An Empirical Examination of Austrian Business Cycle Theory

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There can never be a scarcity of currency except when there is too much of it.
William Graham Sumner 1891

1.

Austrian capital theory (Mises 1949, 1980, 1998; Hayek 1931; subsequently developed by Hayek 1941, 1996, 1969) is used to construct and interpret a vector error-correction model estimated with U.S. macroeconomic data. Using 1959–2003 monthly data, the relationship between real consumable output and the interest rate term spread is examined. The term spread used is the ten-year constant maturity Treasury bond rate minus the three-month Treasury bill secondary market rate. This spread is often used as a measure of the real interest rate (Keeler 2001). When the term spread decreases, the structure of production becomes less roundabout as entrepreneurial managers reallocate resources away from producers' goods toward consumers' goods.

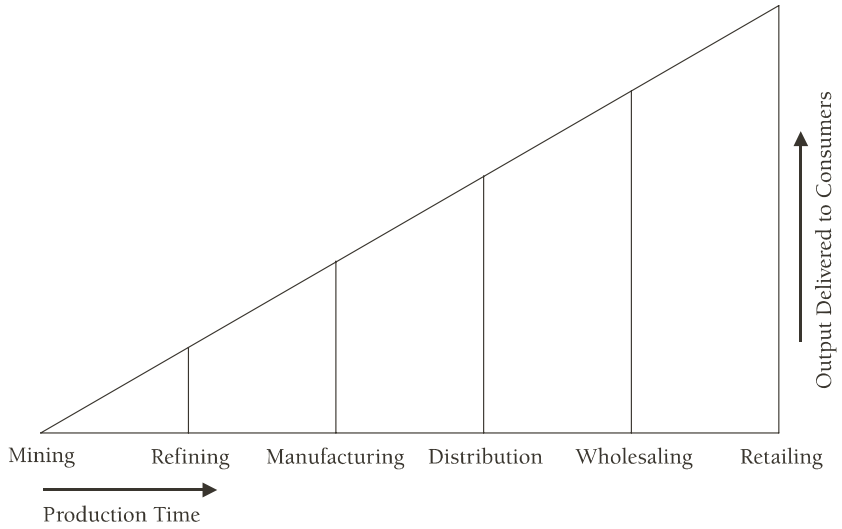
Whenever interest rates rise, higher rates of return in production are necessary to compete with financial instruments, such as relatively higher-yielding government bonds. This is manifested in a shifting of resources away from early stages of production to later stages, and can be shown as a shortening of the base of the Hayekian triangle (Figure 1) (Hayek 1931, p. 39). This paper explicitly tests the main assertion of Austrian business cycle theory, that lowering the interest rate below sustainable market levels raises real consumable

Robert F. Mulligan is associate professor of economics at Western Carolina University. Financial support in the form of a Visiting Research Fellowship from the American Institute for Economic Research, is gratefully acknowledged. Thanks are due to Scott Beaulier, Tony Carilli, Todd Gormley, Richard C.B. Johnsson, C. Edgar Murray, Benjamin Powell, Sudha Shenoy, Edward Stringham, Walker Todd, John Wood, and the referees of the *Quarterly Journal of Austrian Economics* for many helpful comments and criticisms. The author remains responsible for any errors or omissions.

THE QUARTERLY JOURNAL OF AUSTRIAN ECONOMICS VOL. 9, NO. 2 (SUMMER 2006): 69–93

output and investment in the short run, but lowers both over the long run. Credit expansion results in an unsustainable short-run increase in total output, consumption and investment, but a long-run decrease in all three, manifested in the historical data as a recession.

Figure 1
The Hayekian Triangle: Production and Capital Structure



Source: Garrison (2001, p. 47).

The rest of the paper is organized as follows. The theoretical basis for the paper is developed in section 2. Section 3 reviews recent applications of Austrian business cycle theory in the economics literature. Data sources are documented in section 4. Section 5 develops the methodological approach applied in section 6. Section 6 presents and interprets the empirical work, consisting of an error-correction model of real output as measured by real consumption expenditures. This section presents tests for cointegration followed by estimates of the error-correction model. Concluding comments are presented in section 7.

2. The Austrian Theory of the Business Cycle

Consider the problem faced by a capitalist with idle savings to invest, who engages in a specific productive activity. One use of these idle savings is to purchase intermediate inputs or goods-in-process, adding complementary resources such as labor and capital services to raise the sale value to another capitalist who engages in the next stage of production. The decision focuses on the opportunity cost, the prevailing interest rate which could be realized by lending savings to someone else. Capitalists opt for their own productive activity if they expect the return will be higher than could be realized through

lending, and lend out the savings if the market interest rate exceeds the return to their own production. Thus, if the interest rate falls, less money will be lent out and more will be used to finance productive activities, and vice versa.

Because investment projects with higher expected returns should always be funded in preference to those with lower expected returns, the lower the interest rate, the more investment projects will be undertaken by entrepreneurial planners. This result is unambiguous and independent of the source of funding, whether from borrowing or from the firm's retained earnings. In response to lower interest rates, firms shift productive activity into predominantly long-term projects with lower expected returns.

At the same time the interest rate influences consumers' decisions on how to divide their income between consumption and saving. The lower the interest rate, the less consumers save and the more they consume. It is important to distinguish between preference-induced reductions in the interest rate, which reflect agents' lowered time preference, from policy-induced reductions, which result from credit expansion by the central bank. Any policy-induced lowering of the interest rate must simultaneously increase consumption spending, lowering saving, *as well as* increase investment in productive activities.[1] This process would work in reverse when the interest rate rises, if productive activities could be liquidated rapidly and at low cost.

When the interest rate rises, capitalists should liquidate their own productive activities *to the extent possible*, and lend the money out to take advantage of the higher return. However, physical capital comprises illiquid assets, and once savings is invested in productive activities, it cannot be extracted without delay and loss of value. Physical or installed capital is characterized first by its complementarity with other components of an entrepreneurial production plan, and only secondarily by its substitutability in alternative plans, a property Lachmann (1947) calls multiple specificity or multispecificity. Once a capitalist invests in productive equipment, a higher interest rate may make it desirable to lend out the money that could be raised by selling the equipment. The sale may involve a delay, however, and as long as the capitalist enjoys a comparative advantage in the productive activity, the equipment's selling price must be below what the equipment was worth to the capitalist.

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[1]In contrast, preference-induced reductions in the interest rate, that is, general reductions in agents' time preference, simultaneously lower consumption spending and increase household saving out of current income. The market interest rate is arrived at through arbitrage between high-time-preference borrowers and low-time-preference savers. In the absence of the credit injection introduced by expansionary monetary policy, the only funds which can be borrowed to finance investment spending are household savings. When the central bank injects credit, it drives a wedge between saving and investment, ensuring investment spending will exceed the amount saved by households. Under the influence of an expansionary monetary policy, the market interest rate falls because the supply of loanable funds is increased above the amount saved by households, by the amount of additional credit injected by the central bank.

