Inflation, Expectations and Growth in Real Money in the United States

by D.G. Thomas and Y.P. Yin

University of Hertfordshire Business School Working Paper (2011)

Inflation, Expectations and Growth in Real Money in the United States

Abstract: This paper aims to explain the change in the rate of inflation within the United States economy by following a new Classical–Keynesian synthesis view and by incorporating private inflation expectations directly into the inflation determination process. A parsimonious unrestricted VAR approach is adopted to expose the long-run solution that is subsequently included in an error-correction model with the short-run dynamics. The empirical results reveal the full efficiency in private inflation expectations formation and support for the Classical Quantity Theory mechanism of inflation determination in the long run.

Keywords: Rate of inflation · Expectations · Excess demand · Real money balances · Output

J.E.L. Classification: C01, D84, E31, E41

By: Thomas, D.G. and Yin, Y.P.

E-Mail: d.g.thomas@herts.ac.uk

University of Hertfordshire,
Dept. of Accounting, Finance and Economics,
Business School, de Havilland Campus,
Hatfield, Hertfordshire,
AL10 9AB, U.K.

Introduction

The purpose of this paper is to shed new light on the inflation determination process in the U.S. economy, particularly in view of some recent contrasting evidence on the influence of the rate of inflation on the demand and supply of real money balances (specifically M2, see, Bywaters and Thomas, 2011; and Hoover, Demiralp and Perez, 2009). In an unrestricted VAR modelling of M2 in real terms, real Federal debt, inflation, output as well as various short- and long-term interest rates, Bywaters and Thomas find that inflation had a significant lagging effect on real money demand. In contrast, Hoover et al. (2009) adopt a structural VAR of eleven mostly similar variables but find that inflation had no significant impact on the movement of M2 whilst the latter was a lagging cause for inflation. What has in particular motivated the current work is the finding in Hoover et al. (ibid) that the traditional Quantity Theory mechanism is insignificant for explaining money growth and inflation. Given the significance of inflation in the real world – since World War Two, Western advanced economies have experienced an almost continuous rise in aggregate price along with real money balances, and considering the fact that much of the existing theoretical and empirical work on money growth and inflation is centred around the Quantity Theory, a fresh look at the inflation process is warranted.

This paper departs from a largely data-driven approach (as in Hoover et al. 2009) but bases the empirical model on a new classical–Keynesian synthesis theoretical framework of real money growth, inflation and expectations[1]. The essence of this synthesis is that economic agents respond to real balances and not money values, and therefore, that there is an absence of systematic money illusion[2]. What is more, private agents' expectations of future inflation rates are also an important driver of the current inflation rate. A novelty of this paper is that the private agents' inflation expectations are captured by the Livingston expectations series and directly incorporated into the empirical model. In the U.S., private inflation expectations can be captured by the Livingston expectations series, which is a survey of approximately fifty economists, asking for their forecasts of the Consumer Price Index (CPI) over the next six and twelve months[3]. Furthermore, prices respond to demand and supply shocks asymmetrically – prices in general exhibit downward stickiness, which is slow adjustment compared to a rise.

The nub of the matter is that inflation in general can arise from the pressure of excess demand driven by expectations or negative supply-side shocks that generate stagflation pressure. Since the global financial crisis of 2007, inflation world-wide has started to gather momentum, fuelled, once again, by excess demand and expectations in the midst of government activity internationally *via* fiscal and monetary policies to stabilize the banking sector and boost the world economy out of the 'great recession'. This has led to a global environment of rising public debt, leading to money growth in face of falling output and the prospect of rising inflation.

Insofar as the time frame of analysis for this study is concerned (that is 1974 – 2010), the rate of inflation taking place in industrial nations such as the United States has been persistently

[1] For a general overview of Classical economics see Hoover (1988) as well as Sheffrin (1996). For Many key articles see Lucas and Sargent (1981) along with Lucas (1981).
[2] Money illusion refers to the tendency of agents to think of money in nominal terms (the face value), rather than in terms of real purchasing power.
[3] For an analysis of the Livingston survey based on the CPI, see John Carlson (1977).

positive but with significant variations of magnitude before the 1990s. The U.S. economy has experienced various adverse supply-side shocks during this time period (such as oil price hikes and international terrorism), although the underlying trend in gross domestic product has also been persistently upward. Therefore, the basic premise of this paper is that the rate of inflation is a result of the divergent paths of growth in aggregate demand and supply in the long-run. In other words, the long-run trend of aggregate price movements is associated with aggregate demand changes over and above the long-run growth rate in supply.

