Modelling Monetary and Fiscal Policy in the US: A Cointegration Approach
Modelling Monetary and Fiscal Policy in the US: A Cointegration Approach

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Abstract
As governments and economists worldwide reflect on the unprecedented peacetime build-ups of government deficits and debts since 2008 and the Great Recession, the importance of fiscal and monetary policy interactions and their sustainability is key. This involves both thorough theoretical and careful econometric analysis. This paper provides the latter. We use multivariate cointegration methods to investigate monetary and fiscal interactions using the example of the United States since the early 1980s. Using survey data for inflation expectations, we find that monetary policymaking is heavily forward looking, and passive in the sense that it responds to policy rule. Fiscal policy is found to be active in that it does not respond to the fiscal policy rule discovered in the data. Entering into debates on the efficacy of fiscal policy, we find that in the long-term fiscal deficits are very harmful to growth, but in the short run fiscal stimuli can be effective in restoring the economy to equilibrium. The interactions between the two policy spheres appear somewhat limited in that neither policy tool enters the policy rule of the other policy sphere, but the more passive monetary policy does move in reaction to fiscal policy movements — the two policy spheres are complementary in that both respond in the same direction to revive and restrain the economy in downturns and boom times respectively.

JEL Classification: E52, E62, C01.
Keywords: Monetary policy, fiscal policy, policy interactions, cointegrated VAR method.

1 Introduction
Rarely, it seems, is there a period when the issues surrounding fiscal policy and its sustainability are not topical discussion points. Economists interested in fiscal policy have been playing catch-up with their monetary policy counterparts in recent years. Since the early 1980s monetary policy has received a great deal of attention both theoretically and empirically from economists (see, inter alia Barro and Gordon, 1983; Taylor, 1993), and while theoretical investigations into fiscal policy have begun to proliferate in recent years (e.g. Woodford, 2001), in empirical terms fiscal policy analysis appears to have lagged behind monetary policy.¹ A small number of papers have investigated the two in tandem both theoretically (e.g. Dixit and Lambertini, 2003; Kirsanova et al., 2005) and empirically (e.g. Muscatelli et al., 2004), exploring the types of fiscal and monetary policy regimes necessary for stability in the macroeconomy.

As governments and economists worldwide reflect on the unprecedented peacetime build-ups of government deficits and debts since 2007, the importance of fiscal and monetary policy interactions and their sustainability is key. This involves both thorough theoretical investigations such as those noted above, but also careful econometric analysis in order that the results are both structurally interesting and empirically-grounded. It is into the latter of these two arenas that this paper steps. We make use of recent advances in

* I would like to thank Jari Stehn for his input on this paper, which has been substantial. I’d also like to thank many conference participants and colleagues for comments. Naturally all errors are mine.

¹ Of course, notable exceptions exist such as Galí and Perotti (2003)
multiple-equation time-series econometric techniques and also of standard econometric modelling principles to provide a thorough investigation of monetary and fiscal interactions using the example of the United States, based on the theoretical work of Kirsanova et al. (2005).

Econometric principles encourage us to start generally and once we are satisfied that the assumptions upon which our statistical model is based are satisfied, we begin to impose restrictions in order to discover the nature of policy interactions (Hendry, 1995, Ch. 9). The alternative approach to this is to begin with a small, specific model based on a particular economic theory, and generalise the model in the event that obvious problems emerge. The impact of such badly specified models is well known from basic time-series econometrics, where concepts such as omitted variable bias and residual autocorrelation are taught early. It seems likely that neglecting such empirical complications contributes to many of the ‘puzzles’ often noted by economists.

The recent advances in detecting cointegration in vector autoregressions (Johansen, 1996) mean that steady state relationships, such as policy rules, in otherwise non-stationary data can be detected. The definition of a non-stationarity time series is that its moments change over time. Non-stationarity in macroeconomic data series is often downplayed, yet for example in the 1970s US inflation averaged over 10% while in the 1990s and 2000s it averaged under 2%. Such persistent and pronounced changes are indicative of non-stationarity (at least at a statistical level), and hence the need to incorporate time-series methods that allow for this possibility seems clear.2

As part of this thorough investigation, we pick up on another problematic aspect of economic modelling of policy rules: Expectations. The dominance of the rational expectations paradigm in theoretical macroeconomics has come under threat both from a theoretical (e.g. Frydman and Goldberg, 2007) and an empirical (e.g. Juselius, 2006) point of view. Considering the latter view, the econometric modelling of expectations has long been difficult because expectations aren’t measured and compiled by statistical authorities. Methods such as substituting actual lead data for expectations, or Generalised Method of Moment (GMM) estimation, have been attempted with limited success (e.g. Castle, 2008). A second contribution of this paper is to model expectations using published data on inflation expectations.

We find that monetary policy is heavily forward looking and that it responds to its policy rule, which is represented by a cointegrating vector. A fiscal policy rule implying fiscal stability is found, although fiscal policy itself does not respond to this rule, instead influencing the nature of the macroeconomic equilibrium. This has implications both for the recent fiscal stimulus in the US; firstly it suggests that the stimulus will have been effective, since the output gap does respond to the fiscal policy rule, and secondly it suggests that despite the apparent profligey of fiscal policy, debt sustainability will be established — but not necessarily from fiscal policy itself but instead via other variables adjusting. Thus higher future growth, and higher future inflation might be expected on the basis of our model. However, our results do show that long-term fiscal deficits will be harmful for economic growth hence arguing for credible deficit reduction plans for the medium to long-run. The interactions we find between the two policy spheres appear somewhat limited in that neither policy tool enters the policy rule of the other policy sphere, but monetary policy does move in reaction to fiscal policy movements — the two policy spheres are complementary in that both respond in the same direction to revive and restrain the economy in downturns and boom times respectively.

Section 2 introduces models of monetary and fiscal policies and their interactions, then Section 3 considers empirical estimates of these models. Section 4 introduces the cointegrated vector-autoregressive model and attempts to link this with theoretical models of monetary and fiscal policies and their interactions, as well as considering how our econometric methodology compares to previous attempts to estimate policy interactions. In the same section we also introduce the data series we will use. Section 5 contains the econometric output of the paper, before Section 6 concludes.

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2 As is the importance in modelling data series appropriately statistically, in order to not make spurious conclusions.
2 Theoretical Models of Monetary and Fiscal Policies

Theoretical macroeconomic models of monetary and fiscal policy interactions have their roots in the rich literature on monetary and fiscal policy; specifically in the rules-based literature initiated by the classic dynamic inconsistency work of, *inter alia* Barro and Gordon (1983). Because our focus is policy interactions, we focus on theoretical investigations of these interactions in this Section.