This cost asymmetry in converting between financial and physical capital is the basis for Bischoff's (1970) "putty-clay" model of investment. Uninvested "putty" capital, also called financial capital, is highly liquid, and can easily be moved from loan markets into productive activities. Once savings is tied up in installed physical or "clay" capital, it cannot be moved costlessly from productive activities back into loan markets, or even into alternative productive activities. The Austrian school emphasizes these costs associated with adjusting the capital structure—the structure of production—when interest rates rise, though it should be kept in mind that similar adjustment costs are incurred whenever labor, human capital, and raw materials are reallocated to their next best uses (Lachmann 1978, pp. 79–78; Lewin 1999, pp. 130–32, 178–99). Installed capital equipment can be thought of as the least adaptable input and the one that most often constitutes a binding constraint on the process of reallocating production in response to increases in the interest rate.

In the Austrian view, the business cycle cannot be caused by changes in interest rates resulting from changes in actors' time preferences, but only through policy-induced credit or monetary expansion. The prosperity which precedes a recession is marked by a lowering of the nominal interest rate below an appropriate, sustainable, equilibrium interest rate which would prevail in the absence of monetary expansion. While the interest rate is artificially depressed during the expansion phase, firms invest intensively in physical capital. Since the interest rate is so low, the production process can take more time to produce the same amount of real consumable output, so the production process becomes more drawn out, or more roundabout, and the slope of the hypotenuse of the Hayekian triangle becomes flatter, as its base becomes longer.

At the same time, however, the lower interest rate means consumers save less of their income and consume more. The injection of credit through policy-induced monetary expansion makes more nominal funds available both for investment in early-stage, higher-order production, and simultaneously in later-stage, lower-order production. The below-equilibrium interest rate results in an economy which takes longer to produce real consumable output, but also ensures consumers are less willing to wait for their wants to be satisfied. This production structure is unsustainable, and eventually must result in abandonment of much installed capital and goods-in-process in early stages of production, and many entrepreneurial plans, as well as high labor unemployment, even if the interest rate is kept low. Entrepreneurial plans of both producers and consumers are disrupted because they were predicated on a lower interest rate and a longer production structure.

Middle-stage productive activities serve the crucial role of transforming early-stage, higher-order output into late-stage, lower-order output which is used to satisfy consumer wants. But during a period of policy-induced credit expansion, the injection of additional money drives a wedge between saving and investment. There is paradoxically both more investment and less saving, because with the lower interest rate, consumers save less and consume more.

The policy-induced expansion of the money supply may appear to be fully justified by an increase in economic activity, but because the production structure

(a) fails to reflect actors' time preference, and

(b) cannot sustainably transform the overlarge volume of early-stage output, through the starved middle stage, into the similarly overlarge desired amount of late-stage consumable output,

a general collapse of the production structure becomes inevitable, as entrepreneurial planners start to realize their plans cannot be completed and must be modified or abandoned. Once entrepreneurial planners effect general reallocation of existing installed capital, the value of the capital equipment in its next-best employment is generally lower than what it was expected to be in its original position in the original production plan. During the adjustment, output and employment are generally far below the maximum they reached during the overexpansion boom, but also far above what could be realized if entrepreneurial planners were prevented from making this necessary adjustment. Sometimes, as during the Great Depression and the stagflation of the 1970s, policy makers continuously frustrate entrepreneurial planners in performing the adjustment necessary to bring about an end to the downturn, prolonging the contraction.

In Austrian business cycle theory, the onset of a recession can occur in any of three ways:

(1) Deflation: Often, following overexpansion of the money supply, the monetary authorities will recognize the dangers of the low interest rate and will intervene to effect adjustment by tightening the money supply. This is signaled by higher interest rates toward the end of the expansion and the early stages of the recession. This policy response results in a shorter-lived, though usually more severe, recession, which is the relatively rapid process of the economy bringing the production process back in line with the sustainable interest rates and actual time preference. Contractionary policy can be observed most notably preceding the onset of the Great Depression, the Volker recession of 1981–82, and the 2001 recession.

(2) Steady inflation: The monetary authorities continue to inflate the money supply at approximately the same rate as during the expansion. This would normally occur whenever the monetary authorities remain unaware of the ill-advised aspects of their policy-induced credit expansion, or are otherwise innocent of economic theory. As low interest rates persuade entrepreneurial managers to invest more in early stages of production and lower-yielding productive activities, and simultaneously persuade consumers to save less and consume more, the need for complementary resources required to simultaneously increase the resource allocation in

both early and late stages of production becomes critical.[2] Demand for credit finally outstrips the monetary authority's intended oversupply, driving interest rates up, leading to massive abandonment of production plans and lower-yielding capital equipment, precipitating higher unemployment. Most postwar recessions have started this way, including the first Gulf crisis recession of 1990–91.

(3) Accelerating inflation: Finally, the monetary authorities may foresee the recession, or perceive the increased demand for credit, and attempt to forestall the collapse by increasing the money supply even faster. The economic collapse can be postponed as long as credit expansion can support high nominal demand for both consumption and investment goods. Although the unemployment rate and conventional output measures make the economy appear healthy during the unsustainable boom, under a policy of accelerating inflation the economy becomes most fully committed to an unsustainable production structure. Middle-stage productive activities are starved for resources which are allocated to early-stage activities, providing additional demand for investment goods and late-stage activities attempting to satisfy increased demand for consumption goods. The atrophy of the middle stage creates a bottleneck which prevents entrepreneurial production plans from being carried out. The most resources are wasted through misallocation under accelerating inflation, a strategy which delays the onset of a recession, but guarantees a more severe and protracted one. This experience characterized the oil-shock recessions of 1969–70 and 1973–74.

Productive resources have differing degrees of substitutability and complementarity (Garrison 1985, p. 168; 2001, p. 49). ABC theory emphasizes the inflexibility imposed by the high cost of adjusting the production structure by reallocating installed physical capital. It is important to realize that similar kinds of inflexibility and high adjustment costs can come from other resources, particularly labor (Lachmann 1956; Lewin 1999). Workers often resist seeking employment outside preferred venues. Because this source of high unemployment results from high adjustment costs which frustrate resource allocation and adjustment of the production structure, rather than from real or nominal wage or price stickiness, this potential cause of recession, though labor based, should be recognized as Austrian rather than Keynesian. Mulligan (2002) presents evidence that labor employment is reallocated over

[2]As a rule more illustrative than actually descriptive, the need for additional complementary resources for production is approximately proportional to the amount already in use, for example, the amount of physical capital already installed. Thus more capital installed means more additional resources required, so the demand for additional credit accelerates. If the supply of additional credit remains steady as the demand for it increases, the interest rate must rise.

the business cycle in a manner similar to that predicted by ABC theory for the physical capital it complements. Hayek (1967, pp. 136–39) and Garrison (1986, p. 440; 1988; 2001, pp. 71–73) draw a fundamental distinction between ordinary changes in time preference and policy-induced changes in interest rates. Only a decrease in interest rates caused by credit expansion can drive the business cycle. According to ABC theory, there should be no cycle if the decrease in interest rates is due to a general lowering of time preference. Mises (1998, pp. 550-66) develops a similar argument.

