A Rejoinder on the New Keynesian Phillips Curve in the United States

Dr. Gareth Thomas and Dr. Ya Ping Yin

University of Hertfordshire Business School Working Paper (2012)

A Rejoinder on the New Keynesian Phillips Curve in the United States

Abstract:

This paper examines the nexus between money, output and inflation in the United States during the period from 1974 to 2010. The theoretical framework is underpinned by a new Classical–Keynesian synthesis view of inflation, expectations and money growth with the incorporation of a number of neglected areas of contention. The empirical model is based on the error-correction representation of a VAR modelling system and estimated using quarterly time series data. The estimation results reveal full efficiency in private inflationary expectations formation as contained in the Livingston expectations series, although they support the proposition of non-neutrality of money in the long run. The policy implication is that the conduct of monetary policy should attempt to manage not only inflationary expectations but also incorporate the output outlook of private agents.

Keywords: Rate of inflation, Expectations, Excess demand, Real money balances

J.E.L. Classification: D84, E31, E52

By: Dr. Gareth Thomas and Dr. Ya Ping Yin

E-Mail: d.g.thomas@herts.ac.uk; y.p.yin@herts.ac.uk

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

Introduction[1]

The purpose of this paper is to shed new light on the relationship between money, output, and inflation in the U.S. economy in view of the long-standing controversies in both the theoretical and empirical literature. The adoption of successive rounds of 'quantitative easing' of the money supply by governments across the world in the current economic climate adds further legitimacy to a fresh examination of the issue. Insofar as the theoretical literature is concerned, that controversy is rooted in the traditional debate between the classical, and the monetarists' reworked, Quantity Theory of Money (QTM) on the one hand and the Keynesian analysis on the other. In more recent developments, that debate has been recast as the contest between the new Keynesian and the new classical versions of the expectations-augmented Phillips Curve. The essence of the debates hinges on the long-run neutrality of money and hence the inflationary consequence of expansionary monetary policy. The central contributions of the present examination are three-fold: first, it restores the money market adjustment mechanisms (and thus the LM curve) that are usually left out in the recent theoretical frameworks; second, it adds a hitherto neglected dimension in the nexus between money, output, and inflation – the rôle of output expectations; finally, the empirical VAR modelling of the nexus motivates and adopts the broadest measure of money supply in the U.S economy, *viz*. MZM.

The remainder of the paper is structured as follows. The next section provides a summary review of the recent new classical-new Keynesian debate that will help to set the scene for the current examination. This will lead to the development of the theoretical model that restores/captures some neglected aspects in the recent literature. The theoretical model is then implemented in an empirical VAR modelling system. The final section concludes.

[1] The authors would like to thank David Bywaters, Dr.Tassos Patokos and Joe Riordan for their helpful comments.

Literature Survey and Methodological Issues

Recent developments in the debate on the relationship between money, output, and inflation are centered around the new classical version of the vertical Phillips Curve and the new Keynesian version of the conventionally-sloped Phillips Curve – the former is derived from the surprise-supply functions by Lucas (1973) and Sargent and Wallace (1975) whilst the latter builds on the micro-foundations of sticky prices[2]. Furthermore, the New Keynesian Phillips Curve (NKPC) explanation is seeking to become the new all encompassing theory of inflation and the business cycle in contemporary macroeconomics (Bårdsen et al., 2005). The origins of this theory are outlined by Mankiw and Romer (1991), where the focus is mainly on developing micro-fundamentals of the macro economy. Further developments of the theoretical base are laid out in Blanchard and Galí (2007), Clarida et al. (1999, 2000), Svensson (2000) and Woodford (2003). The central concern of the New Keynesian School explanation of persistent inflation is how price stickiness arises in the presence of forward-looking rational expectations (Mankiw, 1990). This line of enquiry began with the research of Taylor (1980) concerning the micro-foundations of sticky prices, building on the rational expectations approach to workers' labour supply decision that was originally developed by Lucas (1976). It rests on the assumption that firms use their market power arising from the existence of imperfect competition to maintain and accelerate their prices above marginal cost (Blanchard and Kiyotaki, 1987).

The recent developments are not explicitly presented as models of inflation determination, although the implied price adjustment mechanisms can be regarded as leading to a number of distinct channels for inflation to persist: (i) the traditional channel of anticipated or unanticipated growth in monetary aggregates (which can be regarded as the inverted process

[2] For a recent review of the theoretical developments along the Phillips Curve line of reasoning of the inflationary process, see Fuhrer et al. (2009). For an introductory discussion of the main themes in the field see Fender (2012).

