## Contrasting impulse mechanisms (hypotheses 1 to 3)

Before contrasting hypotheses on the cycle's impulse mechanisms, Table A1 of the appendix shows the results of the unit root tests, indicating that all variables considered are stationary at least at the five-percent significance level. Using these values, the study of the impulse mechanisms can be summed up in the sequence:

- $\Delta MZM_t$ causes $DIF_t$ in the Granger sense.
- $DIF_t$ causes $\Delta K_{Jt}$ (where $J = 1,...,7$) in the Granger sense.
- $DIF_t$ causes $\Delta IPI_t$ in the Granger sense.

The Granger causality test measures a situation in which one variable changes constantly and predictably before a different one does. Specifically, it says that a variable $X$ causes a different variable $Y$ in the Granger sense, if the prediction of $Y$ improves comparatively using past $X$ and $Y$ values, than if only the past values of $Y$ are used. This definition is criticized in academic literature because it restricts the idea of causality to the concept of 'incremental predictability'.

Therefore, it states that causality implies predictability, yet predictability does not necessarily entail causality. However, although a favorable result of the Granger test does not offer unfailing proof of the existence of a causal relationship between variables, it does offer certain empirical evidence of it.

*Hypothesis 1. Changes to the monetary supply cause variations in the slope of the yield curve ($\Delta MZM_t \Rightarrow DIF_t$) as a result of the liquidity effect*

Column 1 of Table A2 in the appendix shows that the results of the causality contrasts between $\Delta MZM_t$ and $DIF_t$ are consistent, taking into account that in most of the lags analyzed, the value of statistic F is significant, at least at the five-percent level.[11] These results provide empirical evidence that the cyclical oscillations of the MZM cause, in the Granger sense, the variations to the slope of the yield curve.

Therefore, monetary and credit expansion processes have two opposing effects on the interest rate differential. On the one hand, the liquidity effect exerts downward pressure on the entire yield curve. On the other, the inflation expectations linked to the Fisher effect counteract —and in some cases even eliminate— the downward pressures on the long-term interest rates (see Graph 2).[12] Therefore, although the Fed can directly control the short-term interest rates, it has much less influence on long-term interest rates.

In this sense, Bernanke (1990) proves that fluctuations in monetary supply are much more closely related to short-term interest rates than to long-term rates, which in turn influences the existing correlation between the amount of money and the slope of the yield curve. Since long-term interest rates hardly react to changes in monetary policy, they are useful as an approximation to the natural interest rate.

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[11] In the causality relations study, the choice of the number of lags can be an important factor. Therefore, choosing a smaller number can create problems of autocorrelation in the mistakes. On the other hand, choosing too many lags could create problems of multicollinearity. Although information criteria is usually used (Akaike, Schwartz,…) to determine the right number, this study uses a broad range of lags to check the consistency of the results.

[12] For a review of the hypothesis of the expectations of the yield curve, see Russell (1992).

GRAPH **2**
*Initial effect of monetary expansion on the yield curve*
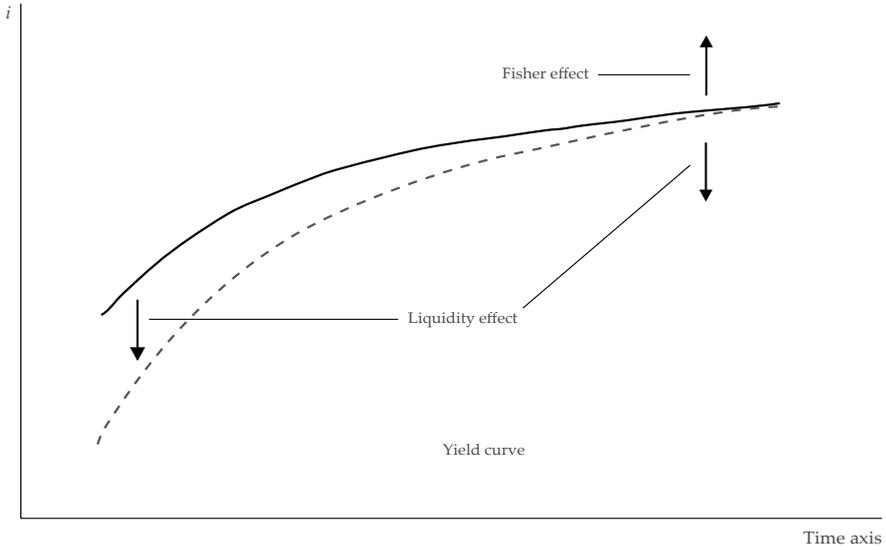