3. Qualitative Applications and Earlier Empirics

ABC theory is unmatched in offering persuasive qualitative explanations of historic business cycles. This fact by itself makes a powerful case for the Austrian School, which should be accepted as the dominant macroeconomic policy paradigm.

Murray Rothbard's (2000a) monumental study of the Great Depression persuasively argues that credit expansion as demonstrated by an increase in the monetary base created an unsustainable boom in the 1920s, and that government policy frustrated the efforts of economic agents to liquidate inefficient capital, resulting in a protracted secondary contraction. Thus, the New Deal transformed what would have been a relatively short recession into the Great Depression by preventing prompt liquidation of overinvestment. Valuable resources which could have been used for more productive purposes, and for output more urgently desired by consumers, were kept tied up in counterproductive attempts to maintain labor employment in the same industries which had overexpanded through the malinvestment boom. Focusing on a monetary aggregate similar to MZM, Rothbard (1978) shows that inflation and credit expansion continued sporadically well into the 1930s, effectively preventing any general liquidation of malinvested capital. Rather than facilitate liquidating malinvestment, continued easy credit policies generated increased opportunities for malinvestment. The misallocation of productive resources was further exacerbated by governmental efforts to restore and maintain artificially high prices through cartelization.

This view contrasts markedly with Friedman and Schwartz's (1963) conclusion that the secondary contraction was caused by the Federal Reserve System's failure to provide *enough* liquidity. Using the standard monetary aggregate that ultimately emerged as M1, Friedman and Schwartz find that the main problem during the depression was an unintentionally contractionary monetary policy. Table 1 summarizes some of the evidence cited by Keynesian, monetarist, and Austrian authors. It is difficult to avoid the conclusion that the Austrian explanation is the most encompassing, because even though ABC theory focuses on the unsustainable expansion which precedes a recession, it also addresses the difference between short recessions where government policy does not interfere with reallocation of malinvested capital, and downturns which are prolonged because of poor or inconsistent policy which frustrates liquidation of malinvestment.

Table 1
Competing Views of the Great Depression

Keynesian	Monetarist	Austrian
Liquidity trap created once nominal interest rates became low enough; bank demand for excess reserves became perfectly elastic. Monetary base doubled between 1929–38: monetary policy was expansionary, but excess reserves accumulated in banks. Demand for loans depressed due to unfavorable business outlook. Banks did not buy securities because nominal yields were so low.	Real interest rates extremely high due to price deflation: e.g., CPI fell 10% in 1931 and 1932. Indicates a contractionary policy. Growth in monetary base mostly attributable to currency held by public, unavailable to be loaned out, rather than bank reserves. "Flight to quality" greatly increased demand for short-term Treasury securities, depressing their yield. Fed tightened discount lending policy in 1931, and doubled the reserve requirement between 1936–37, triggering a secondary recession.	Expansionary monetary policy depressed interest rates and created an unsustainable investment boom throughout the late 1920s. Monetary policy was intermittently both expansionary and contractionary at different times throughout the 1930s. Government intervention initiated under the Hoover administration between 1930–32 delayed the liquidation of malinvested capital. Price fixing, fiscal stimulus, and inconsistent monetary activism, continued and extended under the Roosevelt administration, prevented liquidation of malinvested capital, prolonging the contraction.
Keynes (1936), Hicks (1939), Modigliani (1944)	Friedman and Schwartz (1963), pp. 411–41	Rothbard (1962), Garrison (2001)

The Austrian perspective can be interpreted as intermediate between the Keynesian explanation, emphasizing a liquidity trap which made expansionary monetary policy ineffective, and the monetarist, which criticizes the Fed for implementing a contractionary policy. The Austrian School blames the expansionary policy of the 1920s for the onset of depression, and the reliance on government and central bank policy activism for transforming what would have been a brief recession into a decade-long ordeal.[3] The Austrian School goes beyond the Monetarist School in emphasizing the real discoordination and resource misallocation forced by government and central bank actions, resulting in persistent and abnormally high unemployment.

O'Driscoll and Shenoy (1976) present an account of the stagflation of the 1970s in terms of ABC theory. They note that credit expansion increases nominal demand at the point the newly-created money is injected, distorting the price vector and the allocation of resources. Misallocated capital has a persistent negative impact on consumable output because it cannot be easily reallocated. Credit expansion always increases consumption expenditures because any new money results in increased nominal income to some households.

[3]Monetarist economists distinguish between routine or unexceptional recessions and the protracted ordeal of the Great Depression. In the view of Friedman and Schwartz, poor monetary and government policy prevented the economy from adjusting relatively rapidly. The Austrian School differs only in that recessions cannot start in the first place without being caused by expansionary monetary policy which fuels an unsustainable expansion.

Firms engaging in production most remote from consumption find resource prices bid up, and resources bid away, by firms selling late-stage output directly to consumers. Unemployment starts in these firms remote from final consumption even as prices continue to be bid up by continued injections of cheap credit. Wainhouse (1984) presents what may be one of the first econometric studies of ABC theory. Hughes (1997) and Cwik (1998) apply ABC theory to the first Gulf War recession. Garrison (2001) also provides convincing accounts of both the Great Depression and the stagflation of the 1970s using the Austrian model.

Carilli and Dempster (2001) argue that Austrian business cycle theory places undue reliance on economic agents misperceiving credit expansion as a real increase in loanable funds. They suggest that even if rational agents correctly anticipate inflation, agents maximize profits under uncertainty by taking advantage of the market interest rate whenever it falls below the underlying rate of time preference. Keeler (2001) used standardized quarterly data for eight U.S. business cycles, finding monetary shocks did cause cycles which were propagated through relative price changes, including nominal interest rates.

Powell's (2002) account of the Japanese recession of the 1990s is especially noteworthy because he focuses on exactly how expansionary monetary and fiscal policy recommended to spur recovery actually lengthened and deepened Japan's recession. His conclusion is that monetarist policy prescriptions proved only marginally less ineffective than Keynesian ones. As with the Great Depression, poor policy prescriptions transformed what should have been a brief recession into a decade-long experience. Mulligan (2002) used sectoral labor data as indicators of resource allocation among industrial sectors. Resources are reallocated among early, middle, and late stages of production in response to changes in nominal interest rates, as Austrian business cycle theory predicts.

In marked contrast to orthodox neoclassical and Keynesian accounts of the business cycle, Austrian business cycle theory presents a consistent and coherent explanation of the causes and propagation mechanisms of the business cycle. Though more typically qualitative than quantitative, the explanatory successes of Austrian business cycle theory have proved robust over an impressive time period and range of specific applications. This remarkable success makes it even more puzzling that ABC theory has not been enthusiastically embraced by non-Austrians, and that it has yet to emerge as the dominant macroeconomic policy paradigm.