While monetary policy analysis has remained firmly in flavour throughout since the Second World War, analysis of fiscal policy lost favour with fine-tuning Keynesian counter-cyclical policies in the 1970s to the extent that much of the monetary-focussed literature considered it irrelevant for achieving price stability (Walsh, 2003, See e.g.). Leeper (1991) *inter alia* developed the *Fiscal Theory of the Price Level* (FTPL), investigating which fiscal-policy regimes are optimal given the monetary-policy regime. Leeper (1991) introduced the *active* fiscal policymaker, who does not set policy according to its inter-temporal budget constraint, as opposed to the *passive*, debt-responsive, policymaker. Leeper (1991) defined active monetary policy in the same way, with regard to debt sustainability, and found that for stability and a unique solution, one policy regime must be *active*, the other *passive*. Leith and Wren-Lewis (2000), defined an *active* monetary-policy regime as one satisfying the Taylor principle. They concluded that both monetary and fiscal policies ought to be either active or passive for stability. Dixit and Lambertini (2003) consider policy interactions in a set-up where the monetary authority controls inflation. The source of conflict is that the fiscal authority aims for higher output and inflation than the monetary authority. The non-cooperative Nash equilibrium has both higher inflation and lower output that the cooperative solution. Commitment by the monetary authority is not sufficient if fiscal policy is active; naturally fiscal commitment would yield a better outcome.

Kirsanova et al. (2005) extend the three-equation monetary-policy model to a five-equation model of monetary and fiscal policies by adding the government’s inter-temporal budget constraint and an objective function for the fiscal policymaker that translates into a policy rule. A general specification of the two equations, the IS curve and the inflation-adjustment relation, common to both monetary and fiscal policies would be:

\[ y_t = \gamma^f E_t y_{t+1} + \gamma^b y_{t-1} - \sigma [r_t - E_t \pi_{t+1}] + \phi d_t + \delta pb_t + \varepsilon_{1,t}, \]

\[ \pi_t = \chi^f \beta E_t \pi_{t+1} + \chi^b \pi_{t-1} + k_1 y_t + k_2 y_{t-1} + \varepsilon_{2,t}, \]

where \( y_t \) is the output gap, \( \pi_t \) the inflation rate, \( r_t \) the nominal interest rate, \( d_t \) the stock of public debt and \( pb_t \) the primary government balance defined as government receipts minus spending. The latter two fiscal variables are represented as fractions of GDP, and all these variables are linearised around some steady-state level.

Following the literature, the interest rate \( r_t \) is the monetary-policymaking tool, while \( pb_t \) is defined here as the fiscal policymaker’s tool. There is disagreement whether the fiscal instrument should be taxes or spending or the balance. Kirsanova et al. (2005) take government spending to be the tool, Schmitt-Grohe and Uribe (2004) consider taxation and a number of others take both (for example Muscatelli et al., 2004; Galí and Perotti, 2003). Furthermore there is a need to distinguish the *automatic stabilisers* of fiscal policy, the cyclical movements in the fiscal balance related to, amongst other things, spending on benefits and income/corporation tax receipts, from its discretionary counterpart. Disentangling the two effects is difficult, because the proportion of a given increase attributable to cyclical factors will likely change over time due to structural factors. If fiscal policy is not included, then \( \phi = \delta = 0 \) in (1), reverting back to the three-equation model; if fiscal policy is included, \( \delta \neq 0 \) implies the rejection of Ricardian equivalence. Ricardian equivalence states that government budget deficits do not affect the level of aggregate demand or activity in the economy. The government’s inter-temporal budget constraint is:

\[ d_t \approx [1 + \rho t_{t-1}] d_{t-1} - pb_t. \]

In equation (3), upper case letters refer to variables in levels, lower case as fractions of GDP, \( \rho t = (I - \Delta p - g_{r,t}) \) is the growth adjusted real rate of interest, \( g_{n,t} \) is the nominal rate of GDP growth, and \( g_{r,t} \) is the real rate.

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3Woodford (2001) calls these *non-Ricardian* and *Ricardian* regimes, respectively.
Kirsanova et al. (2005) linearise their inter-temporal budget constraint around arbitrarily defined debt and interest rate levels $r_0$ and $d_0$:

$$d_t = [1 + r_0] d_{t-1} + r_{t-1} d_0 + p b_{t-1}. \tag{4}$$

A passive fiscal policymaker would set policy to satisfy (4), while the FTPL suggests that governments can be active in setting fiscal policy: as policy is set without regard for (4), the price level $P_t$ adjusts to ensure it holds.

Considering the government budget constraint in (3), if $\rho_{t-1} < 0$ (the real interest rate is below the rate of real GDP growth), debt is stable, and (3) satisfies a first-order difference equation. Then the expected value of $d_t$ $n$-periods ahead conditional on information at time $t$ is, assuming $\rho_t = \rho$:

$$E_t [d_{t+n}] = [1 + \rho]^n d_t + \sum_{i=0}^{n-1} [1 + \rho] p b_{t+i},$$

and assuming that the following transversality condition holds:

$$\lim_{n \to \infty} [1 + \rho]^n d_{t+n} = 0,$$

then:

$$\lim_{n \to \infty} E_t [d_{t+n}] = \sum_{i=0}^{n-1} [1 + \rho] p b_{t+i}. \tag{5}$$

If the primary balance is non-stationary, so too will debt be, and from (5) the two must cointegrate. This is the debt-sustainability test of Hamilton and Flavin (1986) and Trehan and Walsh (1991): if a cointegrating vector involving these two variables exists, then debt is sustainable. Bohn takes the existence of a linear regression containing debt and the primary balance as evidence of fiscal sustainability. Bohn (2008) continues the analysis of fiscal sustainability, and insists strongly that the primary balance- and debt-to-GDP ratios are stationary alongside finding debt sustainability.

However $\rho$ is not constant over time, as Figure 1 shows for the US. Relaxing this assumption the more complicated forward solution of (3) is:

$$d_t = E_t \left[ \prod_{i=1}^{n} [1 + \rho_{t+i}]^{-1} d_{t+n} \right] - E_t \left[ \sum_{i=1}^{n} \prod_{j=1}^{i} [1 + \rho_{t+j}]^{-1} p b_{t+i} \right].$$
With the transversality condition on \(d_{t+n}\) holding, then fiscal solvency requires:

\[
d_t = -E_t \left\{ \sum_{i=1}^{\infty} \prod_{j=1}^{i} [1 + \rho_{t+j}]^{-1} pb_{t+i} \right\}.
\]  

(6)

Concurring with Bohn (1998), it may be that omitted variables drives the lack of constancy in the growth adjusted real rate of interest, such as the interest rate and GDP growth. Hence the existence of a cointegrating vector between debt, the primary balance, and other variables would imply fiscal sustainability. Politto and Wickens (2005) express doubts about such measures of fiscal sustainability due to the assumptions required; however, their proposed index measure also suffers this same criticism, predominantly because of a log-linearisation of the budget constraint. Given the large swings in the value of debt and the periods of large disequilibrium in fiscal policy evident from Figure 1, this linearisation is concerning.