of the Lucas-Sargent-Wallace surprise-supply functions); (ii) sticky prices, particularly in the downward direction, arising from the existence of quadratic menu costs for firms to change prices in imperfectly competitive markets (for example, Rotemberg, 1982, 1983); (iii) sticky wages arising from staggered wage contracts with multi-period rigidities (Taylor, 1980). The various theoretical strands of development can be generally captured by the following equation:

$$\pi_t = \alpha E_t \pi_{t+1} + \beta \pi_{t-1} + \gamma z_t + \varepsilon_t, \qquad [1]$$

where π is inflation; E_t indicates expectations at time t; ε is a residual term which may be serially correlated (for example, a moving-average process as in Taylor's model). What really differentiates empirical studies is how z is defined and measured. It is variously defined to be a measure of the contemporaneous market disequilibrium or sluggish adjustments that additionally affect current inflation through mechanisms of temporary money illusion or imperfect information. Typical measures of z include deviation of actual unemployment rate from the natural rate (as in the Friedman (1968) and Phelps (1968) type models), or the variation of the firm's actual price from its optimal price (as in Rotemberg's model), or a measure of the output gap; or expected real marginal cost (as in Galí and Gertler, 1999; Sbordone, 2002).

If current monetary policy stance is fully incorporated into the current information set and thus economic agents' rational expectations of future inflation, the mechanism should be captured by the first term on the right-hand side of the equation and α is expected to take the value of unity. If expectations formation is adaptive or the price adjustment mechanism is sticky, β should be statistically significant and positive. If the conventional Phillips Curve mechanisms (such as irrationality or union militancy) are significant, the effects on inflation will be captured by γ. For the conventional QTM and thus neutrality of money to hold, it should be expected that $\alpha = 1$ whilst β and γ are statistically insignificant. The NKPC emphasizes the significance of the term z that corresponds to the real marginal cost or output gap in determining current inflation, leading to a traditionally sloped Phillips Curve. The existence of real rigidities leads to strategic complementarities in price-setting such that the pass-through of marginal costs into current inflation remains limited even though firms update their prices frequently. Furthermore, through repeated substitution the right hand side of equation [1] can be expressed as a sequence of expected future output gaps. The important policy implication of the NKPC is that low inflation can be achieved immediately by the central bank announcing (and the public believing) that it is committing itself to eliminating positive output gaps in the future.

The statistical evidence seems to be accumulating rapidly on the basis of the models proposed, for example, by such authors as Batini et al.(2000), Christiano et al. (2005), Galí et al. (1999, 2001, 2003 and 2005), Smets and Wonters (2003), Roberts (1995), Rudd and Whelan (2005, 2006), Sbordone (2002, 2005, 2007) and Woodford (2006). These studies suggest that there is considerable empirical evidence for supporting NKPC. Bården et al. (2005), however, re-examined the data employed in two of these studies (Galí et al., 2001 and Batini et al., 2000) and found that the empirical results were rather weak. Furthermore, a publication by Nason and Smith (2008) also found little statistical evidence for the NKPC and a further study by Kuester et al. (2009) suggests that the earlier studies of the NKPC would significantly over-estimate the flatness of the Phillips Curve if cost-push shocks are auto-correlated.

Recent studies for the U.S. economy (for example, Bywaters and Thomas, 2011 along with Hoover, Demiralp and Perez, 2009) also generate contrasting empirical evidence for the significance of various mechanisms. In a VAR model of M2 in real terms, real Federal debt, inflation and output as well as various short- and long-term interest rates, Bywaters and Thomas (2011) 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, although was a lagging cause for inflation with a very limited rôle. Thus, concerning the relationship between the growth of monetary aggregates on the one hand and movements in income and prices on the other, the 'jury' seems to be still out on empirical evidence!

The conflicting empirical results might be a symptom of the omission of a key variable from the new classical and new Keynesian Phillips Curve framework of analysis: real money balances. The implication is the exclusion of the LM curve, or the money market, leaving only the 'IS curve' in the specification of the aggregate demand side of the economy. In fact, many researchers in this field proceed without introducing money into the study. For example, Kerr and King (1996) discuss how one can manipulate an IS curve to study the limits on interest rate rules. Clarida et al. (1999) carry out their analysis of monetary policy without specifying a function of demand and supply of money. The crux of the argument is that the absence of the money market from the specification of the aggregate demand side leads to the omission of any potential financial portfolio adjustment and wealth effect on inflation and income in the monetary transmission mechanism. In the presence of monetary shocks, private agents adjust their decisions not only through inflationary expectations but also through their anticipated prospects of the real economy following any anticipated changes in financial portfolios that affect real wealth.

Particularly over the past two decades as decisions by households and firms become increasingly financialized, monetary disturbances could trigger off substantial adjustments to the structure of assets and liabilities of households, firms and governments, which in turn, have significant ramifications for their real behaviour. A recent work by Haslam et al. (2012) has documented a substantial body of evidence to show the financialization decisions of firms and the implied intrinsic link between expected changes in wealth and behavioural adaptation. This expected 'wealth effect', alongside other Keynesian real adjustment mechanisms, can be reflected in private agents' output expectations beside inflationary expectations. In the real world, surveys of private agents' expectations do cover both inflation and output ones. A case in point is the Livingston expectations series in the U.S.