4. Data

This section documents the data used for econometric estimation and motivates the choice of data. Annualized personal consumption expenditures and its chain-type price index are observed monthly for January 1959 to March 2003 and reported by the U.S. Department of Commerce Bureau of Economic

Analysis. The price index was used to obtain real personal consumption expenditures, which was then put in natural logarithms. This is the measure of real consumable output.

Alternative output measures present special difficulties. Most national income and product account output measures, such as gross domestic product (GDP), are only observed quarterly. Often, the monthly-observed index of industrial production is used to proxy GDP. These broader output measures include investment and government purchases. They are less appropriate from an Austrian perspective because ABC theory purports to explain fluctuations in real consumable output. It would be especially interesting to estimate the relationship between interest rates and real private investment spending, but investment is only observed quarterly.

One difficulty which cannot be avoided is that in the Austrian view, the real value of consumable output is not the objective and observable exchange value captured in real consumption expenditures, but the subjective use value extracted by each consumer. This value is inherently unobservable and disaggregated. Such fundamental issues of methodology and philosophy help explain why there have been so few econometric analyses of Austrian theories.

Interest data are provided by the Federal Reserve Bank of St. Louis. The three-month secondary-market rate and the ten-year constant maturity rate are taken for the same period. The term spread is computed as the ten-year constant maturity rate minus the three-month secondary-market rate. Usually, the term spread falls as the central bank pursues expansionary monetary policy. When a large price premium dominates short-term interest rates, as often occurs in the late stages of monetary expansion, the term spread becomes negative. The term spread rises with tight monetary policy. The term spread is often used as a measure of the real interest rate (Keeler 2001, pp. 338–40). The annualized rate (a) is converted to the monthly rate (m), the actual interest accrued over the month, by taking the twelfth root:

$$m_t = (1 + a_t)^{1/12} - 1.$$

The term spread was found to be a stationary process (see section 6.a.), and thus could not have a stable, cointegrated relationship with a nonstationary process like real consumable output. To overcome this problem, the cumulative sum of the term spread (r) was computed and used in estimation:

$$r_t = \{\Pi_{i=1}^{t}(1 + m_n)\} - 1.$$

If the term spread is interpreted as a measure of the real interest rate, the cumulative term spread can be interpreted as the real return over time, which is then put in natural logarithms. The theoretical justification for using this artificially-constructed cumulative real return over its first-difference, the real

interest rate, is that the information content of the two series is identical.[4] All data are from the Federal Reserve Bank of St. Louis Federal Reserve Economic Data (FRED-II) website.

5. The Error-Correction Methodology

This paper proposes the error-correction model as an econometric methodology especially amenable to interpretation by the Austrian School. Error-correction models provide estimates of both a structural or equilibrium process toward which adjustment is generally effected, and the error-correction or disequilibrium adjustment process through which adjustment is made toward the hypothesized equilibrium. Even if one rejects the reality of any hypothesized equilibrium, estimates of the disequilibrium adjustment process still warrant interest. The error correction model consists of two parts, a structural equation which defines the long-term equilibrium process, and a short-term disequilibrium adjustment process. The residual of the structural equation is an estimate of the disequilibrium in any given time period.

For consumption, the structural equation capturing the long-run relationship between consumption and the cumulative real interest yield is:

$$C_t = AR_t^b E_t$$

where A is a scaling constant, b is a weighting exponent, and E is a multiplicative residual or error. Putting this relationship in logarithms yields:

$$c_t = a + br_t + e_t$$

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[4]The information content of the cumulative term spread is insignificantly superior, because it directly measures the real return from the start of the series. Using the simple (noncumulative) term spread would lose one degree of freedom out of 531 observations. The alternative to regressing the I(1) cumulative term spread on I(1) real consumable output would be to regress the I(0) noncumulative term spread on the I(0) first-difference of real consumable output, that is, additions to current real output. The I(0) alternative is numerically identical except for the loss of one degree of freedom. The regressions reported in section 6 simultaneously measure

(a) how the level of current real output responds to cumulative real returns, and

(b) how changes in real output respond to real current returns.

Austrian business cycle theory asserts a direct, long-term relationship between real current returns and the level of current real output. If real interest rates fall predominantly due to credit expansion as opposed to general lowering of time preferences, that should result, over the long term, in lower levels of current real output. The theoretical relationship can be used to interpret the regression of cumulative returns on the current output level because lower levels of real current returns imply and are implied by, lower cumulative real returns.

where *c* and *r* are the natural logarithms of consumption and the cumulative term spread,[5] and the vector error correction model is:

$$\Delta c_t = \Theta(c_{t-1} - a - br_{t-1}) + \Delta c_{t-1} + \Delta c_{t-2} + \Delta c_{t-3} \ldots + \Delta r_{t-1} + \Delta r_{t-2} + \Delta r_{t-3} \ldots + u_t$$

$$\Delta r_t = \Psi(c_{t-1} - a - br_{t-1}) + \Delta c_{t-1} + \Delta c_{t-2} + \Delta c_{t-3} \ldots + \Delta r_{t-1} + \Delta r_{t-2} + \Delta r_{t-3} \ldots + v_t$$

Note the expression in parentheses is the lagged residual from the structural equation, and thus could be represented simply by e_{t-1}. This is the error which the disequilibrium adjustment process of the error correction model attempts to explain. The upper-case Greek letters are the structural adjustment or disequilibrium adjustment terms, which weight the error-correction processes and so indicate the importance of the past changes in the explanatory variables in effecting adjustment toward the hypothesized equilibrium. The equilibrium represented by the structural equation is generally never realized, and if realized, is not persistent. If equilibrium is ever reached, that is represented by a zero residual in the structural equation for those observations. Whenever the residual is non-zero, that is, whenever the system is in disequilibrium, (virtually every observation,) the nonzero residual in period t results in an adjustment back toward equilibrium in period t+1, represented by the error-correction processes. The error-correction processes can be thought of as indicating how the data processes can best be represented as adjusting to maintain the long-run equilibrium.

Conventional inference is valid in an error-correction model even when the structural variables are nonstationary, provided the residuals are white-noise processes with no serial correlation. It is generally assumed that adding a sufficient number of lagged difference terms in the disequilibrium adjustment process is always sufficient to guarantee white-noise errors.

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[5]In the antilog structural equation:

$$C_t = AR_t^b E_t$$

A is a dimensionless scaling constant, b is a weighting exponent and is also dimensionless, and the multiplicative residual or error term E can always be considered as having the units of the left-hand-side variable divided by the units of the multiplied right-hand-side variables. In this case the error term has dimensions of billions of chained 1996 dollars divided by the cumulative percent return. The denominator is required to cancel out the units on R. When this relationship is put in logarithms:

$$c_t = a + br_t + e_t$$

a and e_t take on the same units as c_t, the natural logarithm of billions of chained 1996 dollars. Since r_t is dimensioned in the natural logarithm of the cumulative percent return, the weighting exponent b takes on units of the natural logarithm of billions of chained 1996 dollars *divided* by the natural logarithm of the cumulative percent return. Empirical researchers confront a choice over whether to put interest rates in natural logarithms. This paper follows the practice of Keeler (2001).