The policymaker uses its instrument to minimise the present discounted value of the social loss function \(W_s\), where \(j = m, f\) signifies monetary or fiscal policy, and \(T_j\) is the relevant policymaker’s tool:

\[
L_j = \min_{T_j} \frac{1}{2} E_{t-1} \sum_{s=t}^{\infty} \beta_{s-t} W_s [\pi_t, y_t, \pi_{t-1}, y_{t-1}].
\]  

(7)

Kirsanova et al. (2005) assume that there is a one-period implementation lag for fiscal policy reflecting the legislative and political procedures required for important discretionary fiscal policy changes, and a one-period effect lag for monetary policy, reflecting the transmission mechanism. Kuttner (2002) doubts whether fiscal policy, given these lags, could achieve interaction with monetary policy. Perhaps reflecting this, Canzoneri et al. (2002) list a number of explicit US fiscal-policy interventions which failed to achieve their intended cyclical effect.

The loss function in (7) is generally taken to be quadratic in the difference between inflation and output and their respective targets:

\[
W_s = [\pi_s - \pi_s^*]^2 + [y_s - y_s^*]^2.
\]

The policymakers re-optimise every period, setting their tool to minimise their social loss function (7) subject to the evolution of the economy (1)–(4), taking inflation expectations as given. Optimal policy under discretion and quadratic preferences with linear constraints can be expressed by a linear rule which depends on inflation and the output gap in a manner dictated by the set-up of the economic model. The general form of a monetary-policy rule is:

\[
r_t = \phi_{E\pi} E_t \pi_{t+1} + \phi_\pi \pi_t + \phi_{\pi 1} \pi_{t-1} + \phi_{Ey} E_t y_{t+1} + \phi_y y_t + \phi_{y1} y_{t-1}.
\]  

(8)

where the optimal feedback parameters \(\phi_j\) depend on the assumed structure of the economy in (1)–(4). An ‘active’ (Leith and Wren-Lewis, 2000) monetary-policy regime would be described as fulfilling the Taylor principle and raising real interest rates in response to a rise in inflation, hence \(\phi_{E\pi} + \phi_\pi + \phi_{\pi 1} > 1\). A positive response would be expected to a positive output gap despite the lack of an explicit output objective, because output is generally thought to lead inflation (Svensson, 1999), so \(\phi_{Ey} + \phi_y + \phi_{y1} > 0\). For fiscal policy, a rule will resemble:

\[
pb_t = \psi_y y_t + \psi_\pi \pi_t + \psi_d d_t,
\]  

(9)

where \(\psi_y > 0, \psi_\pi > 0, \) and \(\psi_d > 0\). Again particular signs and magnitudes are expected of the coefficients in the fiscal-policy rule; Kirsanova et al. (2005) find in their model that for stability and non-cyclicity, substantially smaller coefficient values than in the monetary-policy rule must hold.

While the coefficients in (8) and (9) will be explicit functions of the parameters of the constituent parts of the model (1)–(7), estimating on macroeconomic data only affords insight on to equations such as (1), (2), (4) and the policy rules (8) and (9). A number of studies, such as Clarida et al. (1999) and Muscatelli et al. (2004) make additional restrictions to attempt to estimate and identify ‘deeper’ parameters within the model, such as policymaker preferences. We restrict our attention to reduced form estimations in order to provide data-rigorous estimates for reduced form parameters to help form the stylised facts that economic theory must match.
3 Empirical Monetary and Fiscal Policy

As with our theoretical review, we focus on explicit monetary and fiscal interaction studies and pass briefly over the formative empirical investigations of monetary and fiscal policies individually. The celebrated Taylor (1993) rule was a single-equation static model, and while subsequent multiple-equation modelling methods have suggested endogeneity bias existed in those original estimations, the Taylor principle has been upheld and perhaps even strengthened, with for example Dennis (2004) finding even greater coefficients that Taylor originally did for the interest rate responses to inflation and the output gap. Lags of the interest rate are also required due to their strong significance: Such inclusion also helps mitigate the possible effects of non-stationarity, and have been justified on economic grounds as optimal inertial policymaking that helps steer inflation expectations (e.g. Woodford, 2003). In a modelling approach most similar to ours, Johansen and Juselius (2003) and Christensen and Nielsen (2009) estimate vector autoregressive models and find cointegrating vectors corresponding to the policy rule. Troublingly, Johansen and Juselius found that inflation did not respond to the policy rule, and Christensen and Nielsen found that the interest rate did not adjust to the policy rule. Nonetheless, once Christensen and Nielsen proxied for inflation expectations using a long-term interest rate, they uncovered satisfactory correction of the interest rate.

As with monetary-policy estimations, single-equation approaches to estimate fiscal rules have been used, and in the light of EMU and the Stability and Growth Pact, attention has focussed on Europe. The main disagreement has been over the cyclicality of fiscal policy; Wyplosz (1999) suggests it is pro-cyclical while Galí and Perotti (2003) suggest it is often and increasingly counter-cyclical. Although these studies consider different countries, it would nonetheless seem somewhat unlikely that differences in developed nations would be particularly large. One potential reason for differences is the econometric method: Wyplosz uses single-equation OLS modelling while Galí and Perotti use panel estimation methods. Höppner (2001) has investigated fiscal policy using a multiple-equation approach, again to help account for potential endogeneity between variables, but his emphasis is on the existence of Ricardian equivalence.

Melitz (2002) considers interactions between monetary and fiscal policies in a pooled regression of annual data on nineteen OECD countries. He finds first that monetary and fiscal policies move into opposite directions, so are substitutes, and secondly that fiscal policy fulfills a weak debt stabilizing role: taxes behave in a stabilising fashion but spending moves in a destabilising manner.

Hughes-Hallett (2005) uses individual instrumental-variables regressions to investigate interactions between monetary and fiscal policies in the UK and the Eurozone. He finds that monetary and fiscal policies act as substitutes in the UK but complements in the Eurozone. He finds that monetary and fiscal policies act as substitutes in the UK but complements in the Eurozone.