Cochrane (2007) has expressed a similar concern regarding this mainstream approach in that monetary policy is conducted by means of a central bank policy rule for adjusting the short-run nominal interest rates in the absence of any key function for money in the transmission mechanism (McCallum, 2009). This omission of the real money function is based on premise that since 1973, real balances with rates of interest have become an unstable relationship on account of rapid financial innovations, which have changed the objects that can be used as mediums of exchange. In other words, the function of real money may not be closely knitted to aggregate expenditure.

The source of instability, however, in the real money demand function may well exist partly on account of mis-specification of econometric models because of missing variables such as the rate of inflation, which has emerged as an important influence on the holding of money after 1973 with the oil 'hikes' igniting the process of inflationary and output expectations. If either of these variables, for example, is absent, then empirical models will be mis-specified and appear unstable. In fact, the econometric study by Bywaters and Thomas (2011) shows that there is a statistically significant link between the rate of inflation and real money balance with income along with a array of interest rates as determining factors of real balances, which is a stable relationship over the period of 1960 to 2007 in the U.S. economy.

Therefore, in conceptualizing the relationship between money, income, and inflation the present study brings back real money growth and output growth along with the change of inflationary and output expectations. The present approach departs from a largely data-driven approach (as in Hoover et al. 2009) but bases the empirical estimation on a new Classical–Keynesian synthesis framework of real money balances and output growth as well as inflation and output expectations. The essence of this synthesis is that economic agents respond to real balances and not nominal values, and therefore, there is an absence of systematic money illusion[3]. What is more, apart from the conventional imbalance between the growth of aggregate demand and supply, actual inflation is also driven by economic actors' expectations of inflation and output. Thus, the expected inflation will be factorized into higher current prices, which in turn feeds into the expectations of prices and output, giving rise to the actual-future inflationary spiral. The swiftness in the formation of such an escalation depends on the efficiency of information processing and decision-making by private agents. Furthermore, prices respond to demand and supply shocks asymmetrically – prices in general exhibit downward stickiness. A final important constituent of this framework is the inclusion of output expectations, which are used to capture the 'wealth effects' in the monetary transmission mechanism as well as other Keynesian structures (see more detailed discussion later).

In the empirical implementation this study found difficulties with estimating the hypothetical concept of potential output and thus the output gap. A number of procedures were attempted through mechanic linear trends or relatively 'inert' production functions, but all the alternatives were ill-suited to capture demand and supply shocks that ensure inflationary pressure[4]. Therefore, instead of attempting to measure this non-observable variable directly,

[3] 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).
[4] For an overview of the possible methods see Kuttner (1994) along with M^{c}Morrow and Roeger (2001).

this study takes a structural approach by treating inflation as essentially arising from the excess of aggregate demand over aggregate supply, with forward-looking **price** and **output** expectations being incorporated into the structural equations of the traditional IS-LM model to determine aggregate demand. this approach eschews an explicit (and rigorous) treatment of sticky prices or surprise supply decisions (which could give rise to the output gaps) from a supply-side perspective, although the potential mechanisms leading to inflation are nonetheless approximately captured by the excess supply term and the incorporation of price and output expectations terms into the IS-LM model.

In this paper private agents' inflationary and output expectations are captured by the Livingston expectations series and directly incorporated into the empirical model. In the U.S., the Livingston expectations series are based on surveys of approximately fifty economists, asking for their forecasts of such variables as the Consumer Price Index (CPI)[5] and the Gross Domestic Product (GDP). The efficiency of inflation expectations can be empirically revealed by examining the relationship between the actual rates and the Livingston inflationary 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[6]. It is worth pointing out, however, that even though private agents' inflationary expectations may be fully rational, there is no guarantee that money is necessarily neutral in this framework. This theme is not fully explored in this paper, although non-neutrality may occur from a number of sources including the 'wealth' effect discussed previously, the sluggish price adjustments as in the

[5] For an analysis of the Livingston survey based on the CPI, see John Carlson (1977).
[6]These 'hidden experts' are more than likely to include simple statistical as well as econometric models that forms a forecasting scheme to generate predictions, which is subject to a non-stationary process of learning and discovery. This means that the expectational observations are non-stationary in nature even though the Survey asks for 'change'.

NKPC, as well as the responses of autonomous shifts that arise from potential changes in aggregate demand.

This 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 a practical matter of estimation. The current empirical work adopts 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 expectations and the self-reinforcing mechanism of inflation, and is captured by the long-run co-integrating relationship. The latter part reflects temporary shocks that generate economic disequilibrium arising from excess demand, and is revealed in the short-term dynamics equation. The next part formally introduces the 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 aggregate demand:

$$\dot{P} = \lambda(Y_t^D - Y_t^S), \qquad [2]$$

where $\dot{P}$ is the rate of inflation with Y_t^D and Y_t^S representing the log levels of aggregate demand and supply. Since in the majority of cases the growth in supply is within narrow limits and stable in the long run, any rapid changes in the rate of inflation can typically be attributed to adjustments in the level of aggregate demand, leading to a change in future output or heightened inflationary expectations.