6. The Vector Error-correction Model

This section presents and interprets empirical estimates based on the simple parameterization of Austrian business cycle theory introduced above. One advantage of this parsimonious specification is that it allows the isolation of influences due to credit expansion on consumable output. All other influences are omitted except to the extent they might act through credit expansion, as manifested in the cumulative term spread. In the subjectivist theory of a capital-using economy, entrepreneurial planners act as the subjects of productive activities, creating real consumable output as the object (Garrison 1985, pp. 164–65; 2001, p. 15). Interest rates facilitate intertemporal coordination of productive resources by clearing the loanable funds market (Garrison 1986, p. 440; 2001, p. 39). In this regard disequilibrium interest rates play the same role as prices in signaling opportunities for entrepreneurial discovery (Kirzner 1984a, p. 146; 1984b, pp. 160–61; 1997), and individual entrepreneurs respond by maintaining the production structure, that is, they adjust it by reallocating resources.

a. Unit Root and Cointegration Tests

Most macroeconomic time series display an increasing trend, and unit root tests were developed to identify this characteristic. Stationary time series are said to have zero roots or be integrated of order zero [I(0)]. Nonstationary series may have a unit root or be first-order integrated [I(1)]. Unit root series become I(0) when first-differenced. Regressions estimated with nonstationary data will not have the white-noise residuals needed for valid inference. The regression could be estimated in first-differences, but then any long-term information carried by the levels of the variables is lost. Error-correction models overcome this difficulty by estimating a regression in first-differences augmented by error-correction terms, the lagged differences between the actual and estimated value of the left-hand-side variable, collectively referred to as the error-correction process, also called the disequilibrium adjustment process. The coefficients on the first-differenced variables constitute the cointegrating vector or structural relationship. A sufficient number of lagged error-correction terms are added to guarantee white-noise errors and valid inference (Davidson and McKinnon 1993, pp. 720–30; Kennedy 1998, pp. 266–70).

The Johansen-Juselius (1990) procedure was used to identify stable, long-term relationships between real consumable output and the interest rate term spread. Table 2 reports augmented Dickey-Fuller (1979) and Phillips-Perron (1988) unit-root tests for each variable. Because unlike consumption expenditures, interest rates do not generally rise as the economy grows, the term spread would be expected to be I(0) a priori. This result was obtained empirically here with the augmented Dickey-Fuller test, in contrast to Mulligan (2002), who found interest rates I(1) with the Phillips-Perron test. Although the Phillips-Perron test indicates both the term yield and the cumulative term yield are I(0), following the Dickey-Fuller results, the cumulative term yield was treated as I(1).

Table 2
Unit Root Tests
January 1959–March 2003

Augmented Dickey-Fuller Tests 24 Lags				
Variable	Levels		First differences	
	Intercept	Intercept + Trend	Intercept	Intercept + Trend
ln consumption	-2.0083	* -3.1785	*** -4.7783	*** -5.0474
Term spread	**-3.3285	** -3.7654	*** -5.8408	*** -5.8424
Cumulative term spread	0.3041	-2.6624	*** -4.5022	*** -4.4574
ln critical values	1% -3.4456 5% -2.8675 10% -2.5700	1% -3.9805 5% -3.4207 10% -3.1327	1% -3.4456 5% -2.8675 10% -2.5700	1% -3.9805 5% -3.4207 10% -3.1327
Phillips-Perron Tests 5 lag truncation for Bartlett kernel (Newley and West 1987)				
ln consumption	-1.5698	-2.0846	*** -27.6197	*** -27.6900
Term spread	*** -4.0010	*** -4.2686	*** -17.6879	*** -14.6700
ln cumulative term spread	*** -3.7480	*** -8.6765	*** -25.4000	*** -25.1331
Critical values	1% -3.4450 5% -2.8673 10% -2.5696	1% -3.9797 5% -3.4203 10% -3.1325	1% -3.4450 5% -2.8673 10% -2.5698	1% -3.9797 5% -3.4203 10% -3.1325

Rejection of the null hypothesis of a unit root [H_0: x ~ I(1); H_A: x ~ I(0)] at the 10%, 5%, and 1% significance levels indicated by *, **, ***. Results suggest that the logarithms of real consumption expenditures and the cumulative term yield are I(1) processes, while the term yield is I(0). For the unit root tests, the term yield is not put in logarithms because it is a percentage and occasionally takes on negative values.

An I(1) process like consumption cannot be cointegrated with an I(0) process like the term spread. One way around this difficulty would be to difference consumption, yielding an I(0) process. Almost equivalently, the cumulative sum of the term spread could be generated. Though these two procedures are numerically nearly identical, cumulative summing the term spread avoids losing one observation and one degree of freedom in estimation, and that was the procedure followed here. Unit root tests confirm the cumulative term spread is I(1). The null hypothesis of a unit root is always rejected for the first-differenced series, demonstrating both variables are integrated of order one [I(1)] and not of higher order.

Table 3 reports Johansen-Juselius tests for cointegration. Results of the trace test, a likelihood ratio, indicate a stable, cointegrated relationship between real consumable output and the cumulative yield spread. Stronger evidence for cointegration was found when the model was specified without a constant in the structural equation, but the intercept was left in to avoid imposing an unrealistic restriction. This determined the specification of the vector error-correction model.

Table 3
Tests for Cointegration between Consumption and Cumulative Term Spread December 1959–March 2003
(434 observations after adjusting endpoints with 96 lag intervals)

Hypothesized # CE(s)	*Maximum Eigenvalue*	*Trace Statistic*	*5% Critical Value*	*1% Critical Value*
None*	0.039698	18.21093	15.41	20.04
At most 1	0.001452	0.630509	3.76	6.65

Critical values from Osterwald-Lenum (1992).
*(**) denotes rejection of the hypothesis at the 5% (1%) level.
Trace test indicates 1 cointegrating equation at the 5% level.
96 lag intervals in disequilibrium adjustment process (96 lagged first-differences).
Trend assumption: No intercept or deterministic trend in cointegrating equation or disequilibrium adjustment process.