Muscatelli et al. (2004) estimate a forward-looking New-Keynesian model augmented to allow for a fiscal policy regime in addition to the standard monetary authority for the US using quarterly data from 1970Q1 to 2001Q2. They use generalised method of moments (GMM) estimation for their multiple-equation system. They allow fiscal policy to have two instruments, taxation and spending, and motivate policy interactions first through the cyclicality of each policy, and secondly through the direction of movements to output shocks. Muscatelli et al. find that monetary policy smoothes, fulfills the Taylor principle and responds to output in a stabilising manner. Each part of fiscal policy smoothes: government spending responds in a destabilising manner to contemporaneous output, but in a stabilising manner to lagged output, making the overall response just counter-cyclical. Taxes respond positively to output. Both instruments respond to the lagged budget deficit ratio in a stabilising manner: higher deficits reduce spending and raise taxes (where the former correction mechanism is stronger). The fiscal-policy rules here do not distinguish between discretionary policy and automatic stabilisers.

Muscatelli et al. find that monetary and fiscal policies have acted like asymmetric complements. Fiscal policy is found to relax when monetary policy tightens, but monetary policy tightens when fiscal policy tightens. Muscatelli et al. (2004) model the channel of policy interactions to be that of the impact each other has on the jointly held objectives: stabilisation of output and inflation about target. Via impulse-response analysis, Muscatelli et al. (2004) find that interaction depends on the shock: for output shocks fiscal and monetary policy act as complements whilst for inflation or instrument shocks they act as substitutes. They admit the results depend critically on the type of structural model used; furthermore, impulse-response analysis is crucially dependent on the identification structure imposed.
Public debt is omitted by Muscatelli et al., as they find it insignificant (as do Galí and Perotti, 2003) and hence debt sustainability is not addressed. Favero (2004) is very critical of this. In a similar study to Muscatelli et al., Fragetta and Kirsanova (2007) model policy interactions in the UK, Sweden and the US. As well as interactions, Fragetta and Kirsanova attempt to distinguish leadership, or dominance (Leeper, 1991), and find no evidence for dominance in the US, suggesting that the two authorities ignore each other.

Favero and Monacelli (2003) model policy interactions using a Markov-switching vector-autoregressive model (Krolzig, 1997), although only fiscal policy is subject to endogenously determined regime switching estimation; monetary regime shifts are imposed exogenously. The fiscal-policy regimes they identify correspond to the passive and active terminology introduced by Leeper (1991). Favero and Monacelli find that only between 1987 and 2001 can the US fiscal regime be described as passive, although Woodford (1998) asserts that since 1980 passivity would be a good description, and Galí and Perotti (2003) found fiscal policy to be increasingly passive over this period.

Having discussed the salient contributions to monetary and fiscal policies and their interactions, we now begin to introduce our econometric approach. First we set out the cointegrated VAR model before we discuss the data we use. Throughout we attempt to nest our strategy within the existing policy interactions literature and emphasise where this strategy represents an improvement over what been attempted previously.

4 Empirical Strategy and Data

Having discussed the salient theoretical and empirical contributions to the interactions of monetary and fiscal policies, we now turn to elucidating our estimation strategy. As we emphasised in the Introduction, we have concerns about estimation methods employed by other studies in the area of monetary and fiscal policy interactions, and hence we will nest our strategy into the context of these previous studies. It also seems easiest to describe our data at the same time, as the data series we select are motivated by our empirical strategy. In testing any theory, measured variables that most closely accord to the variables described in the theory should be sought (Juselius, 2007). While it might be reassuring to find that a different measure of the same variable provides similar results, this need not in itself be any gauge of how ‘robust’ the findings are, because a different measure may correspond to a different theoretical model, and hence a different theory is being tested. Thus, the choice of data variables is of crucial importance to any empirical investigation, in addition to the selection of econometric model.

Two primary observations on the empirical studies described in Section 3 can be made to motivate our strategy; those of non-stationarity and rational expectations. Considering non-stationarity, Österholm (2005) criticises the scant attention given to the distinct possibility of spurious regression as a result of the presence of unit roots in the data. Information about the levels of the processes is either distorted by inappropriate modelling techniques, or discarded by differencing to stationarity. Gerlach-Kristen (2001) uses a cointegration approach, which explicitly accounts for non-stationarity, to estimate a monetary-policy rule for the Eurozone. Gerlach-Kristen finds that the simple Taylor rule formulation in (8) is too restrictive and that additional lags must be added to produce a well-specified econometric model.

The data we use are for the US and due to restrictions on our inflation expectations series (discussed further down) are for the period 1982q1–2010q2. They are plotted in Figure 2 and some series, such as the Federal Funds interest rate, the primary balance and output gap, are clearly non-stationary although theoretically they should not be non-stationary. Unit root testing is carried out and reported in Table 1. Augmented Dickey-Fuller (ADF) unit root tests are carried out using enough lags for each variable to ensure that no residual autocorrelation remains. As mentioned earlier, debt is the series which is closest to being I(2), yet this cannot be the case: This would require the primary balance to be I(1) and \( \rho = 1 \) in (3). However, Figure 1 plots \( \rho \) for the US economy, and it clearly fluctuates around zero and at no point is greater than 0.1, and hence we treat debt as an I(1) variable and continue modelling. Furthermore, an AR(1) model in

\[ \Phi(L) y_t = \theta_0 + \epsilon_t \]

where \( \Phi(L) \) is a polynomial in the lag operator \( L \).

In fact it ought to be of concern if very different measures provide similar regression results, as it raises questions of what the estimation technique is estimating. See for example Clarida et al. (1999) who use different measures as a method of robustifying their findings, and Hendry (2001) who questions single-variable explanations from multiple choices of measures.
the first difference of the debt-to-GDP ratio yields an autoregressive parameter of just 0.45.\(^5\) ADF tests are oft-criticised for a lack of power and as a result alternative tests, such as those of Phillips and Perron (1988) and Kwiatkowski et al. (1992). However, the cointegrated VAR framework introduced in the next Section does not require that all the series be \(I(1)\). All that is required is that the data series are at most \(I(1)\). Furthermore, Juselius (2007) argues it is better to treat near-non-stationary data series as \(I(1)\) in order to exploit the co-movements between series. Thus, unit-root testing is not of utmost importance. An \(I(0)\) variable in a cointegrated VAR model will appear as a cointegrating vector on its own. Nonetheless, for completeness we present some unit-root testing evidence. Of the six variables under consideration, only the output gap returns a rejection of the null hypothesis of a unit root. The primary balance-to-GDP ratio is found to be \(I(1)\), although the test statistic is closer to the 5\% critical value than for any other variable apart from the output gap.\(^6\)

Strategies to cope with this have developed since; a common one is to take transformations (usually differences) of data series until they are rendered stationary. Another strategy involves representing non-stationary data in differences and linear combinations of levels in what is called the equilibrium-correction form. If these linear combinations of \(I(1)\) data are \(I(0)\) then they are said to be cointegrating (Engle and Granger, 1987). These cointegrating relationships have an interpretation in terms of the steady-state relationships often posited in economic theory, and as such research into these empirical methods has blossomed, aided by the work of Johansen (1995) and perhaps best encapsulated in Juselius (2007).