Equation [2] 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 will fall by a slower rate on account of downward price rigidity in comparison to the rise in prices as a result of a growth in demand, there an asymmetrical process of adjustment. In other words, prices will rise faster than they will fall, because of the widespread existence of oligopoly and monopolistic conditions or menu costs 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:

$$Y^D = \bar{\alpha}(\bar{A} - br), \quad [3]$$

where $\bar{A}$ represents autonomous expenditure, $\bar{\alpha}$ is the multiplier and r 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, i, in the form of $r = log((1 + i)/(1 + \pi^e)) \approx i - \pi^e$. The real rate of interest, therefore, is equal to the nominal interest, i minus the expected rate of inflation, π^e, which allows [3] to be rewritten as

$$Y^D = \bar{\alpha}(\bar{A} - bi + b\pi^e). \quad [4]$$

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, Y^D, because this induces a fall in the real rate of interest, and therefore, raises the rate of capital expenditure.

As stated earlier, a crucial part of the current framework is the re-introduction of the money market through the money market equilibrium condition $M - P = \kappa Y^D - hi$, where the nominal rate of interest, i, determines the opportunity cost of holding money. Re-arranging the equation in terms of the nominal rate, then

$$i = \frac{1}{h}\left(\kappa Y^D - (M - P)\right). \quad [5]$$

Substituting [5] into [4] gives

$$Y^D = \bar{\alpha}(\bar{A} - \frac{b}{h}(\kappa Y^D - (M - P) + b\pi^e),$$

or, $$Y^D = \gamma\left(\bar{A} + \frac{b}{h}(M - P) + b\pi^e\right), \quad [6]$$

where $\gamma = \frac{\bar{\alpha}}{1+(\bar{\alpha}b\kappa/h)}$.

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, $\dot{Y^D}$, is determined by

$$\dot{Y^D} = \sigma\left(\dot{\bar{A}}\right) + \varphi\left(\dot{M} - \dot{P}\right) + \eta(\dot{\pi}^e), \quad [7]$$

or $$Y_t^D \approx Y_{t-1}^D + \sigma\left(\dot{\bar{A}}\right) + \varphi\left(\dot{M} - \dot{P}\right) + (\dot{\pi}^e). \quad [8]$$

Now substituting [8] into [2] gives

$$\dot{P} = \lambda\left(\sigma\left(\dot{\bar{A}}\right) + \varphi\left(\dot{M} - \dot{P}\right) + \eta(\dot{\pi}^e) - (Y_t^S - Y_{t-1}^D)\right),$$

or $$\dot{P} = \lambda\sigma\left(\dot{\bar{A}}\right) + \lambda\eta(\dot{\pi}^e) + \lambda\varphi\left(\dot{M} - \dot{P}\right) - \lambda\dot{Y}, \quad [9]$$

using equilibrium in the goods market, then the supply and demand superscripts on real output are equal.

Moreover, the new dynamic IS curve proposed by the new Keynesian School incorporates expectations of future output as a major determinant of aggregate demand. This mechanism runs through autonomous shifts in the aggregate demand curve as a result of changes in household expenditure, gross capital formation, net exports and fiscal policy that stem from anticipated changes in current and future monetary policy affecting real interest rates and wealth. Therefore, $\dot{A}$ in expression [9] should be replaced with a variable that estimates the change in expectations of future output, $\dot{Y}^e$, leading to inflation in the form of

$$\dot{P} = \lambda\sigma(\dot{Y}^e) + \lambda\eta(\dot{\pi}^e) + \lambda\varphi(\dot{M} - \dot{P}) - \lambda\dot{Y}. \qquad [10]$$

Equation [10] is the theoretical expression that outlines the long-run determinants of the rate of inflation: a 'drift' term in terms of the change in expectations of future output, the adjustment in price expectations along with the growth of real money balances and current output, representing the changes in aggregate demand and supply. This is equivalent to expression [1] in the absence of π_{t-1}, but with the added ingredient of a 'drift' term in the form of expected changes in future output. The next stage of the paper is the empirical estimation of [10] using the Granger error-correction representation of the vector auto-regression (VAR) modeling system.

Empirical Analysis

The first step was to choose appropriate data variables that relate to equation [10]. The rate of inflation was calculated from the Consumer Price Index (CPI) in the form of $\dot{P} = \ln CPI_t - \ln CPI_{t-1}$, and $\dot{Y}^e$ is denoted by the changes in the Livingston's expectations of the real Gross Domestic product (GDP) over the next six months, interpolated from monthly observations and divided by two to give quarterly statistics. $\dot{\pi}^e$ is represented by the adjustments in the Livingston's expectations of the CPI over the next six months, also interpolated from monthly observations and divided by two to derive quarterly figures. With regard to the money supply, this study departs from the previous ones in that instead of using

$M2$, the broadest measure of money, MZM, is used and the real money balance is calculated as $R\dot{M}Z = (M\dot{Z}M - \dot{P})$. Both $M2$ and MZM contain many common components and the only difference between the two measures is that whilst $M2$ also contains time deposits of less than $100,000 and money-market deposit accounts for individuals, these items are replaced by 'all' money market funds in MZM. The reason for using MZM instead of $M2$ is on account of the significant rise in the reliance on short-term money-market funds for long-term lending by financial institutions over the past two decades, MZM rather than $M2$ can better reflect theses market liquidity conditions. Finally, the growth in output (or income), $\dot{Y}$, is estimated by $\ln Y_t - \ln Y_{t-1}$, where Y_t is actual GDP[7].