GRAPH **3**
*Impact of the cyclical behavior of MZM
on the interest rates differential*
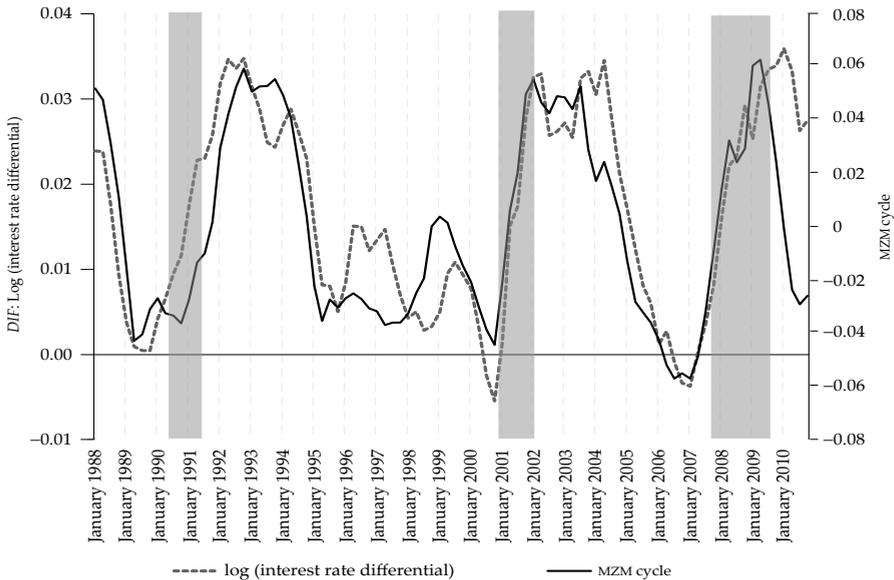
Graph 3 shows the strong correlation (above 0.80) observed between the tone of monetary policy and the interest rates differential during the period between 1988 and 2010.[13] This representation illustrates the strong monetary expansions, resulting in significant increases in the slope of the yield curve, adopted by the Federal Reserve during the recessive periods taking place between mid-1990 and early 1991, the final quarters of 2000 and 2001, and December 2007 to mid-2009. Also, one can observe major decreases in the interest rate differential, linked to MZM contractions, during the expansive periods between 1988 and late 1989, mid-1999 and the final quarter of 2000, and the first quarters of 2004 and 2007. These results display the strongly anti-cyclical nature of the Fed's monetary policy during the period analyzed.

*Hypothesis 2. Variations in the slope of the yield curve cause changes to the economy's output structure ($DIF_t \Rightarrow \Delta K_{Jt}$)*

As an aspect of the cycle's essential transmission, the ABCT emphasizes the distortions which on a microeconomic scale affect capital structure as a result of monetary and credit expansion processes. The results of column 2 in Table A2 show that variations in the slope of the yield curve ($DIF_t$) precede the changes in the $\Delta K_{1t}$ ratio (capital goods/consumer goods), without the effects of feedback from apparently being observed between the variables under consideration. These results are consistent with the idea that the interest rate differential affects the U.S. economy's output structure, with a special impact on those sectors located in the initial, more time- and capital-intensive stages of the production process.

Column 3, meanwhile, shows the absence of causality between $DIF_t$ and $\Delta K_{2t}$ (durable consumer goods/consumer goods).[14] Although this result differs from the previous one, it can be justified on the basis that the production of durable consumer goods does not include activity related to the construction sector, but instead to the manufacture of computers, audio and video equipment,

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[13] In turn, this figure relates to the fact that the existing correlation between the MZM's cyclical deviations and the short-term interest rate is –0.56, while the correlation with the long-term interest rates drops to –0.16.

[14] It can equally be shown that the slope of the yield curve does not have an impact on the behavior of the production of durable consumer goods compared to the production of nondurable consumer goods. Data not included for reasons of space, but may be consulted by the reader.

household appliances, and motor vehicles. However, as we saw at the start of this section, the credit expansion orchestrated by the Fed, in particular since 2001, was mainly channeled toward the mortgage market, causing a boom in the real estate sector to the detriment of other industrial sectors producing general consumer goods.

On this basis, column 4 contrasts the existence of a possible causal relationship between $DIF_t$ and $\Delta K_{3t}$ (cyclical behavior of the construction/consumer goods ratio). As can be demonstrated, the hypothesis of the absence of causality in the Granger sense is rejected in most of the considered lags, suggesting that the variations in the slope of the yield curve exerted a differential effect on the behavior of the construction sector with regard to the production of consumer goods during the period analyzed.

Equally, column 5 shows that the differential of interest rates causes, in the Granger sense, the ratio $\Delta K_{4t}$ (durable materials/consumer goods), without a bidirectional relationship being observable between these variables. Finally, columns 6 and 7 offer empirical evidence that variations in the slope of the yield curve precede the behavior of the $\Delta K_{5t}$ (durable/nondurable materials) and $\Delta K_{6t}$ (durable/nondurable manufactured goods) ratio, illustrating the hypothesis that changes in the slope of the yield curve have a differential effect on the production of more time- and capital-intensive elements of their corresponding productive sectors.

*Hypothesis 3. Variations in the slope of the yield curve cause cyclical oscillations of the aggregate production function ($DIF_t \Rightarrow \Delta IPI_{it}$)*

Finally, column 8 offers evidence that variations in the slope of the yield curve precede cyclical oscillations of the U.S. IPI during the period analyzed. However, the existence of a clear relation of inverse causality between these variables ($\Delta K_{it} \Rightarrow DIF_t$) is symptomatic of the anti-cyclical nature of the Federal Reserve's monetary policy during the 1988-2010 period.