\(^5\) An \(I(2)\) variable \(x_t\) would have \(\Delta x_t \sim I(1)\) hence in an autoregression of \(\Delta x_t\) one would expect to find a unit root.

\(^6\) Our sample covers a twenty year period which should be enough for most time series to allow a stationary conclusion. It should be emphasised that this is a statistical conclusion as opposed to an economic one — exploring the consequences for the economy of a random walk debt series is beyond the scope of this paper.
Table 1: Augmented Dickey-Fuller test outcomes for the six variables under consideration. Constant indicates whether a constant was included in the test (to allow for non-zero means or random walks with drift), lags is the number of lags required to remove residual autocorrelation, ADF is the test statistic, 5% the relevant 5% critical value, as is 1%.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lags</th>
<th>Constant</th>
<th>ADF</th>
<th>5%</th>
<th>1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Fund Rate</td>
<td>9</td>
<td>Yes</td>
<td>-1.650</td>
<td>-2.89</td>
<td>-3.48</td>
</tr>
<tr>
<td>Primary Balance-to-GDP Ratio</td>
<td>3</td>
<td>No</td>
<td>-1.514</td>
<td>-1.94</td>
<td>-2.58</td>
</tr>
<tr>
<td>Inflation (excluding energy prices)</td>
<td>16</td>
<td>Yes</td>
<td>-1.837</td>
<td>-2.89</td>
<td>-3.48</td>
</tr>
<tr>
<td>Median Inflation Expectation</td>
<td>3</td>
<td>Yes</td>
<td>-1.952</td>
<td>-2.89</td>
<td>-3.48</td>
</tr>
<tr>
<td>Output Gap</td>
<td>10</td>
<td>No</td>
<td>-3.322**</td>
<td>-1.94</td>
<td>-2.58</td>
</tr>
<tr>
<td>Debt-to-GDP Ratio</td>
<td>3</td>
<td>Yes</td>
<td>-0.382</td>
<td>-2.89</td>
<td>-3.48</td>
</tr>
</tbody>
</table>

A data vector of our variables of interest can be formed and a vector autoregression specified:

$$X_t = \Pi_0 + \Pi_1 t + \sum_{i=1}^K \Pi_i X_{t-i} + u_t, \quad u_t \sim N(0, \sigma^2) .$$

(10)

Here, $X_t$ is a $p \times T$ data matrix, while $\Pi_0$ is a $p \times p$ coefficient matrix, where $p = 6$ is the number of variables in the system, and $T$ the number of observations. The $\Pi_0$ matrix refer to the constant terms in each equation of the VAR system. If the data are non-stationary, so $X_t \sim I(1)$, then in order for (10) to be balanced (given the stationarity assumption on $u_t$), it must be rearranged into equilibrium-correction form:

$$\Delta X_t = \Pi^* X_{t-1}^* + \sum_{i=1}^{K-1} \Gamma_i \Delta X_{t-i} + u_t,$$

(11)

where $X_{t-1}^* = (X_{t-1}, 1)'$, $\Pi^* = (\Pi, \Pi_0)$, $\Pi = \sum_{i=1}^K \Pi_i - I$, and $\Gamma_i = -\sum_{j=i+1}^K \Pi_j$. The coefficients for the lagged regressors and the constant term have been banded together, for ease of exposition. Further, if $X_t \sim I(1)$, then given that $u_t \sim I(0)$ and $\Delta X_t \sim I(0)$ then $\Pi$ must be of reduced rank for (11) to be balanced. If $\Pi$ is of reduced rank then there exist $p \times r$ matrices $\alpha$ and $\beta$ such that $\Pi = \alpha \beta'$, and (11) becomes:

$$\Delta X_t = \alpha \beta' X_{t-1}^* + \sum_{k=1}^{K-1} \Gamma_i \Delta X_{t-k} + u_t,$$

(12)

where $\beta = (\beta, \beta_0)'$ and $X_{t-1}^* = (X_{t-1}, 1)$. The $\beta' X_{t-1}^*$ terms are cointegrating vectors, the stationary relationships between non-stationary variables, or steady-state relationships. Importantly, $E \left( \beta' X_t \right) = 0$ since these cointegrating vectors describe steady state relationships which must be mean zero. In the context of monetary and fiscal policy, we might expect a rank of two, with a monetary policy vector, and a fiscal policy vector. The number of cointegrating vectors is denoted by the rank $r$, which is chosen formally on the basis of a Likelihood Ratio test more commonly known as the trace test (Johansen, 1995). There are well-known small-sample size distortions for the trace test, and hence given our sample is relatively short, we shall employ additional information to help determine the rank, such as considering the remaining roots of the system, the size of eigenvalues and correlations between candidate cointegrating vectors and the data differences, and the economic interpretability of additional cointegrating vectors (Juselius, 2007).

The interpretation of these cointegrating vectors $\beta' X_{t-1}$ is important: They are stationary, static linear combinations of non-stationary economic variables, and in economic theory terms we can think about them...
corresponding to economic theory. The simple Taylor rule relationship of Taylor (1993) is a static and stationary relationship between heavily time-persistent variables; time persistence demands an autoregressive structure in order to deliver unbiased estimators of coefficients. Cointegrating vectors are static in the sense they do not include lagged variables and only contemporaneous ones, and since they are stationary hence we can seek to interpret them as economic theory relationships. However, we cannot necessarily infer causality from them as might be implied from economic theory, and as might be commonly attempted to be inferred from simple econometric estimations. The cointegrating vectors describe economic steady states: Linear combinations of variables that deliver equilibrium for that particular theoretical relationship; hence if the output gap takes a particular value, and inflation another value, then the equilibrium interest rate is determined by that particular cointegrating relationship, if it is found for monetary policy.