Because the two variables in the model are cointegrated, the ordinary least squares estimate of the structural relationship has the property of superconsistency. The OLS estimate is presented in Table 4, and it can be seen that OLS provides an estimate of the structural relationship or cointegrating equation fairly consistent with that provided by the error-correction model (Table 5.) The OLS estimate also allows for a test of the hypothesis that a lower interest rate accompanies a permanently lowering of the level of real consumable output, the key assertion of Austrian business cycle theory. This interpretation assumes that interest rates fall only due to expansionary monetary policy and not due to general lowering of time preference. The adjusted R square is 97 percent. The intercept and coefficient on the cumulative term spread are both positive and significant. Coefficient values of 6.862 for the intercept and 0.162 for the slope indicate that a one percent increase in interest rates permanently raises consumption expenditure by 955.3 billion chained 1996 dollars each month the higher interest rate persists.[6]

Perhaps more revealingly, a one-percent *decrease* in the cumulative term spread, such as results from policy induced monetary expansion, has on average *decreased* real consumable output over the long run by the same amount. The results of the t-test on the cumulative term spread provide strong empirical confirmation of Austrian business cycle theory. This amount is more than great enough to account for any historic recession. Further, the output measure used here, real consumption expenditures, comprises only approximately

[6]The Jarque-Bera (1980) test statistic for normality of the OLS residual series is 40.67, with an asymptotic probability of zero, strongly rejecting the null hypothesis of normality. The pronounced negative skewness, -0.4753, is strongly suggestive of non-normality. The Breusch-Godfrey (1986) Lagrange multiplier test for twenty-fourth-order autocorrelation of the residuals yields an F-statistic of 355, with an asymptotic probability of approximately zero, and is strongly suggestive of autocorrelated residuals. These results do not motivate setting aside the OLS estimates in light of the superconsistency of OLS estimates based on cointegrated series.

70 percent of GDP, thus any impact on real consumption implies a somewhat greater impact on total real output.

Table 4
OLS Estimate of Cointegrating Equation
January 1959-March 2003

Variable	*Coefficient*	*Standard Error*	*t-Statistic*	*Probability*
Constant	6.862534	0.009921	*** 691.7204	0.0000
ln Cumulative term spread	0.165032	0.001270	*** 129.9966	0.0000
R-squared	0.969647	Mean of dependent variable		8.079763
Adjusted R-squared	0.969589	S.D. of dependent variable		0.433241
S.E. of regression	0.075551	Akaike info criterion		-2.324248
Sum squared residual	3.019538	Schwarz criterion		-2.308147
Log likelihood	619.0879	F-statistic		*** 16899.12
Durbin-Watson statistic	0.013518	Probablility (F-statistic)		0.000000

Number of included observations = 531.
Dependent variable is the natural logarithm of real consumption expenditures.

b. The Cointegration Space

The estimate of the vector error correction model (VECM) is reported in Table 5. To facilitate interpretation, the VECM is normalized with respect to and solved for consumption. Estimated coefficients of the cointegrating equation are similar in sign and magnitude to those found by OLS. The VECM intercept and slope coefficients 7.120 and 0.136, indicating a one-percent decrease in the cumulative term spread decreased real consumable output by approximately 1.2 trillion 1996 dollars for every month the term spread falls.[7] This is significantly greater than the amount indicated by OLS, but the two estimates are reasonably consistent. The t-test on the VECM estimate of the structural equation provides further evidence in support of Austrian business cycle theory's key assertion that lowering the real interest rate lowers real consumable output over the long run. The coefficients on the 96 lagged difference terms are not reported, partly due to space limitations, and also because individual coefficient estimates hold limited interest. The implications of the disequilibrium adjustment process can be inferred from the variance decomposition and impulse response graphs (Figures 1 and 2).

[7]The impact of the interest rate on consumption is evaluated by taking the slope coefficient estimate of 0.136, multiplied by 1.0 representing a decrease (increase) of the interest rate by 1 percent for one month, and taking the antilog of 0.136, which equals a 1.15 billion chained 1996 dollar loss (gain) in consumable output (consumption spending) for every month the cumulative term spread is lowered by 1 percent. The longer the interest rate is kept 1 percent below the sustainable market rate, the greater the impact on the cumulative term spread and thus on real output. See table 6.

Table 5
Vector Error Correction Model:
Real Consumable Output Explained by Cumulative Term Spread
December 1959–March 2003 (527 observations after adjusting endpoints)

Cointegrating equation			
	Coefficient	*S.E.*	*t-statistic*
Constant	7.120293		
ln Cumulative term spread	0.135673	(0.00884)	[15.3553] ***
Error correction process Summary Statistics			
	Δ(ln Consumption)	*Δ(ln Cum. term spread)*	
Disequilibrium adjustment terms	-0.017780	0.004338	
S.E.	(0.00589)	(0.00447)	
t-statistics	[-3.01976] ***	[0.96966]	
R-square	0.533446	0.955389	
Adjusted R-square	0.158258	0.919514	
Sum of squared residuals	0.006424	0.003708	
Standard error of equation	0.005173	0.003931	
F-statistic (zero slopes)	1.421810	26.63105	
Logarithm of likelihood function	1797.401	1916.644	
Akaike information criteria AIC	-7.388943	-7.938453	
Schwarz criteria SC	-5.568274	-6.117783	
Mean of dependent variables	0.002726	0.016250	
Standard deviation of dependent variables	0.005639	0.013855	
Determinant of residual covariance matrix		$4.13x10^{-10}$	
Logarithm of likelihood function		3714.176	
Logarithm of likelihood function adjusted for degrees of freedom		3457.072	
Akaike information criterion AIC		-14.13397	
Schwarz criterion		-10.47386	
Standard errors in (); t-statistics in []. 10%, 5%, and 1% significance indicated by *, **, and ***.			

The adjusted R-square for the disequilibrium adjustment process is very high (92 percent) for the cumulative term spread disequilibrium adjustment process, but very low (16 percent) for the real consumable output process. Ideally a model with high explanatory power would explain the adjustment processes well for both consumption and interest rates, but it is a significant triumph for ABC theory that the adjustment process appears to work primarily through the interest rate. The feedback loop through consumption is relatively weak. In spite of the low R-square, the disequilibrium adjustment term in consumption [Θ] is negative and significant, indicating that consumption adjusts downward whenever consumption exceeded the putative equilibrium fitted value ($a + br_{t-1}$) in the previous month, or in other words, whenever c_{t-1}

> a - br_{t-1}, or whenever e_{t-1} was positive. The disequilibrium adjustment term in the term spread [Ψ] is positive but not significant.

Table 6
Impact of 1 Percent Decrease in the Term Spread in Billions of Chained 1996 Dollars of Real Consumable Output

Time	Estimation Technique					
	OLS			VECM		
	mean − 1 s.e.	mean	mean + 1 s.e.	mean − 1 s.e.	mean	mean + 1 s.e.
1 month	1.18	1.18	1.18	1.14	1.15	1.16
1 year	7.14	6.99	7.36	4.58	5.11	5.66
2 years	50.92	48.81	54.12	20.99	26.15	32.08
3 years	363.37	341.04	398.17	96.16	133.75	181.72
4 years	2593.01	2382.70	2929.23	440.53	683.97	1029.29
5 years	18503.59	16647.04	21549.76	2018.24	3497.84	5830.05

Real consumable output is measured in billions of chained 1996 dollars. The mean values are computed by the OLS and VECM coefficient estimates. Plus or minus one standard error confidence intervals are also provided. The table estimates the impact of lowering the term spread by 100 basis points, and keeping it depressed at that level for up to five years continuously.

Table 6 shows the literal implications of the coefficient estimates. The clear implication is that whenever the term spread has been lowered significantly below its average value, real consumable output is permanently lowered by a significant amount. In fact, the amount of lost output predicted by the model in response to a permanent lowering of the term spread rapidly exceeds U.S. GDP after just a few years. Rather than dismiss the validity of the estimate, it seems most plausible that the sample data is dominated by shorter-term adjustments in the interest rate targets.