## Analysis of the cycle's propagation mechanisms (hypotheses 4 to 6)

The contrasts of the previous section show that the tone of monetary policy affects the slope of the yield curve. In turn, this changes the economy's capital

structure, causing the initial monetary shock to be transmitted to the produc-
tion process represented by the industrial production index.

Nevertheless, the ABCT goes beyond simply affirming that variations in the
slope of the yield curve precede production's cyclical behavior and causes
changes to the economy's capital structure. It also predicts that an artificial in-
crease of the interest rate differential can only have positive temporary effects
on economic activity (see Graph 1). In other words, the induced distortions
in the productive structure and resulting resource restrictions cause the initial
expansion to turn into a recession as the market takes stock of the malinvest-
ments induced by lax monetary policies and the abundance of cheap credit.

In this sense, understanding the existence of *endogenous* inflection points in
the effect of the slope of the yield curve on the structure of the production
process and the behavior of aggregate production would reveal the existence
of economic cycles that self-perpetuate in line with the contributions of the
Austrian approach. To formalize this process, a polynomial distributed lag model
(Almon, 1965) of the production variables ($\Delta K_{1t}, \ldots, \Delta K_{7t}, \Delta IPI_t$) is specified
as a function of $n$ lags of the interest rate differential:

$$\Delta K_{Jt} = \alpha + \sum_{i=0}^{n} \beta_i DIF_{t-i} + \varepsilon_i \quad (J = 1, \ldots, 7)$$

$$\Delta IPI_t = \alpha + \sum_{i=0}^{n} \beta_i DIF_{t-i} + \varepsilon_i$$

where $\beta_i = a_0 + \sum_{j=1}^{m} a_j i^j$. In addition to the $m + 1$ parameters of the polyno-
mial, there are two unknowns that must be defined: the length of the lags ($n$)
and the degree of the polynomial ($m$) used to estimate the value of the betas.
Based on Greene (1999), both unknowns are selected on the basis of the value
of $\bar{R}^2$ and the Akaiki and Schwartz information criteria.

Using the business cycle model referred to at the beginning of this study
as a reference, a process of monetary expansion in an economy situated in its
PPF would cause an unsustainable displacement of economic activity beyond
that frontier. Therefore, based on Graph 1, Carilli and Dempster (2008) and
Cotter (2010) argue that an artificial increase in the slope of the yield curve
would trigger an initial expansive cycle ($\sum_{i=0}^{p} \beta_i > 0$), followed by a recessive
period ($\sum_{i=p+1}^{n} \beta_i < 0$). However, these authors do not consider the possibility

of the central banks expanding the monetary supply in the recessive stages of the cycle —in other words, positioning the economy below its PPF— and that the effect of these measures is displayed with a certain lag of a variable duration.[15] In this case, the pattern of temporary evolution of the $\beta_i$ could show a different profile in its initial lags.

*Hypothesis 4. The slope of the yield curve tends to be reverted in line with the new restrictions on resources linked to the initial expansive monetary cycle*

Table A3 shows the correlation coefficients observed between the interest rate differential in the period $t$ and different lags $(t-i)$ of the cyclical behavior of the MZM. The first positive correlations confirm that monetary expansion creates a statistically significant liquidity effect until the fourth quarter, causing an increase in the slope of the yield curve. However, from the eighth quarter, the correlation coefficients become negative, with statistical significance, between the thirteenth and fifteenth quarters. This result would be consistent with the idea that the slope of the yield curve tends to be reverted in line with new restrictions on resources linked to the initial expansive monetary cycle. However, it should be recalled that, in order to counteract the inflationary tendencies linked to the injection of fiduciary resources, intervention by the Fed itself could increase this trend by reinforcing the bases of the subsequent recession.

*Hypothesis 5. The expansive ratio between the initial and final stages in the production process tends to be reverted as the market begins to discover the malinvestment driven by the credit bubble*

Monetary expansions begun during the cycle's recessive periods cause a credit bubble that stimulates over-investment in long-term projects, distorting the economy's capital structure. This results in unsustainable growth: new investments are allocatively inefficient since they respond neither to the economy's real volume of resources nor to consumers' intertemporal preferences. In this scenario, when resource limitations appear and give rise to an increase and flat-

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[15] In this sense, Friedman and Schwartz (1963) argue that the effect of monetary policy measures on the real economy would be shown with a 6- to 18-month lag.

tening out of the yield curve, many of the long-term projects undertaken in the bubble phase of the economy cease to be profitable and must be liquidated. This is when the initially expansive ratio between the initial and final stages of the production process tends to be endogenously reverted, showing a marked deterioration during the cycle's recessive phases.