We attempt to identify, depending on the rank we discover, these cointegrating relationships as monetary and fiscal policy rules; however, if after imposing the restrictions, the coefficient values are very strange, and uninterpretable, then it may be an error has been made and that we cannot impose these particular relationships on the data. The process of moving from this point is part of the econometric exercise of learning from mistakes, or errors made previously in formulating the model. We use theoretically motivated restrictions to attempt to achieve identification; neither debt nor the primary balance appear in (8), and neither the interest rate nor inflation expectations appear in (9). Because these identification restrictions are untestable in that they are simply a reordering of \( \alpha \) and \( \beta \) such that \( \alpha \beta = \Pi^\ast \), where possible we investigate the consequences of other identification strategies in our empirical Section.

The \( \alpha \) coefficients also allow extra insight into the economic dynamics taking place in the data, as they dictate whether and how a variable adjusts to a particular cointegrating vector, and the speed of that adjustment, if any is found. Because the left-hand-side variable is \( \Delta X_t \), then a significant positive \( \alpha \) coefficient corresponds to a positive adjustment to positive disequilibrium. It may be expected that the monetary policymaking tool, \( r_t \), adjusts to the monetary policy rule; we would also expect it to correct when disequilibrium is positive, hence we would expect to find a negative coefficient relating to that variable and the monetary policy cointegrating vector in our estimated \( \alpha \) matrix. As will be discussed in more detail when presenting our estimations, a positive disequilibrium for a policy vector implies that the actual observed policy tool is higher than the level that the economic data predicts, and we characterise this thus as a tight policy (high interest rates, a budget surplus) stance. We expect then that both the policy tool, and the target variables (output gap, inflation, inflation expectations), all adjust to the policy rule vector. The policy tool follows its rule, and its rule is effective in influencing the variables of interest to that policymaker.

A variable not adjusting to any cointegrating vectors is said to be weakly exogenous: It ‘drives’ the system as the variable dictates what level that cointegrating relationship takes as opposed to being influenced by it. For example, had we modelled general inflation, instead of core inflation excluding food and energy prices, then we might have expected that inflation was weakly exogenous since energy prices cannot be controlled by a central bank.

Before presenting the results of the empirical exercise, it is important to note what the economic theory divulged above should produce in our estimated model. For the monetary policy rule it is expected that the inflation reaction terms fulfil the Taylor principle. We will normalise on the interest rate coefficient, \( \beta_{11} \), and hence we expect that \( (\beta_{31} + \beta_{41}/\beta_{11}) = \beta_{31}^\ast + \beta_{41}^\ast < -1 \), where \( \beta_{11}^\ast \) denotes a normalised coefficient. The restriction is expressed with a negative sign; to see why we could equivalently write the cointegrating relationship in terms of an stationary error term, say \( ecm_{1t} \sim (0, \sigma^2) \), giving:

\[
ecm_{1t} = r_t + \beta_{21}^\ast \pi_t + \beta_{31}^\ast y_{t-1}^{gap} + \beta_{41}^\ast \pi_t + \beta_{51}^\ast y_{t-1}^{gap} + \beta_{61}^\ast d_{1t} + \beta_{01}^\ast + \beta_{00}^\ast
\]

(13a)

\[
r_t = -\beta_{21}^\ast \pi_t - \beta_{31}^\ast y_{t-1}^{gap} - \beta_{41}^\ast \pi_t - \beta_{51}^\ast y_{t-1}^{gap} - \beta_{61}^\ast d_{1t} + \beta_{01}^\ast + ecm_{1t}.
\]

(13b)

Hence when the cointegrating vector is expressed as a relationship in terms of \( r_t \), the coefficients are negative. Continuing, it would be expected that the response of interest rates to the output gap is negative, hence counter-cyclical: \( \beta_{31}^\ast < 0 \). From (8) we might expect that the primary balance and debt variables play no role in monetary policymaking, hence \( \beta_{21}^\ast = \beta_{61}^\ast = 0 \), although violation of this restriction would imply a specific form of policy interactions.

Turning to fiscal policymaking, from (9) we note the absence of inflation expectations and the interest
rate and hence we could use either or both of these to identify our cointegrating vector, depending on the rank we find for our system. We can write, using $\beta_{22}$ to normalise on the primary balance:

$$ecm_{2t} = \beta_{12}^{*}r_{t} + py_{t} + \beta_{32}^{*}\pi_{t} + \beta_{12}^{*}\pi_{t}^{e} + \beta_{52}^{*}y_{t}^{gap} + \beta_{62}^{*}dy_{t} + \beta_{62}^{*}$$

(14a)

$$py_{t} = -\beta_{12}^{*}r_{t} - \beta_{32}^{*}\pi_{t} - \beta_{12}^{*}\pi_{t}^{e} - \beta_{52}^{*}y_{t}^{gap} - \beta_{62}^{*}dy_{t} + \beta_{62}^{*} + ecm_{1t}.$$  

(14b)

Hence our identification restrictions are one of either or both of $\beta_{12}^{*} = 0$ and $\beta_{42}^{*} = 0$. We do not rule out policy interactions if we are forced to impose the restriction $\beta_{12}^{*} = 0$ because we can still observe whether or not the interest rate and hence monetary policy adjusts to disequilibrium in the fiscal policy sphere. Our theory earlier based on Kirsanova et al. implies that the reactions of fiscal policy to inflation and output are of a smaller magnitude than monetary policy; hence $|\beta_{12}^{*}| < |\beta_{31}^{*}|$ and $|\beta_{52}^{*}| < |\beta_{31}^{*}|$. Counter cyclical policy implies that $\beta_{12}^{*} < 0$ and $\beta_{42}^{*} < 0$ while debt sustainability requires that at a minimum $\beta_{62}^{*} < 0$.

As an aside here, the cointegration approach does allow us to investigate debt sustainability somewhat more coherently than a number of other studies of this issue. As noted, Bohn takes the existence of a linear regression containing debt and the primary balance as evidence of fiscal sustainability, while Bohn (2008) is critical of cointegration methods for investigating debt sustainability, arguing that they are biased in favour of finding sustainability. This criticism seems a little overdone however; if debt had followed an unsustainable path this path would have been non-stationary (mean and variance increasing with time) and hence would not have been found as a cointegrating vector, implying unsustainability. The existence of a stationary relationship relating the primary balance to the stock of debt is evidence that policy has been sustainable; naturally this finding is conditional on the information set under consideration and this ought to be the most pertinent criticism of the method. Using information available at time $t$ is all we are able to do; future changes in demographics and macroeconomic policy which may render fiscal policy unsustainable cannot be introduced to our model nor is this our intention. Given the information available to us, the multivariate cointegration method employed here would appear to be the most effective method for uncovering whether or not fiscal policy has been debt sustainable.