The specification of the disequilibrium adjustment process includes only lagged first-differences of both consumption and the cumulative term spread, one through 96, eight years of lagged differences. This lag specification was arrived at through Wald tests for lag exclusion. A full year of lagged differences were retained as long as any one of the twelve was statistically significant.[8] In addition to hypothesis tests, appeal could be made to a priori,

[8]Lagrange multipliers were computed for residual correlation up to ten years (120 lags). The null hypothesis of white noise errors was rejected 12 times at the five percent level (one tail), for lag orders of 6, 8, 15, 20, 29, 34, 42, 50, 66, 69, 82, and 91. Rejection at the 5 percent level would be expected at least six times. However, the Lagrange multiplier test has low power for higher lag order, suggesting the white-noise null hypothesis should be rejected more frequently, as was actually observed here.

theoretical, or observational-empirical considerations in setting the lag length. The median length of a recession is somewhat less than two years, but the median length of an expansion may be as long as ten years. One approach would be to average the two figures to ensure capturing most of the dynamics in the disequilibrium adjustment process. However, the average expansion generally cannot last so long if it is characterized by policy-induced credit expansion. The complete dynamics of the business cycle may be captured with four to five years of lagged differences. This would be the case if a recession always results after so many years of credit expansion, and if the recessions are always shorter than the expansions. This study, in contrast, errs on the side of caution and statistical formalism by including the longer, statistically justified, lag structure.

Validity of the error-correction specification depends on cointegration among the variables in the model and white-noise characteristics of the residuals. Jarque-Bera (1980) tests of normality of the residuals are reported in Table 7. Unfortunately these results strongly suggest the residual series are non-normal. It should be emphasized, however, that normality is a sufficient, rather than a necessary, condition for valid VECM estimates. The Johansen-Juselius procedure estimates the VECM by maximum likelihood, imposing the most nearly normal character possible on the residuals. In the absence of a clear finding of normal residuals, appeal has to be made to the very similar coefficients of the superconsistent OLS estimate. Even when 96 lagged differences, representing eight years, were added to the model, the Jarque-Bera test yielded a result of non-normality.

Table 7
Vector Error Correction Model
Jarque-Bera Test for Multivariate Normality of Residuals

Component	*Skewness*	*Chi-square*	*d.f.*	*Probability*
Consumption	0.003443	0.000857	1	0.9766
Cum. term spread	-0.138378	1.385063	1	0.2392
Joint		1.385920	2	0.5001
Component	*Kurtosis*	*Chi-square*	*d.f.*	*Probability*
Consumption	1.021981	70.75212	1	0.0000
Cum. term yield	1.818217	25.25540	1	0.0000
Joint		96.00752	2	0.0000
Component		*Jarque-Bera*	*d.f.*	*Probability*
Consumption		70.75297	2	0.0000
Cum. term yield		26.64047	2	0.0000
Joint		97.39344	4	0.0000

H_0: residuals are multivariate normal. 434 included observations.
Cholesky orhogonalization (Lütkepohl 1991). Results suggest non-normality of residuals.

Non-normal residuals can be interpreted as evidence of specification error, and from the perspective of the Austrian school, specification error is necessarily present in all econometric models. The measure of real consumable output is not the subjective use value of the output delivered to consumers, and the real interest rate measure is not the idealized interest rate hypothesized by Hayek and Mises (Garrison 1985, pp. 169–70; 2001, p. 50; Rothbard 1963, pp. 321–23). Thus, Austrian methodological arguments suggest an a priori expectation of unavoidable misspecification and measurement error in any econometric empirical work.

c. Granger Causality Tests

Granger causality tests (Granger 1969) are presented in Table 8, indicating rejection of the null hypotheses that the 96 lagged differences of consumption and the cumulative yield spread can be deleted from the system. Thus both variables are endogenous with respect to one another. This is found both in the context of the VECM and with a generalized, non-VECM-specific test. Granger causality tests depend on the maintained hypothesis that all relevant variables have been included in the VECM (Davidson and MacKinnon 1993, p. 686). Although ABC theory asserts that real consumable output depends on the stability of the money supply and the maintenance of an appropriate, sustainable interest rate, it might reasonably be questioned whether all relevant variables have been included, especially in light of the Austrian school's methodological criticisms of output and interest rate measures. Orthodox neoclassical and Keynesian economists could contribute additional reasons to suspect omitted variables. The Granger causality tests should be viewed as inherently context dependent.

Table 8
Granger Causality Tests

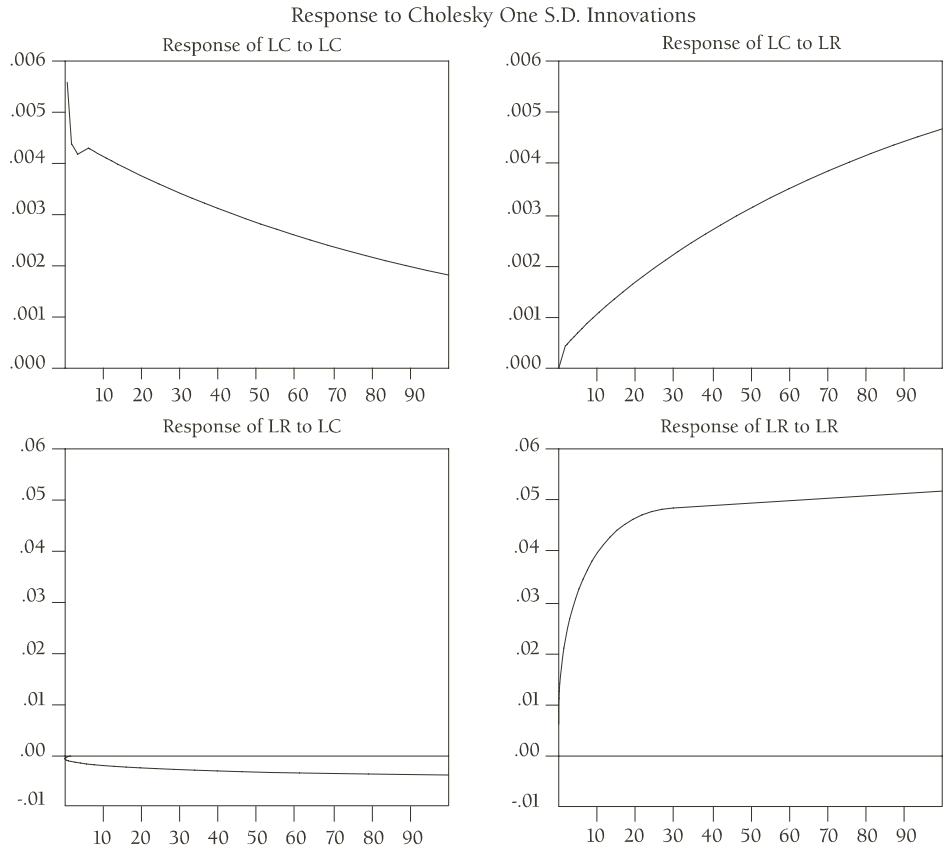
VECM Contest-Dependent Tests			
Variables excluded under H_0	*Chi square*	*d.f.*	*Probability*
Δ(*ln Consumption(-1:-96)*)	172.3585	96	0.0000 ***
Δ(*ln Cumulative term spread (-1:-96)*)	128.0766	96	0.0160 **
General Pairwise Granger Causality Tests			
Null Hypothesis:	*Obs*	*F-stat*	*Probability*
LC does not Granger Cause LR	435	1.73391	0.00039 ***
LR does not Granger Cause LC	435	1.43181	0.01478 **