Apart from the conventional imbalance between aggregate demand and supply, actual inflation is also driven by economic actors' expectations of inflation in the future and their current action to guard against future inflationary effects. Thus, future inflation will be factorized into higher current prices, which in turn feeds into the expectations of future prices, giving rise to the actual-future inflationary spiral. The swiftness in the formation of such a spiral depends on the efficiency of information processing and decision-making by private agents. In the U.S., private inflation expectations can be captured by the Livingston expectations series, which is a survey of approximately fifty economists, asking for their forecasts of the Consumer Price Index (CPI) over the next six and twelve months[4]. The efficiency private inflation expectations can be empirically revealed by examining the relationship between the actual inflation rates and the Livingston expectations. If the actual inflation is unitary elastic with respect to the Livingston observations, then private inflation expectations can be argued to be fully efficient or rational with the 'hidden experts' embodied in the series. In that case, the data set seems to proxy the markets' expectations on the grounds that the observations 'pass' the test for rationality by achieving a one-to-one relationship with actual inflation rate in the long-run. Therefore, money illusion is absent in the long-run and there can only be 'surprise' changes in the growth of real money balances

[4] For an analysis of the Livingston survey based on the CPI, see John Carlson (1977).

that will affect employment and output in the short run. Conversely, a less than unitary elasticity indicates perhaps adaptive behaviour in expectations formation and stickiness in prices, allowing the potential non-neutrality result of monetary or fiscal policy to arise.

The theoretical analysis provides guidance on the qualitative relationship between inflation and potential determinants, although the quantitative strength and especially the rich dynamics of the relationship is an empirical matter. The current empirical work will adopt the VAR methodology to decompose the actual path of inflation into two parts: a long-run path and the short-term deviations from this. The former is consistent with inflationary expectations and the self-reinforcing mechanism of inflation. The latter part reflects temporary shocks that generate economic disequilibrium that arises from excess demand. The next part of the paper extends the proposed theoretical model.

The Theoretical Model

Assuming that all the variables are in log-form, the starting point in this theoretical analysis is that inflation arises from excess demand:

[1]

where is the rate of inflation with and representing the log levels of aggregate demand and supply. Since in the majority of cases the growth in supply is limited and stable in the long run, any rapid changes in the rate of inflation can only be attributed to adjustments in the level of aggregate demand or heightened inflation expectations. Aggregate supply depends on economic growth of output and disturbances that arise from fluctuations in natural endowments on account of disasters, war, political upheaval or labour unrest as well as significant changes in the price of energy, technical progress and government regulations. Essentially, the aggregate supply curve in the long run is vertical. There have certainly been historical periods when negative supply shocks outweighed demand surprises, but the end results are excess demands, driving the rate of inflation upwards.

Equation [1] suggests that even if supply grows and thus exerts a downward pressure on prices, inflation can still occur if the growth in demand generates a greater upward pressure on prices. In situations of growth in supply, prices and real wages will fall by a slower rate on account of downward inflexibility in comparison to the rise in prices as a result of a growth in demand. In other words, prices will rise faster than they will fall, because of the widespread existence of oligopoly and monopolistic conditions that prevail in most markets.

Aggregate demand is modelled in the usual Keynesian fashion – it is determined by the level of autonomous expenditure as well as the real interest rate:

[2]

where represents autonomous expenditure, is the multiplier and equals the real rate of interest in the form of the Fisher effect. It is assumed that investment expenditure is determined by the 'real' and not the nominal interest rate, , in the form of with measuring the responsiveness. The real rate of interest, therefore, is equal to the nominal interest, minus the expected rate of inflation, which allows [2] to be re-written as

[3]

In this format, the product market equilibrium depends on both the nominal interest rate and the expected inflation rate. Given the nominal rate of interest, an upward movement in the expected rate of inflation increases aggregate demand income, because this induces a fall in the real rate of interest, and therefore, raises the rate of capital expenditure.