All these variables can be expressed in the general matrix form of

$$\Delta X_t = C + B_1 \Delta X_{t-1} + \alpha\beta' X_{t-1} + B_2 \Delta X_{t-2} + \cdots + B_{K-1} \Delta X_{t-K+1} + \rho D_j + \epsilon_t, \qquad [11]$$

where $X_t = (\dot{P}\ ,\ \dot{Y}^e,\ \dot{\pi}^e\ ,\ M\dot{Z}M - \dot{P},\ \dot{Y})'$ are the explanatory variables with K denoting the maximum lag, C is the intercept term, which can be included separately if required, or restricted to lie within X_{t-1} of [11]. D_j represents a vector of non-stochastic variables such as structural break dummies with $j = 1$ to 2 and ϵ_t 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 to maintain normality in the construction of the restricted error correction model are: $D_1 =$ 1980:Q3 (set to -1), $D_2 =$ 2005:Q3 (set to +1) and 2008:Q4 (set to -1); otherwise all other values are zeros[8]. D_1 takes into account the exceptional slowdown in economic activity during the early 1980s bringing down the growth of inflation. In the case of D_2, despite the effects of the hurricanes in 2005, the growth of income led to a rise in prices before dipping back. Furthermore, there was a

[7] The Dickey-Fuller tests for stationarity are in Appendix A.
[8] For further details concerning the dummy variables see Appendix B.

significant decline in economic activity in 2008 because of the global financial crisis, reducing the rate of inflation. All raw observations are seasonally adjusted and obtained from *Fred Databank* at the Federal Bank of St. Louis, except for the Livingston expectations, which were obtained 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 $\alpha\beta' X_{t-1}$, representing the long-run relationship among the variables. The number of different co-integrating vectors can be found by examining the significance of the characteristic roots, which is equal the rank of the co-integrating 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] below.

Table [1]: Co-integration with no intercepts and trends in the VAR[9]
Co-integration LR Test Based on Maximal Eigen-value of the Stochastic Matrix
****
152 observations from 1974Q1 to 2011Q4. Order of VAR=8
List of variables included in the co-integrating vector:
$\dot{P}\ \dot{Y}^e\ \dot{\pi}^e\ (M\dot{Z}M - \dot{P})\ \dot{Y}$
List of unrestricted deterministic variables:
$D_1\quad D_2$
List of eigen-values in descending order:
0.38019 0.14137 0.077088 0.029725 0.010551
****

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
$r = 0$	$r = 1$	72.7070	29.9500	27.5700
$r \leq 1$	$r = 2$	23.1676	23.9200	21.5800
$r \leq 2$	$r = 3$	12.1936	17.6800	15.5700
$r \leq 3$	$r = 4$	4.5868	11.0300	9.2800
$r \leq 4$	$r = 5$	1.6123	4.1600	3.0400

****

[9] 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 (s). The autocorrelation from over fitting was removed by Hendryfication, suggesting the correct lag length of eight.

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

****

152 observations from 1974Q1 to 2011Q4. Order of VAR=8
List of variables included in the co-integrating vector:
$\dot{P}$ $\dot{Y}^e$ $\dot{\pi}^e$ $(M\dot{Z}M - \dot{P})$ $\dot{Y}$
List of unrestricted deterministic variables:
D_1 D_2
List of eigen-values in descending order:
0.38019 0.14137 0.077088 0.029725 0.010551

****

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
$r = 0$	$r = 1$	114.2673	29.9500	27.5700
$r \leq 1$	$r = 2$	41.5603	23.9200	21.5800
$r \leq 2$	$r = 3$	18.3927	17.6800	15.5700
$r \leq 3$	$r = 4$	6.1991	11.0300	9.2800
$r \leq 4$	$r = 5$	1.6123	4.1600	3.0400

****

The two statistics in Tables [1] and [2] imply two or less co-integrating vectors amongst the explanatory variables. Given the one, long-run solution of expression [10] suggested in the theoretical section, the resulting one vector is presented in Table [3] below. The restrictions imposed were tested using the t-statistics and the log-likelihood statistic, which is distributed chi-square, at each stage.