d.f. indicates degrees of freedom. ** and *** indicate % and 1% significance. Tests indicate neither variable is Granger-causally prior to the other, that is, each variable is endogenous with respect to the other. Granger causality tests are sensitive to changes in model specification, including but not limited to, lag structure, intercepts, and variables included (Davidson and MacKinnon 1993, pp. 629–31).

d. Impulse Response Functions

Graphs of the impulse response functions are presented in Figure 2. The upper-right-hand graph is the one of interest for Austrian business cycle theory. It indicates that over the period studied, a one standard-deviation increase in the term spread has resulted, on average, in an upward adjustment of approximately .004 in the logarithm of consumption, equivalent to 1.004 billion 1996 dollars after eight years or 96 months. A one standard deviation decrease in the yield spread decreased real consumable output by an equivalent amount, on average.

Figure 2
Vector Error Correction Model
Impulse Response Runctions

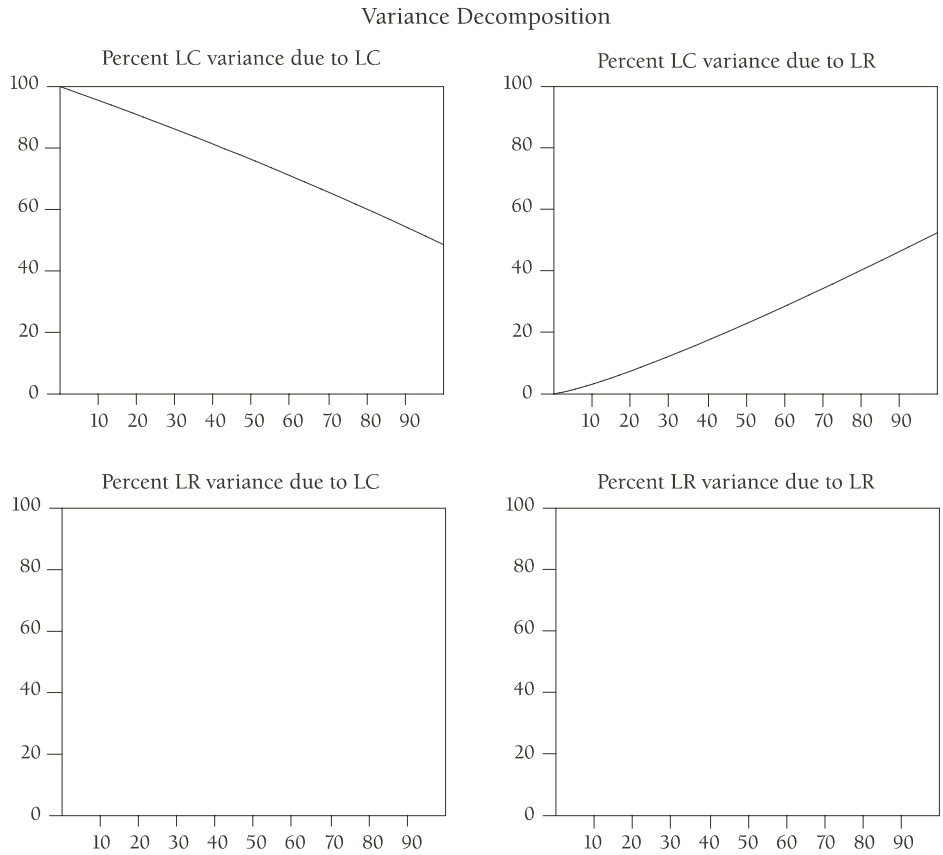


e. Variance Decomposition Functions

Graphs of the variance decomposition functions are presented in Figure 3. Again, the upper-right-hand graph is the one of interest for Austrian business cycle theory. This graph indicates that after eight years or 96 months, nearly 45-50 percent of the variance in real consumption expenditures has been

attributable to variation in the cumulative term spread, over the period studied. Interestingly, no variation seems to be transmitted from consumption to the interest rate. This is not surprising since interest rates are set by policy and output, including consumption, responds to policy initiatives, though not favorably.

Figure 3
Vector Error Correction Model
Variance Decomposition



7. Conclusion

This paper presents evidence of cointegration between real consumable output and the cumulative interest rate term spread. This demonstrates a close relationship between the change in real consumable output and the term spread, as well as the real interest rate it proxies. Austrian business cycle theory is applied to interpret these empirical regularities. A simple vector error-correction model is specified and presented, and demonstrated to have a great deal of explanatory power over 1959–2003 historical data.

Cointegration analysis identifies a stable long-term relationship between consumption and the cumulative term spread. The cointegrating vector constitutes a dynamic equilibrium entrepreneurial planners have generally effected adjustment toward during the 1959–2003 observation period. This equilibrium is not necessarily ever realized. The market process consists of entrepreneurial planners effecting adjustment toward a dynamic equilibrium they continuously redefine. The prevailing term structure of interest rates determines resource allocation among early, middle, or late stages of production, allocating resources and production in accordance with consumers' time preference and available investment alternatives. Estimates of a stable long-run relationship using U.S. data provide convincing support for Austrian business cycle theory as an encompassing explanation of intertemporal resource allocation, production, and employment.

If every month the real interest rate falls 100 basis points below its hypothesized market-clearing rate costs us approximately one trillion dollars worth of real consumable output, it might be assumed that ABC theory prescribes raising the interest rate as high as possible. The reason this interpretation is untenable is that the data include many periods where interest rates were kept inappropriately low, but none where they were inappropriately high. Because policy imperatives impose this asymmetric character on the data, interpretation does not allow the conclusion that monetary policy works symmetrically in both directions.

ABC theory is founded on the concept of a sustainable, market-determined interest rate, and predicts negative consequences when that equilibrium is persistently disturbed. Economists and laypeople are well aware of these consequences: the periodic high unemployment associated with the business cycle. The policy prescriptions of the Austrian School are unmistakable: first, never disturb the interest rate with credit expansion or monetary inflation, and second, after the first policy prescription has been violated, never interfere with entrepreneurial planners' efforts to liquidate suboptimal production plans as rapidly as possible. As long as economists and policy makers believe the business cycle can be avoided through the activism of charismatic central bankers, recessions will be inevitable.

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