The analysis has reached the stage where the asset market is included by stating that the supply of real money balances equals the demand in the form of where the nominal rate of interest, , determines the opportunity cost of holding money. The parameters and reveal the sensitivity of the demand for real balances to the level of income and the interest rate. Re-arranging the equation in terms of the nominal rate, then

$$- \quad [4]$$

Substituting [4] into [3] gives

$$-$$

or, $$- \quad [5]$$

where ———

This is the aggregate demand function showing that the 'level' is determined by autonomous components, real money balances and the expected rate of inflation. Any increase in the three elements will raise the level of aggregate demand. It follows that the rate of 'change' in aggregate demand, is determined by

[6.a]

or

Now substituting [6.b] into [1] gives

[7]

Also, it can be shown using differentiation on the quantity theory of money in log form, , that it is possible to derive assuming that V is a constant, so that [7] can be re-written as a restricted form of[5]

or [8]

using equilibrium in the goods and services market to ignore the supply and demand superscripts on real output.

Equation [8] is the theoretical expression that outlines the long-run determinants of the rate of inflation: a constant term, the change in expectations along with the deviations from the growth of real money balances and output, representing the changes in aggregate demand and supply. The next stage of the paper is the empirical calculation of [8] using the VAR system of estimation, which is combined with the short-run dynamics in an error-correction model, explaining the change in the rate of inflation.

The Empirical Analysis

The first step was to choose appropriate data variables that relate to equation [8]. The rate of inflation was calculated from the Consumer Price Index (CPI) in the form of and is represented by the changes in the Livingston's expectations of the rate of inflation over the next six months, based on the CPI, interpolated from monthly observations and divided by two to give quarterly figures. is measured by the log differences in the money measurement of M2 and the CPI, and finally, the growth in output (or income) is estimated by where is real gross domestic product (GDP).

[5] This is statistically tested later in the empirical section of the paper.

This list of variables can be expressed in the general matrix form of

[9]

where are the explanatory variables with denoting the maximum lag, is the intercept term, which can be included separately if required, or restricted to lie within of [9]. represents a vector of non-stochastic variables such as structural break dummies with to 3 and is a column vector of random errors, which may be contemporaneously connected with one another but are assumed not to be serially correlated over time. The dummy variables used in the study are: 1980:Q3 put to -1, 2004:Q4 set to -1, 2005:Q3 consigned to +1 and 2008:Q4 set to -1; otherwise all other values are zeros. All raw observations are seasonally adjusted and obtained from *Fred Databank* at the Federal bank of St. Louis, except for the Livingston expectations, which came from the Philadelphia Reserve Bank.

The empirical analysis now proceeds to determine the number of co-integrating vectors existing between the variables of interest within representing the long-run equilibria. The number of different co-integrating vectors can be found by examining the significance of the characteristic roots, which is the rank of a matrix (Johansen, 1988; Stock and Watson, 1988). The tests for the total number of roots that are significantly different from one use the maximum and trace statistics, which are reported in Tables 1 and 2 overleaf.

Table [1]: Co-integration with intercepts and no trends in the VAR[6]
Co-integration LR Test Based on Maximal Eigen-value of the Stochastic Matrix

****

146 observations from 1974Q1 to 2010Q2. Order of VAR=8
List of variables included in the co-integrating vector:

List of unrestricted deterministic variables:

List of eigen-values in descending order:
0.22003   0.032816   0.012083

****

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
		36.2812	22.0400	19.8600
		4.8715	15.8700	13.8100
		1.7749	9.1600	7.5300

****

Table [2]: Co-integration with intercepts and no trends in the VAR
Co-integration LR Test Based on Trace of the Stochastic Matrix

****

146 observations from 1974Q1 to 2010Q2. Order of VAR=8
List of variables included in the co-integrating vector:

List of unrestricted deterministic variables:

List of eigen-values in descending order:
0.22003   0.032816   0.012083

****

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
		42.9276	34.8700	31.9300
		6.6465	20.1800	17.8800
		1.7749	9.1600	7.5300

****

The two statistics in Tables [1] and [2] seem to be in agreement on one co-integrating vector amongst the explanatory variables with the inclusion of a constant term, proxy for the autonomous components embodied in the proposed theoretical model.