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

****

152 observations from 1974Q1 to 2011Q4. Order of VAR=8
List of variables included in the co-integrating vector:
$\dot{P}$ $\dot{Y}^e$ $\dot{\pi}^e$ $(M\dot{Z}M - \dot{P})$ $\dot{Y}$
List of unrestricted deterministic variables:
D_1 D_2

****

		[e]
$\dot{P}$	a1	1.0000 ($None$)
$\dot{Y}^e$	a2	−0.16169 (0.068280)
$\dot{\pi}^e$	a3	−1.0000 ($None$)
$(M\dot{Z}M - \dot{P})$	a4	−0.062606 (0.027364)
$\dot{Y}$	a5	0.53068 (0.083278)

Total number of restrictions (2) – number of just-identifying restrictions (1)
LR Test of Restrictions CHSQ (1) = 0.95459 [0.757]

****

The mix of variables in Table [3] with different orders of integration, indicating a multi-co-integrating vector, was tested for a linear combination that is unique and stationary using the Dickey-Fuller statistic. The test statistic is -9.6806 in the absence of auto-correlation, indicating a residual time series that is $I(0)$ and thus the long-run relationship is non-spurious.

Actual inflation turns out to be unitary elastic with respect to inflationary expectations in Table [3], which means that the expected changes in prices translate into the same proportional changes in current prices. Rational inflationary expectations seem to prevail in the empirical model. One point worth noting is that although many other potentially relevant variables for inflation determination such as stock market returns are absent in the model, the informational content of such variables may have already been captured by private agents in their price expectations *via* the information set. Thus, on grounds of the 'law of parsimony' the Livingston price expectations term in lieu of the other variables is sufficient for the current purpose.

Even though there is still a one-to-one correspondence between money growth and inflation as suggested by the Classical Quantity Theory, the long-run neutrality of money no longer holds because of the significant coefficients on the expected and current output growth terms in the long-run relationship. Whilst growth in actual output reduces inflation, which is consistent with the effects of the outward shifts of the aggregate supply curve on inflation, expected growth in output pushes up current inflation, perhaps due to the outward shifts of the aggregate demand curve associated with improvements in private agents' confidence. Thus, by manipulating private agents' output expectations, current monetary policy has real effects, even in the long-run. The inclusion of the output expectations term signifies a further significant channel for inflationary determination that is related to the positive Keynesian "animal spirit".

The empirical study has reached the stage where the long-run vector, e, is put together with the short-run dynamics to enlist the all-embracing equation: the error correction model, which is shown overleaf in expression [12]. 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, e, at $t-1$.

$$\begin{aligned}\Delta\dot{P} = &-\underset{(0.058140)}{0.18421}\,\Delta\dot{P}_{t-1} + \underset{(0.34676)}{2.4282}\,\Delta(\dot{\pi}^e)_{t-1} + \underset{(0.021811)}{0.24997}\,\Delta\dot{Y}_{t-1} + \underset{(0.053243)}{0.27865}\Delta\dot{Y}_{t-2} + \underset{(0.054346)}{0.18830}\,\Delta\dot{P}_{t-3}\\ &+ \underset{(0.050016)}{0.14928}\,\Delta\dot{Y}_{t-3} + \underset{(0.061411)}{0.15128}\,\Delta\dot{P}_{t-4} + \underset{(0.044536)}{16259}\,\Delta\dot{Y}_{t-4} + \underset{(0.056818)}{0.13280}\,\Delta\dot{P}_{t-5} + \underset{(0.10632)}{0.43206}\,\Delta(\dot{Y}^e)_{t-6}\\ &+ \underset{(0.31905)}{1.3713}\,\Delta(\dot{\pi}^e)_{t-6} - \underset{(0.016128)}{0.044565}\,\Delta\big(M\dot{Z}M - \dot{P}\big)_{t-6} + \underset{(0.037888)}{0.13454}\,\Delta\dot{Y}_{t-7} - \underset{(0.067605)}{\mathbf{0.76165}}\,\mathbf{e_{t-1}}\\ &+ \underset{(0.0045239)}{0.023974}\,D_1 + \underset{(0.0032139)}{0.024229}\,D_2 + \varepsilon_t \qquad [12]\end{aligned}$$

$R^2 = 0.76400$, $\overline{R}^2 = 0.73797$, $S = 0.0042760$, $RRS = 0.0024866$, $LL = 621.8959$, $DW = 1.7798$, $T = 152$.

Table [5]: the Diagnostic Statistics for Expression [12]

Test Statistics	**LM Version**
A: Auto-correlation	$\chi^2(4) = 5.8615$ [0.210]
B: Functional Form	$\chi^2(1) = 0.48156$ [0.488]
C: Normality	$\chi^2(2) = 0.83974$ [0.657]
D: Heteroskedasticity	$\chi^2(1) = 0.80832$ [0.369]

In fact, the co-integrating vector is highly significant within the empirical model of [12] with a negative adjustment coefficient of -0.76165, which implies that any disequilibrium should start to return back to the path of equilibrium within approximately one quarter with the aid of the counter-balancing short-run dynamics, although this is dominated by the accelerated change in positive price expectations. From the long-run equation earlier it is clear that the equilibrium path is shifted by changes in output expectations, this process is, however, very slow as any acceleration (or deceleration) in the change in output expectations will not have an impact on the change in inflation until six quarters later.