We expect to find two cointegrating vectors, but we may find additional steady-state relationships in the data, particularly when we consider that the Kirsanova et al. theory model has five equations; we view the most likely candidate for a third cointegrating vector if found to be an expectations-augmented Phillips Curve relating output to inflation and inflation expectations.

The cointegration structure allows us a number of insights into the interactions between the two policies we are investigating. Assuming we are able to identify cointegrating relationships as policy vectors, we have three possible sources of information:

1. Does one policy tool enter the steady state relationship of the other?

   This may seem like the most intuitive method, yet it suffers practically from the inability to identify relationships if we include the alternative policy rule in each individual policy rule cointegrating vector.

2. Does one policy tool respond to disequilibrium in the steady state relationship of the other?

   As noted earlier, the $\alpha$ matrix coefficients reveal the response of variables to disequilibrium in cointegrating relationships. Hence if one policy tool has a significant $\alpha$ coefficient corresponding to the other policy tool’s cointegrating vector, then this is a form of interaction: If one policy is tight and hence the cointegrating vector is out of equilibrium, does the other respond by tightening or loosening?

3. Historically what have the co-movements of the two policy spheres been?

   Because $\beta^{*}X_{t-1}$ is a linear combination of economic variables, we can calculate the implied path of the relationship. In expectation the relationship is zero, yet clearly it will deviate from zero if a shock hits one or more of the variables in that relationship. The deviation will be temporary since the linear combination is stationary, and hence one or more of the variables will adjust to correct the disequilibrium. Nonetheless, we can interpret the disequilibrium of a policy rule as tight or loose policy; if the policy tool is $x_{t}$, then the optimal level of the tool we can think of as a function of the other variables in the policy rule, hence $x_{t}^{*} = f(y_{t}, z_{t}, \ldots)$, and the cointegrating vector can be written as
Thus, if the cointegrating vector is positive then \( x_t > x_t^* \) and the policy tool is higher than economic conditions would dictate, as represented by \( x_t^* \); hence we could say that in this case policy is tight. Clearly also if the cointegrating vector is negative then we could say policy is loose. Thus, plotting the cointegrating vectors for the policy rules will allow us to investigate the co-movements of policies and determine whether there are any systematic patterns to be detected.

The second motivation for our empirical strategy and data choice is the use of rational expectations in many theoretical models. There are at least two issues here; first, the most appropriate way to model rational expectations, and second the appropriateness of the assumption of rational expectations. Considering the first issue, to capture the rational expectations implied restrictions on these models, generalised method of moments estimation is often used claridaetal::(e.g. Clarida et al., 1999). Mavroeidis (2004) has provided a strong critique of such estimation procedures, showing that they are weakly identified in the case of weak instruments. Regressing the interest rate variable on Clarida et al.’s (1999) instruments yields just three mildly significant variables, implying weak instruments. Bound et al. (1995) show biased and inconsistent estimators can also result from the use of weak instruments. Other studies have used the long-term interest rate (Gerlach-Kristen, 2001; Christensen and Nielsen, 2009) as a proxy for inflation expectations. The long-term interest rate encompasses expectations about expected future inflation and the state of the economy as it is the price of storing money in non-cash forms and hence being shielded from the effect of inflation. However, the long rate likely picks up a number of other effects such as structural breaks, and in a model with the short rate included, it is hard to identify a monetary-policy rule from a term structure relationship.

Turning to the second issue about the appropriateness of the assumption of rational expectations, Juselius (2006) has shown, using a cointegrated vector-autoregressive model and the rational-expectations-testing procedure of Johansen and Swensen (2004) that rational expectations restrictions are heavily rejected in the data.9 This addresses the second issue, that of the adequacy of rational expectations. Responding to all these developments, we deem it inappropriate to attempt to model rational expectations given their empirical failure.10 Instead we follow what we believe is a novel strategy in the literature: We estimate our policy rules using published inflation expectations data.11

As a novel alternative method for capturing inflation expectations, we use published data on inflation expectations. The University of Michigan’s Survey Research Centre has recorded monthly expectations of consumer price inflation since January 1978 and the Survey of Professional Forecasters has also recorded its expectations of inflation quarterly since 1981:3. The only study to our knowledge making use of inflation expectations data is Fendel et al. (2008) who estimate Taylor rules entirely on expectations data and find that agents do indeed expect interest rates to follow Taylor rules in G7 countries. Another proxy for inflation expectations is to consider the difference between the yield on inflation linked treasury bills and non-inflation linked bills, and recently an additional measure of inflation expectations has been provided by Haubrich (2009) who makes use of both the SPF inflation forecasts, Blue Chip economic forecasts and inflation swaps. These inflation swaps are available from one to thirty years and hence Haubrich provides a wealth of information on inflation expectations.

Naturally, survey-based inflation expectations are far from a perfect measure of actual expectations. In practical terms, we are only able to use expected inflation one or more years ahead, which is a little incongruous given our data is at the quarterly frequency. Furthermore, survey expectations give us little means to dig deeper into preference structures; we have no underlying structural model. Nonetheless, despite these deficiencies, it appears from the left panel of Figure 3, which plots the squared forecast errors from forecasting inflation using the various methods, that survey expectations forecast inflation well. If \( \pi_{t,t+12}^{c,i} \) is the one-year ahead expectation of inflation formed at time \( t \) from measure \( i \), then the squared forecast error for that expectation measure is \( \pi_{t+12} - \pi_{t+12}^{c,i} \). The right panel plots the different time

---

9In an unreported exercise using the restrictions implied by the theoretical models given in this paper, we also strongly rejected the null hypothesis of rational expectations.

10In a previous incarnation of this paper rational expectations testing of the Johansen and Swensen (2004) ilk was carried out with emphatic rejections of the implied restrictions (Reade, 2007, Ch. 4).