[6] The optimum lag length based on the information criterions suggested Var (1) or 2, but this led to under fitting with serial correlation and mis-specification problems that could not be removed, apart from extending the lag length to eight. The appropriate lag length plays a crucial role in the accuracy of the empirical model as the results of the Var are sensitive to the selection of the lag length, especially the specification of the co-integrating vector.

Table [3]: ML estimates subject to over identifying Restrictions
Estimates of Restricted Co-integrating Relations (Standard errors shown in brackets)
****

146 observations from 1974Q1 to 2010Q2. Order of VAR=8

List of variables included in the co-integrating vector:

List of unrestricted deterministic variables:

****

E

a1

a2

a3

a4

Total number of restrictions (2) – number of just-identifying restrictions (1)

LR Test of Restrictions CHSQ (1) = 0.024411 [0.876]

****

The resulting single vector is outlined in Table 3 above. The restrictions imposed were tested using the t-statistics and the log-likelihood statistic, which is distributed chi-square, at each stage. This includes the test for the restrictions on using real money and output separately. This is empirical evidence for the constancy of the velocity of money.

Actual inflation is unit elastic with respect to inflation expectations in Table [3], which means that the expected change in prices translates into the same proportion as current prices. Rational expectations seem to prevail in the empirical model, which employs the 'concealed specialists' embodied in the Livingston data. They seem to proxy the market's expectations on the grounds that the observations 'pass' the test of rationality by achieving a one-to-one relationship with the actual rate of inflation in the long run. One further point worth noting is that although many other potentially relevant variables such as the interest rates and stock market returns are absent in the model, the informational content of such variables may have already been captured by private agents in their expectations *via* the information set. Thus, on grounds of the law of parsimony the inclusion of the Livingston expectations term in lieu of the other variables is sufficient for the current purpose.

In order to examine the Classical Quantity Theory mechanism, it is useful to rewrite the long-run solution by replacing the expectations term with the actual long-run inflation rate. Note that the Livingston inflation expectations term is calculated as:

))/2, where $LECPI_{t+1}$ is the expected CPI index in six months' time in the Livingston series. Thus, assuming stable quarterly inflation rate in the long-run, the expected inflation in six months' time must be twice the expected quarterly inflation rate, that is,

. Therefore, in the long-run,

. As a result, the long-run solution can be simplified as . This turns out to be simply the Classical Quantity equation with a drift! Therefore, in essence, the long-run solution is showing that expected inflation no longer depends on past inflation, but on expected monetary instruments embodied in the growth rate of money balances. Given the combination of rational expectations hypothesis and the assumption of upward price flexibility of market clearing, then an increase in aggregate demand over the supply growth does not produce systematic real effects in the long-run, but increases in actual inflation.

Moreover, private agents eventually foresee the actions of the authorities and absorb this information in their expectations of the future. If, for instance, the Federal Reserve seeks to increase the growth of real money balances *via* the money supply to induce a fall in interest rates in the hope of uplifting the growth of output, then agents will comprehend this and correctly forecast that the rate of increase in prices will be raised. Labour then pushes for more nominal wages in line with the forecasted rate of inflation to maintain real wages; employment and output growth all remain unchanged. Thus, agents fully anticipate changes in real money balances that arise from monetary policy, and therefore, completely neutralise any policy effect on the growth of output.

The avenue open to the authorities to influence growth is by surprising agents with demand policies. An unanticipated increase in the money supply growth within real monetary balances reduces interest rates causing workers and businesses to perceive that the increase in the general price level as a rise in relative prices. They react by increasing the supply of labour and output, so that the economy moves to a new short-run aggregate supply curve as a temporary solution. Once agents realize there is no change in relative prices, output growth returns to the previous level at higher expected prices.