Conclusions/Summary

This paper examined the nexus between money growth, output, and inflation in the U.S. economy over the period 1974-2011. The theoretical model that led to the empirical estimation has been informed by the new Classical–Keynesian synthesis view of money and output growth with expectations in price and output movements determining the direction of inflation. The empirical approach is based on a parsimonious specification of the VAR system of the actual growth of prices, inflationary and output expectations that are represented by the Livingston series, and a term denoting real money growth along with the current economic growth that stems from entrepreneurship, technical progress, creativity and thrift. The empirical findings provide fresh support for this new Keynesian specification of the Phillips Curve and long-run non-neutrality of money, albeit with new complications.

Specifically, the results reveal that private inflationary expectations in the U.S. are fully efficient, but the neutrality of money breaks down, even in the long-run. In the presence of monetary shocks, while there are mechanisms to bring inflation back to the long-run equilibrium path, the latter itself is shifted by changes to private output expectations as well as actual economic growth. Therefore, the inflationary process in the U.S. economy in the period 1974-2011 is fundamentally underpinned in the long-run not just simply by the Classical Quantity Theory of Money but also possible ‘drifts’ from expectations of future output that may be altered by current monetary policy manipulation to aid stability and growth. Furthermore, over the sample period, the usual supply-side impact on inflation through growth in actual output seems to dominate the demand-side impulses arising from changing optimism or pessimism about future output growth. Such results suggest that the conduct of monetary policy should be concerned with the management of not just inflationary expectations, but also the current and future direction of output. Thus, more sophisticated rules for monetary policy conduct than the current conventions of the Taylor's rule should be considered.

References:

Bårdsen, G., Eitrheim, Ø., Jansen, E.S. and Nymoen, R. (2005) *The Econometrics of Macroeconomic Modelling*, Oxford University Press, Oxford.

Batini, N., Jackson, B. and Nickell, S. (2000) Inflation Dynamics and the Labour Share in the U.K., Discussion Paper 2., *External MPC Unit, Bank of England*.

Blanchard, O.J. and Kiyotaki, N. (1987) Monopolistic Competition and the Effects of Aggregate Demand, *American Economic Review*, Vol.77, N°.4, pp 647-666.

Blanchard, O.J. and Galí, J. (2007) Real Wage Rigidities and the New Keynesian Model, *Journal of Money, Credit and Banking*, 39(1), pp 35-65.

Bywaters, D.S. and Thomas, D.G. (2011) Real Money Demand and Supply meets Federal Debt, *Applied Economics Letters*, 18:12, pp 1189-1193.

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

Christiano, L.J., Eichenbaum, M. And Evans, C.L. (2005) Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy, *Journal of Political Economy*, Vol.113, N° 1, pp1-45.

Clarida, R., Galí J. and Gertler, M. (1999) The Science of Monetary Policy: A New Keynesian Perspective, *Journal of Economic Literature*, 37(4), pp 1661-1707.

______________________________ (2000) Monetary Rules and Macroeconomic Stability: Evidence and Some theory, *Quarterly Journal of Economics*, Vol.105, Issue 1, pp147-180.

Cochrane, J.H. (2007) Inflation Determination with Taylor Rules: A Critical review, *NBER*, Working Paper 13409.

Fender, J. (2012) *Monetary Policy*, John Wiley and Sons Ltd, Chichester.

Friedman, M. (1968) The Role of Monetary Policy, *American Economic Review*, Vol. LVIII, March, pp 1-17.

Fuhrer, J., Kodrzychki, Y.K., Little, J.S. and Olivei, G.P. (eds.) (2009) *Understanding Inflation and the Implications for Monetary Policy*, MIT Press.

Galí, J. and Gertler, M. (1999) Inflation Dynamics: A Structural Econometric Analysis, *Journal of Monetary Economics*, Vol.44, N°.2, pp195-222.

Galí, J., Gertler, M. and López-Salido, D. (2001) European Inflation dynamics, *European Economic Review*, 45 (7), pp 1237-1270.

________________________________(2003) Erratum to European Inflation Dynamics, *European Economic Review*, 47 (4), pp 759-760. ?

_________________________________(2005) Robustness of the Estimates of the Hybrid New Keynesian Phillips Curve, *Journal of Monetary Economics*, Vol.52, Issue 6, pp 1107-1118.

Haslam, C, T Andersson, N Tsitsianis, and Y P Yin (2012) Redefining Business Models: Strategy for a Financialized World, Routledge: Oxon.

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.

Kerr, W. and King, R.G. (1996) Limits on Interests Rules in the IS Model, *Federal Reserve Bank of Richmond, Economic Quarterly*, Vol.82, Spring, pp 47-56.

Kuester, K, G J Müller, and S Stölting (2009) Is the New Keynesian Phillips Curve Flat? *Economics Letters*, Vol. 103, Issue .1, pp 39–41.