Columns 1 to 7 of Table A4 show the existing relationship between the ratios that illustrate the cyclical performance of capital's intertemporal structure ($\Delta K_{Jt}$) and the slope of the yield curve after having made the corresponding adjustments to avoid problems derived from the existence of residual auto-correlation, which in turn is the reflection of the persistence of the economic cycle.[16] Given the values of $\bar{R}^2$ and of Akaike and Schwartz's information criteria, and in order to standardize results, in each case we chose a third-order polynomial with 20 lags.

Based on the ratio observed between the interest rate differential and the cyclical behavior of the industrial production index ($\Delta IPI_t$), which makes it possible to define the areas of recession, recovery, and expansion, and deceleration and recession of the following graphs, Graph 4 suggests that during the expansive phases of the monetary cycle and credit there is a boom in the initial stages of the production process (capital goods, construction, and durable materials) to the detriment of the final stages (consumer goods) as a consequence of the temporary discount effect. On the other hand, during recessive periods, the most time- and capital-intensive stages are those that tend to contract more as the market discovers the malinvestments induced by the preceding credit expansion processes.

Meanwhile, Graph 4 reveals that a change in the slope of the yield curve initially has negative effects on all the ratios that illustrate the behavior of the structure of the capital's economy ($\Delta K_{Jt}$), suggesting that the Federal Reserve's monetary policy is anti-cyclical. However, as a general rule, this ratio tends to diminish between the third and fourth quarters, even becoming positive. The reversion in the value of the betas compared to the initial quarters would reflect the lagged expansion effect —which in turn would result in the economic

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[16] One explanation of the persistence of cyclical fluctuations lies in the changes in investment and therefore in the capital structure that can happen when agents are induced to make errors due to artificial interest rate movements. Excessive capital accumulation at specific stages in the production process and a slow adjustment of distortions undergone by the production process can explain why the output and its composition by sector can show persistent (long-lasting) movements above or below its long-term trend.

Graph **4**
*Lagged effects of the interest rate differential on ratios that represent
the structure of the production process*
(third-order Almon polynomial)
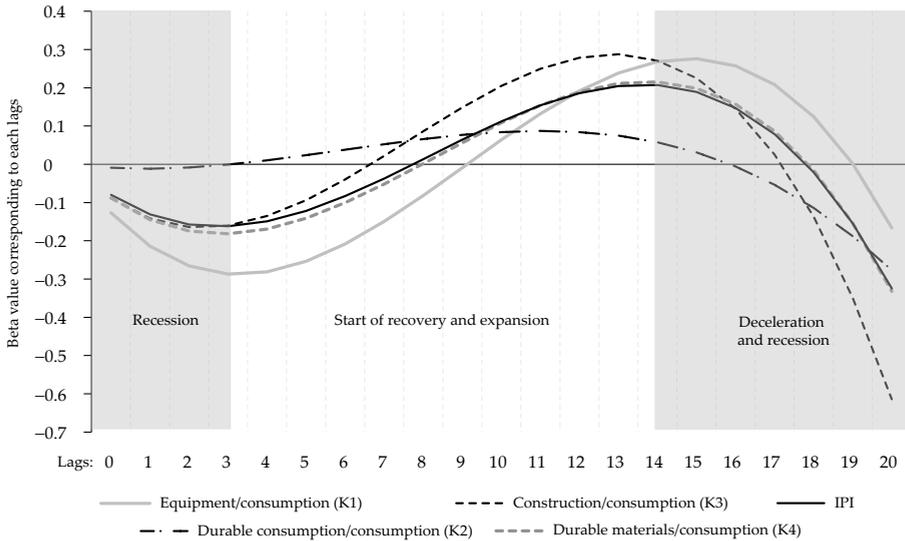


cycle's persistence— that an increase in the interest rate differential would have on the initial stages of the productive process in comparison to the final ones. Nevertheless, in the final stages of the expansive cycle this effect would tend to diminish, even becoming negative in the early stages of the recession. Significantly, the observed expansive-recessive pattern would be particularly noticeable in the construction sector ($\Delta K_{3t}$), reflecting the creation of the real-estate bubble prior to 2007 and its later collapse. On the other hand, in line with the results of the second hypothesis, there is no statistically significant effect on the interest rate differentials on the behavior of the $\Delta K_{2t}$ ratio (durable consumer goods/consumer goods).

Finally, Graph 5 shows that the slope of the yield curve has an amplified positive (negative) and lasting effect on production in the materials ($\Delta K_{5t}$), manufactured goods ($\Delta K_{6t}$) and consumer goods ($\Delta K_{7t}$) sectors, during the expansive (recessive) phases of the cycle. However, once again, this effect is not statistically significant in the case of the ratio $\Delta K_{7t}$, which reflects the behavior of durable consumer goods production in relation to the manufacture of nondurable consumer goods.