The more often the authorities try to engineer upward movements in output growth through monetary shocks of real monetary balances, the less likely it is that workers and firms are fooled, and the Phillips curve becomes more vertical[7]. Essentially, agents' forecast of expected inflation incorporates the Federal authorities into the model, which ensures the invariance of policy. Briefly, agents believe that expansionary monetary policy within real money balances has no real effects, but only causes an increase in the rate of inflation, and they respond immediately by raising expectations over the next six months.

The empirical study has reached the stage where the long-run vector, is put together with the short-run dynamics to enlist the all-embracing equation: the error correction model, which is shown as expression [10]:

[7] For a simple overview of the literature on the Phillips curve see Chapter 6 in Bain and Howells (2009).

+ 0.012082 + 0.025397 + [10]

Table [5]: the Diagnostic Statistics for Expression [10]

Test Statistics	**LM Version**
A: Auto-correlation	$\chi^2(4) = 5.2114$ [0.266]
B: Functional Form	$\chi^2(1) = 2.4262$ [0.119]
C: Normality	$\chi^2(2) = 0.019006$ [0.971]
D: Heteroskedasticity	$\chi^2(1) = 1.8744$ [0.171]

This is the restricted version derived by 'Hendryfication' of the general form, which entails the process of removing insignificant variables *via* t-statistics to expose the significant short-run dynamics that go alongside the long-run solution, at [8]. In fact, the co-integrating vector is highly significant within the empirical model of [10] with a negative adjustment coefficient of -0.56634, which means that any disequilibrium should start to return back to the path of equilibrium within two quarters with the aid of the short-run dynamics, although dominated by the accelerated change in positive expectations.

Conclusions/Summary

This paper determines the inflation process in the U.S. economy over the period 1974-2010. The theoretical model that led to the empirical estimation has been informed by the new Classical–Keynesian synthesis view of money growth and inflation. The empirical approach is based on a parsimonious specification of the VAR system of actual inflation, expectations

[8] This is general-to-specific methodology associated with Professor D.F. Hendry. For an account of this approach, see Hendry (1983).

that are represented by the Livingston series, and a term denoting excessive real money growth. The empirical findings reveal that private inflation expectations in the U.S. are fully efficient. Furthermore, any unanticipated changes in the growth of real money do affect output and employment in the short run before returning back to their long-run steady-state values with expectations of higher inflation, which is translated into actual rate on a one-to-one basis. Therefore, the inflationary process in the U.S. economy in the period 1974-2010 is fundamentally underpinned in the long-run by the Classical Quantity Theory of Money.

References:

Bain, K. and Howells, P. (2009) *Monetary Economics: Policy and its Theoretical Basis*, Palgrave Macmillan, New York.

Bywaters, D.S. and Thomas, D.G. (2011) Real money demand and supply meets Federal debt, *Applied Economics Letters*, February, pp 1-5.

Carlson, J.A. (1977) A Study of Price Forecasts, *Annals of Economic and Social Measurement*, Winter, pp 27-56.

Hendry, D.F. (1983) Econometric modelling: the consumption function in retrospect, *Scottish Journal of Political Economy*, 30, pp 193-220.

Hoover, K.D. (1988) *The New Classical Macroeconomics: A Sceptical Inquiry*, Blackwell, Oxford.

Hoover, K.D., Demiralp, S. and Perez, S. J. (2009) Empirical Identification of the Vector Autoregression: The Causes and Effects of U.S. M2, in Castle, J. and Shephard, N. (eds.) *The Methodology and Practice of Econometrics: A Festschrift in Honour of David F. Hendry*. Oxford University Press: Oxford.

Johansen, J. (1988) Statistical Analysis of Co-integration Vectors, *Journal of Economics Dynamics and Control*, 12, pp 231-54.

Lucas, R.E., Jr. (1981) *Studies in Business Cycle Theory*, Blackwell, Oxford.

Lucas, R.E., Jr. and Sargent, T. J. (eds.) (1981) *Rational Expectations and Econometric Practice*, Allen and Unwin, London.

Sheffrin, S.M. (1996) *Rational Expectations*, 2nd Edition, Cambridge University Press, Cambridge.

Stock, J. and Watson, M. (1988) Testing for Common Trends, *Journal of the American Statistical Association*, 83, pp 1097-107.