Kuttner, K.N. (1994) Estimating Potential Output as a latent Variable, *Journal of Business and Economic Statistics*, Vol.12, N°.3, July, pp 361-368.

Lucas, R.E., Jr. (1973) Some International Evidence on Output-Inflation Tradeoffs, *The American Economic Review*, Vol.63, N^{o}.3, June, pp 326-334.

Lucas, R.E., Jr. (1976) Econometric Policy Evaluation: A Critique, *Carnegie-Rochester, Conference Series in Public Policy*, 1, pp 19-46.

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.

Mankiw, N.G. (1990) A Quick Refresher Course in Macroeconomics, *Journal of Economic literature*, Vol.28, December, pp1645-60.

Mankiw, N.G. and Romer, D. (eds.) (1991) *New Keynesian Economics*, Vol.1: Imperfect Competition and Sticky Prices, Vol.2: Co-ordination Failures and Real Rigidities, MIT Press.

McCallum, B.T. (2009) Inflation Determination with Taylor Rules: Is New Keynesian Analysis Critically Flawed, *Tepper School of Business*, paper 299.

M^{c}Morrow, K. and Roeger, W. (2001) Potential Output: Measurement Methods, "New" Economy influences and Scenarios for 2001-2010 – Comparison of the EU-15 and the US, *European Economy, Economic Papers*, 150, April, pp 1-142.

Nason, J.M. and Smith, G.W. (2008) Indentifying the New Keynesian Phillips Curve, *Journal of Applied Econometrics*, Vol.23 (5), pp 525-551.

Phelps, E.S. (1968) Money-Wage Dynamics and Labor-Market Equilibrium, *Journal of Political Economy*, Vol.76, pp 678-711.

Roberts, J.M. (1995) New Keynesian economics and the Phillips Curve, *Journal of Money, Credit and Banking*, Vol.27, N^{o}.4, November, pp 975-984.

Rotemberg, J.J. (1982) Sticky Prices in the United states, *Journal of Political Economy*, Vol.90, N^{o}.6, December, pp 1187-1211.

_______________________ (1983) Aggregate Consequences of Fixed Costs of Price Adjustment, *The American Economic Review*, Vol.73, No.3, June, pp 433-436.

Rudd, J. and Whelan, K. (2005) New Tests of the New Keynesian Phillips Curve, *Journal of Monetary Economics*, 52 (6), September, pp 1167-1181.

______________________ (2006) Can Rational Expectations Sticky-Price Models Explain Inflation Dynamics? *American Economic Review*, 96, pp 303-320.

_____________________ (2007) Modelling inflation Dynamics: A Critical Review of Recent Research, *Journal of Money, credit and Banking*, 39, (1), February, pp 155-170.

Sargent, T.J. and Wallace, N. (1975) "Rational" Expectations, the Optimal Monetary instrument, and the optimal Money Supply Rule, *Journal of Political Economy*, Vol.83, N^{o}.2, April, pp 241-254.

Sbordone, A. (2002) Prices and Unit Labour Costs: A New test of Price Stickiness, *Journal of Monetary Economics*, 49, (2), pp 235-456.

___________ (2005) Do Expected Future Marginal Costs Drive Inflation dynamics? *Journal of Monetary Economics*, 52, pp 1183-1197.

____________ (2007) Globalization and Inflation Dynamics: The Impact of Increased Competition, *NBER*, Working Paper, N^{o}. 13556, October.

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

Smets, F. And Wonters, R. (2003) An Estimated Stochastic Dynamic General equilibrium Model of the Euro Area, *Journal of European Economic Association*, 1(5), pp 1123-1175.

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

Svensson, L.E.O. (2000) Open Economy Inflation Targeting, *Journal of International Economics*, 50, pp155-183.

Taylor, J.B. (1980) Output and Price Stability; An International Comparison, *Journal of Economic Dynamics and Control 2*, February, pp 109-32

Woodford, M. (2003) *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press, Princeton, NJ.

____________ (2006) Does a "Two-Pillar Phillips Curve" Justify a Two Pillar Monetary Policy Strategy? Paper presented at the *Fourth ECB Central Banking Conference*, November.

Appendix A

Table [A.1]: Stationarity Tests over sample period of 1974 Q1 – 2011 Q4*

Statistic	$\dot{P}$	$\Delta(\dot{Y}^e)$	$\Delta(\dot{\pi}^e)$	$\dot{Y}$	$M\dot{Z}M$	$RM\dot{Z}M = (M\dot{Z}M - \dot{P})$
DF				-8.0506	-7.7545	-7.2997
ADF(2)	-3.0124					
ADF(4)		-5.9875	-4.4584			

* Statistics above reject non-stationarity at the 5% level of significance and are absent of auto-correlation.

It is worth pointing out that the original variables in the VAR, $\dot{Y}^e$ and $\dot{\pi}^e$, are not stationary, but their first differences are. Thus, $\Delta(\dot{Y}^e)$ and $\Delta(\dot{\pi}^e)$ are I(1) whilst the other three variables in the VAR are I(0) variables.