Graph 5
*Lagged effects of the interest rate differential
on the composition of three production sectors*
(third-order Almon polynomial)



Durable/nondurable materials (K5)    Durable/nondurable manufactured goods (K6)
---- Durable/nondurable consumer goods (K7)
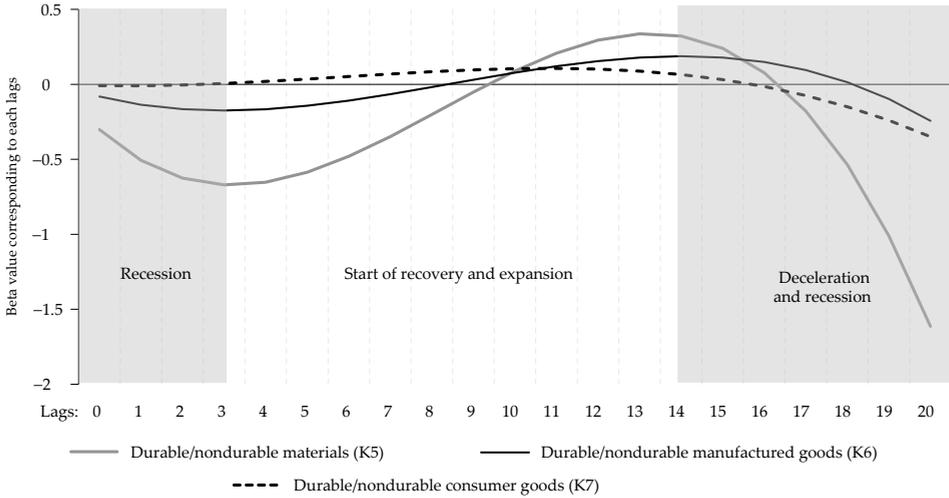
*Hypothesis 6. The IPI's expansive cycle tends to be reverted
as the market discovers the malinvestments induced
by credit expansion processes*

Empirical literature argues that most recessive (expansive) episodes are usually preceded by a steep decline (increase) or inversion in the slope of the yield curve. Estrella and Hardouvelis (1991) show that the interest rate differential between treasury instruments makes it possible to predict the U.S. cycle for between four to six quarterly horizons. In this sense, in line with the work of these and other authors, we can conclude that recessive (expansive) cycles are usually preceded by several quarters of strong decreases (increases) in the slope of the yield curve, to become a *forecast* of cyclical oscillations of production.[17]

Graph 4 and column 8 of Table A4 provide evidence of an endogenous inflection point in the effect of the interest rate differential on the cyclical behavior of the IPI. In this sense, as in the previous cases, we can observe that an

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[17] Wheelock and Wohar (2009) produced a magnificent survey of literature that analyzes the predictive capacity of the slope of the yield curve to forecast the cycle.

increase in the slope of the yield curve stimulates industrial production with a certain lag. Over time, however, this effect tends to disappear, becoming negative as the market discovers the malinvestments induced by the preceding credit bubble. As such, the economy shifts from an upturn to a recessive period that will stimulate a new expansive use of monetary policy.

## Conclusions

While monetary theory seeks to prevent recessions through the active use of monetary policy instruments, proponents of ABCT try to avoid the situation of monetary and credit bubbles that tend to precede recessions.

The Austrian School blames the fractional-reserve banking system under the management and supervision of the central banks for creating monetary and credit bubbles that lead to the creation of self-perpetuating expansive-recessive economic cycles. The Austrian School economists contend that the expansion of credit without the prior backing of real savings pushes the short-term credit market's interest rate below its natural rate, the rate that is consistent with companies' real long-term profit rate, the economy's real resource availability, and agents' intertemporal consumption preferences.

When, as a result of a credit expansion process, the differential between the natural interest rate and the current interest rate in the credit market increases, malinvestments accumulate in the initial, more time- and capital-intensive stages of the production process, causing a distortion to the economy's productive structure that does not correspond either to the availability of real resources or to the agents' intertemporal consumer preferences. Finally, the productive structure must be adjusted to these restrictions, from which it should never have strayed, at the expense of a painful recessive process during which there will be a liquidation of the long-term malinvestments (made during the preceding credit-bubble phase) that the market is not able to absorb.

Based on these premises, this study examines the behavior of the U.S. economy between 1988, the first year of Alan Greenspan's tenure at the Federal Reserve, and 2010, in light of the predictions of the endogenous monetary cycle theory. For this purpose we analyze the propagation and impulse mechanisms of the Austrian cycle, using Granger's causality contrasts and polynomial distributed lag models.

Using the slope of the yield curve corresponding to treasury instruments during the 1988-2010 period as an approximation to the differential between the natural interest rate and the short-term credit market interest rate, this article shows that the degree of monetary policy laxness affects the structure of the production process and the behavior of aggregate production represented by the industrial production index.

Specifically, we can observe that an increase in the slope of the yield curve has a positive differential effect on the initial, more capital- and time-intensive stages of the production process (capital goods, construction, durable materials,…), in relation to those destined for the production of consumer goods. Meanwhile, using Almon's polynomial distributed lag model, we see an anticyclical use of monetary policy that begins to affect, with a certain lag (between three and four quarters), the $(\Delta K_{Jt})$ ratios that represent, at least partially, the capital structure of the U.S. economy. This lagged effect can also be seen in the behavior of aggregate industrial production $(\Delta IPI_t)$.

It should also be emphasized that the positive differential effect on the initial stages of the production process resulting from an artificial increase in the slope of the yield curve tends to diminish in the closing stages of the expansive cycle, and reverses in the early stages of the recession. This illustrates the existence of expansive-recessive cycles that self-perpetuate in line with the predictions of proponents of the Austrian business cycle. Finally, it should be noted that the observed pattern of boom and bust is especially significant in the construction sector, reflecting the intensity of the real-estate bubble prior to 2006-2007 and the severity of its subsequent collapse.

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**Appendix**

Table **A1**
*Contrasts of unit roots.*
*Value of t and p statistic in brackets*
Analysis period: 1988-2010 (92 observations)

| Null hypothesis | Augmented Dickey-Fuller test |
|---|---|
| $\Delta MZM_t$ has a unit root | −3.943 (0.0026) |
| $DIF_t$ has a unit root | −2.900 (0.0445) |
| $\Delta IPI_t$ has a unit root | −5.485 (0.0000) |
| $\Delta K_{1t}$ has a unit root | −4.081 (0.0017) |
| $\Delta K_{2t}$ has a unit root | −4.778 (0.0001) |
| $\Delta K_{3t}$ has a unit root | −5.281 (0.0000) |
| $\Delta K_{4t}$ has a unit root | −4.815 (0.0001) |
| $\Delta K_{5t}$ has a unit root | −5.537 (0.0000) |

## Table A2
### Granger causality test of variables included in the study

| n | Lags | Column 1 | | Column 2 | | Column 3 | | Column 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | $\Delta MZM_t \Rightarrow DIF_t$ | $DIF_t \Rightarrow \Delta MZM_t$ | $DIF_t \Rightarrow \Delta K_{1t}$ | $\Delta K_{1t} \Rightarrow DIF_t$ | $DIF_t \Rightarrow \Delta K_{2t}$ | $\Delta K_{2t} \Rightarrow DIF_t$ | $DIF_t \Rightarrow \Delta K_{3t}$ | $\Delta K_{3t} \Rightarrow DIF_t$ |
| | | Statistic F | Statistic F | Statistic F | Statistic F | Statistic F | Statistic F | Statistic F | Statistic F |
| 91 | 1 | 4.906 (0.029)* | 2.010 (0.160) | 6.555 (0.012)* | 2.191 (0.142) | 0.759 (0.386) | 12.65 (0.000)* | 1.114 (0.294) | 1.465 (0.229) |
| 90 | 2 | 7.296 (0.001)* | 0.697 (0.500) | 4.246 (0.017)* | 2.371 (0.099) | 0.367 (0.693) | 4.419 (0.014)* | 2.586 (0.081) | 1.950 (0.148) |
| 89 | 3 | 4.783 (0.004)* | 1.585 (0.199) | 3.619 (0.016)* | 1.604 (0.194) | 0.657 (0.580) | 3.533 (0.018)* | 4.134 (0.008)* | 1.739 (0.165) |
| 88 | 4 | 3.593 (0.009)* | 1.276 (0.286) | 3.415 (0.012)* | 0.982 (0.422) | 0.882 (0.479) | 2.744 (0.034)* | 4.689 (0.002)* | 1.356 (0.256) |
| 87 | 5 | 3.186 (0.012)* | 0.966 (0.444) | 4.218 (0.001)* | 1.003 (0.422) | 1.275 (0.283) | 2.210 (0.061) | 3.252 (0.010)* | 1.334 (0.259) |
| 86 | 6 | 2.835 (0.015)* | 0.693 (0.656) | 2.281 (0.045)* | 1.720 (0.128) | 1.704 (0.132) | 1.975 (0.080) | 3.214 (0.007)* | 1.142 (0.347) |
| 85 | 7 | 2.332 (0.034)* | 0.864 (0.538) | 3.304 (0.004)* | 1.519 (0.175) | 1.488 (0.185) | 1.843 (0.092) | 2.637 (0.017)* | 0.655 (0.708) |
| 84 | 8 | 1.733 (0.107) | 1.163 (0.334) | 2.721 (0.011)* | 0.932 (0.496) | 1.460 (0.188) | 1.451 (0.192) | 2.618 (0.014)* | 0.515 (0.840) |
| 83 | 9 | 2.188 (0.034)* | 1.403 (0.206) | 2.085 (0.043)* | 0.554 (0.829) | 1.225 (0.296) | 1.079 (0.390) | 2.179 (0.035)* | 0.667 (0.735) |
| 82 | 10 | 1.937 (0.056) | 0.904 (0.535) | 2.170 (0.032)* | 0.605 (0.803) | 0.927 (0.515) | 1.116 (0.365) | 1.874 (0.066) | 0.637 (0.776) |

| n | Lags | Column 5 | | Column 6 | | Column 7 | | Column 8 | |
|---|---|---|---|---|---|---|---|---|---|
| | | $DIF_t \Rightarrow \Delta K_{4t}$ | $\Delta K_{4t} \Rightarrow DIF_t$ | $DIF_t \Rightarrow \Delta K_{5t}$ | $\Delta K_{5t} \Rightarrow DIF_t$ | $DIF_t \Rightarrow \Delta K_{6t}$ | $\Delta K_{6t} \Rightarrow DIF_t$ | $DIF_t \Rightarrow \Delta IPI_t$ | $\Delta IPI_t \Rightarrow DIF_t$ |
| | | Statistic F | Statistic F | Statistic F | Statistic F | Statistic F | Statistic F | Statistic F | Statistic F |
| 91 | 1 | 0.187 (0.666) | 1.468 (0.229) | 0.378 (0.540) | 0.395 (0.531) | 2.476 (0.119) | 0.016 (0.901) | 2.5E-05 (0.996) | 3.843 (0.053) |
| 90 | 2 | 5.231 (0.007)* | 2.285 (0.108) | 4.274 (0.017)* | 2.428 (0.094) | 4.980 (0.009)* | 3.141 (0.048)* | 5.867 (0.004)* | 5.996 (0.004)* |
| 89 | 3 | 5.566 (0.002)* | 1.940 (0.130) | 4.537 (0.005)* | 1.824 (0.149) | 4.012 (0.010)* | 2.072 (0.110) | 3.721 (0.014)* | 5.778 (0.001)* |
| 88 | 4 | 5.295 (0.001)* | 1.341 (0.262) | 3.748 (0.007)* | 1.404 (0.240) | 3.790 (0.007)* | 1.367 (0.253) | 4.337 (0.003)* | 4.584 (0.002)* |
| 87 | 5 | 3.662 (0.005)* | 1.280 (0.281) | 2.761 (0.024)* | 1.796 (0.123) | 2.881 (0.019)* | 1.380 (0.241) | 3.433 (0.007)* | 3.329 (0.009)* |
| 86 | 6 | 3.299 (0.006)* | 1.045 (0.404) | 3.729 (0.002)* | 1.458 (0.204) | 2.367 (0.038)* | 1.403 (0.225) | 2.736 (0.019)* | 3.136 (0.009)* |
| 85 | 7 | 2.822 (0.012)* | 0.755 (0.627) | 3.748 (0.002)* | 1.133 (0.353) | 2.159 (0.050)* | 0.059 (0.343) | 2.257 (0.039)* | 2.574 (0.020)* |
| 84 | 8 | 2.454 (0.022)* | 0.537 (0.824) | 3.669 (0.001)* | 1.011 (0.436) | 1.849 (0.083) | 0.911 (0.513) | 1.974 (0.063) | 2.712 (0.012)* |
| 83 | 9 | 2.186 (0.034)* | 0.823 (0.597) | 3.455 (0.002)* | 0.849 (0.574) | 1.578 (0.141) | 1.600 (0.134) | 1.461 (0.182) | 2.211 (0.032)* |
| 82 | 10 | 1.975 (0.052) | 0.872 (0.564) | 3.121 (0.003)* | 0.798 (0.630) | 1.842 (0.072) | 1.376 (0.213) | 1.191 (0.315) | 1.916 (0.060) |

Note: */ Significant relation at least at the five-percent level (value p between brackets).

## TABLE A3
### Correlation between the differential of DIF interest rates and the lag values of the MZM cyclical behavior

| $DIF_t$, MZM cycle $(t - i)$ | $i$ | Lags |
|---|---|---|
|  | 0 | 0.8064 |
| | 1 | 0.8135 |
| | 2 | 0.7388 |
| | 3 | 0.5882 |
| | 4 | 0.3887 |
| | 5 | 0.2278 |
| | 6 | 0.0924 |
| | 7 | 0.0103 |
| | 8 | -0.0415 |
| | 9 | -0.0731 |
| | 10 | -0.1141 |
| | 11 | -0.1602 |
| | 12 | -0.2021 |
| | 13 | -0.2346 |
| | 14 | -0.2518 |
| | 15 | -0.2305 |
| | 16 | -0.1875 |
| | 17 | -0.1428 |
| | 18 | -0.0976 |
| | 19 | -0.0681 |
| | 20 | -0.0744 |

Table **A4**

*Lagged effects of the interest rate differential on ratios that represent the intertemporal structure of the production process*

(third-order Almon polynomial)

| Coefficient $\beta_i$ | Column | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | $\Delta K_{1t}$ | $\Delta K_{2t}$ | $\Delta K_{3t}$ | $\Delta K_{4t}$ | $\Delta K_{5t}$ | $\Delta K_{6t}$ | $\Delta K_{7t}$ | $\Delta K_{8t}$ |
| $DIF_0$ | –0.1269* | –0.0090 | –0.0885* | –0.0876* | –0.3021* | –0.0816* | –0.0088 | –0.0796* |
| $DIF_1$ | –0.2140* | –0.0114 | –0.1416* | –0.1446* | –0.5066* | –0.1357* | –0.0099 | –0.1309* |
| $DIF_2$ | –0.2659* | –0.0081 | –0.1640* | –0.1747* | –0.6250* | –0.1657* | –0.0048 | –0.1572* |
| $DIF_3$ | –0.2868* | –0.0004 | –0.1604* | –0.1817* | –0.6703* | –0.1748* | 0.0054 | –0.1621* |
| $DIF_4$ | –0.2812* | 0.0107 | –0.1353 | –0.1692* | –0.6531* | –0.1661* | 0.0192 | –0.1491* |
| $DIF_5$ | –0.2534* | 0.0240 | –0.0934 | –0.1408 | –0.5858* | –0.1429* | 0.0353 | –0.1215* |
| $DIF_6$ | –0.2079* | 0.0384 | –0.0394 | –0.1004 | –0.4802* | –0.1085 | 0.0524 | –0.0830 |
| $DIF_7$ | –0.1491* | 0.0527 | 0.0221 | –0.0515 | –0.3480* | –0.0659 | 0.0692 | –0.0368 |
| $DIF_8$ | –0.0812 | 0.0659 | 0.0865 | 0.0020 | –0.2012 | –0.0185 | 0.084 | 0.0135 |
| $DIF_9$ | –0.0088 | 0.0767 | 0.1489* | 0.0566 | –0.0517 | 0.0305 | 0.0964 | 0.0644 |
| $DIF_{10}$ | 0.0638 | 0.0842 | 0.2049* | 0.1085 | 0.0887 | 0.0779 | 0.1042 | 0.1124* |
| $DIF_{11}$ | 0.1322 | 0.0871 | 0.2499* | 0.1540 | 0.2082 | 0.1206 | 0.1063 | 0.1542* |
| $DIF_{12}$ | 0.1920 | 0.0844 | 0.2790* | 0.1895* | 0.2949* | 0.1552 | 0.1014 | 0.1862* |
| $DIF_{13}$ | 0.2388* | 0.0749 | 0.2877* | 0.2112* | 0.3370* | 0.1786* | 0.0882 | 0.2050* |
| $DIF_{14}$ | 0.2683* | 0.0574 | 0.2713* | 0.2155* | 0.3226* | 0.1875* | 0.0653 | 0.2071* |
| $DIF_{15}$ | 0.2760* | 0.0309 | 0.2252* | 0.1986* | 0.2398* | 0.1787* | 0.0314 | 0.1890* |
| $DIF_{16}$ | 0.2575* | –0.0057 | 0.1447* | 0.1569* | 0.0768 | 0.1491* | –0.0148 | 0.1473* |
| $DIF_{17}$ | 0.2085* | –0.0537 | 0.0252 | 0.0867 | –0.1782 | 0.0953 | –0.0746 | 0.0785 |
| $DIF_{18}$ | 0.1245 | –0.1141 | –0.1379 | –0.0157 | –0.5371* | 0.0142 | –0.1495 | –0.0208 |
| $DIF_{19}$ | 0.0012 | –0.1880 | –0.3495* | –0.1541 | –1.0118* | –0.0975 | –0.2406 | –0.1542 |
| $DIF_{20}$ | –0.1658 | –0.2766 | –0.6140* | –0.3321 | –1.6141* | –0.2429 | –0.3494 | –0.3251* |
| AR(1) | 1.368* | 1.122* | 1.241* | 1.504* | 1.477* | 1.385* | 1.114* | 1.647* |
| AR(2) | –0.566* | –0.465* | –0.482* | –0.768* | –0.780* | –0.642* | –0.452* | –0.853* |
| Constant | *n.s.* | *n.s.* | *n.s.* | *n.s.* | 0.1006* | *n.s.* | *n.s.* | *n.s.* |
| $\sum\beta_i$ | –0.278 | 0.020 | 0.021 | –0.173 | –6.197 | –0.213 | 0.006 | –0.063 |
| Adjusted $R^2$ | 0.885 | 0.700 | 0.822 | 0.881 | 0.891 | 0.849 | 0.677 | 0.939 |
| Box-Pierce Q(1) (value $p$) | 1.615 (0.204) | 0.001 (0.975) | 1.046 (0.306) | 0.914 (0.339) | 2.849 (0.091) | 0.3478 (0.555) | 2.E-06 (0.999) | 0.009 (0.922) |
| Box-Pierce Q(2) (value $p$) | 4.347 (0.114) | 1.188 (0.552) | 1.588 (0.452) | 0.915 (0.633) | 3.903 (0.142) | 0.3484 (0.840) | 0.9393 (0.625) | 0.482 (0.786) |
| Statistic F Probability | 102.9 (0.000) | 29.02 (0.000) | 62.25 (0.000) | 100.7 (0.000) | 110.5 (0.000) | 78.51 (0.000) | 28.515 (0.000) | 205.81 (0.000) |
| Log-Likelihood | 186.6 | 179.7 | 194.1 | 193.0 | 163.26 | 201.92 | 160.76 | 240.87 |
| Akaike | –5.343 | –5.111 | –5.562 | –5.530 | –4.625 | –5.792 | –4.581 | –6.937 |

Note: */ Significant values at the five-percent level.