11Reade and Stehn (2010) first attempted to use survey expectations of inflation in the context of Taylor rule estimation, and Fendel et al. (2008) estimate Taylor rules entirely based on survey expectations investigating whether expectations are consistent with the Taylor rule methodology.
series, and shows that it is very hard to reconcile long-term interest rates with inflation expectations, unless it is assumed agents are extremely bad forecasters and non-rational (forecasts are systematially biased). In particular the drastic misforecasts in the early 1980s suggest that the long rate is indeed factoring in structural uncertainty — although the experience of the current economic crisis might appear to challenge that interpretation somewhat, since long rates have remained low.\footnote{An alternative explanation for long rates remaining low is quantitative easing, the intention of which is to manipulate long-term interest rates (see, e.g. Bernanke, 2010).} Survey expectations also appear to make systematic errors implying non-rational agents; from the middle panel of Figure 3 forecasts appear to have been consistently too high since the mid-1990s. A perhaps clearer indication of the relative accuracy of the survey expectations is given in the right panel which plots the average squared error over the entire sample period for the Michigan expectations (leftmost bar) and the Haubrich expectations for horizons 1 to 10 in the remaining bars. This rightmost panel shows that the combination survey and inflation-swap expectations of Haubrich perform better than Michigan although the margins are quite small as gauged from the numbers on the vertical axis. An analysis however of forecast errors is not the same as an analysis of the appropriate expectations variable; it is merely indicative. A thorough and complete investigation of inflation expectations is not the focus of this paper thus we conclude here that survey expectations are a more appropriate variable to use than long interest rates and in particular we take the Haubrich inflation expectations measure.

Considering briefly the other data series that we use for our empirical study, For inflation, we calculate this from the consumer price index (CPI) measure as the most appropriate measure; other candidates might have been the GDP deflator, or Personal Consumer Expenditures (PCE). It is unclear which of these measures will achieve greater consistency with the theoretical measure of inflation that central bankers seek to target; Rich and Steindel (2005) find that no one measure outperforms the other.\footnote{Cointegration analysis (not reported) shows that these different measures are not cointegrated hence can be expected to provide different results, emphasising the need to make the right choice.} Furthermore, we take core inflation excluding food and energy prices. This is because while it is plausible that a central bank can control inflation of domestically produced goods and services, it is not sensible to expect energy prices or weather and hence harvests to be controllable by any central bank.

CPI and survey expectations data are released monthly, and when aggregating to a quarterly frequency to match all other data series, we take the average value of each measure for the three months in that given quarter.

Turning to economic activity, it may seem sensible to consider the information provided in a wide range of different measures when considering economic activity, as policymakers surely consider various measures

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{The squared forecast error for forecasting one quarter ahead inflation using current long-term interest rates, and inflation expectatations (left panel), actual inflation and expectations (middle panel), and the mean squared forecast error from using different expectation measures to forecast inflation.}
\end{figure}
when deciding upon the level of economic activity. Although this might suggest taking the principle component of a number of measures of economic activity, previous Taylor rule studies have generally taken the output gap or some measure of firms real marginal costs to be the indicator of economic activity.\textsuperscript{14} We use the OECD output gap measure. In the top left panel of Figure 2 we plot both the OECD and CBO measures of the output gap; both are production function approaches and arrive at slightly differing pictures of US economic activity relative to trend: The CBO has been much more pessimistic in its assessment of US economic activity since the mid-part of the last decade. We ran our models using both measures and the formative results presented later are unaffected despite the differences in these measures.\textsuperscript{15}

Considering fiscal variables, there is disagreement over whether taxes, government spending or the primary balance ought to be used as the fiscal tool. Using the primary balance reduces the dimension of the system, enables us to consider a single fiscal policy rule, and corresponds to the theoretical set-up from Kirsanova et al. (2005), hence it will be used. To isolate automatic stabilisers from discretionary policy, we considered the cyclically adjusted primary balance measure from the OECD (Girouard and André, 2005); however, because this is simply a linear transformation based on the elasticity of the primary balance to the output gap, the effect is somewhat trivial on our results.\textsuperscript{16} From the middle-left panel of Figure 2 the cyclically adjusted balance still appears to be very cyclical, suggesting either that the adjustment is insufficient, or that discretionary fiscal policy is also highly cyclical.

Turning to debt, from the middle-right panel of Figure 2 we see the recent explosion in US debt-to-GDP ratio to 90\% by 2010q2. From Figure 2, the debt-to-GDP ratio is at least I(1), which contradicts Bohn (1998), who asserts that it is stationary. As mentioned above, it seems though that Bohn is suggesting that debt is cointegrated since he asserts it is stationary when other variables (the primary balance and economic activity) are controlled for. Tuxen (2007) has found that for the Eurozone, hence many of the countries in the Galí and Perotti (2003) study, debt is statistically I(2).

A striking correlation can be noted in Figure 2 between the primary balance (middle-left) and the output gap (top left): They are very positively correlated in that a positive output gap is associated with a positive (or less negative) primary balance. A reasonably intuitive explanation of this is that a growing economy has more taxpayers and less benefit seekers, and although the cyclically adjusted balance should remove these effects the adjustment appears to be insufficient. Romer and Romer (2007) attempt to isolate discretionary fiscal policy, as do Alesina and Ardagna (2010) more recently, using a descriptive approach in order to isolate explicit cases of determined fiscal policy changes as opposed to simply taking the primary balance as the measure of fiscal policy stance. Leigh et al. (2010) however argue that such identification methods can be distortionary in that they are more qualitative and subjective, emphasising that the decision about how to identify discretionary fiscal policy is a difficult one. We avoid these kinds of issues by cyclically adjusting our primary balance measure as mentioned earlier using the output-gap elasticity of the primary balance as published by the OECD. Our analysis, by considering which variable(s) adjust to steady state relationships involving these variables, also ought to help us untangle this correlation and begin to understand the dynamics of the relationship; is it output causing the primary balance, or vice versa?

Muscatelli et al. (2004) is the closest existing empirical study to ours, yet it differs along many important dimensions from our study. The model Muscatelli \textit{et al} employ includes all variables in percentage deviations from some steady-state, carries out no misspecification testing, neither is any formal or informal testing of the levels of integratedness of their data conducted. The restrictions imposed by assuming rational expectations are not tested, a number of difficult-to-estimate parameters in the model are calibrated before estimation, and others are restricted, without testing, to be less than unity.

A number of these procedures are standard in the empirical macroeconomic literature now, but that need not mean their use should not cause concern. First one must be concerned about exactly what is the steady state the variables are moving around. Time-series econometric methods allow the modelling of the steady state of a set of time series jointly, whereas Muscatelli \textit{et al} consider each variable in isolation. Furthermore,

\begin{itemize}
\item[\textsuperscript{14}]Exceptions are Gali and Gertler (1999), who motivate their use of firm marginal costs through a Calvo-pricing assumption for firms in the construction of their Phillips curve, while Christensen and Nielsen (2009) use the unemployment rate.
\item[\textsuperscript{15}]This is perhaps surprising given that it is unlikely that the two output gap measures are cointegrated, yet we are happy to provide the results from using the CBO measure to interested readers if contacted by email.
\item[\textsuperscript{16}]Where any material differences emerge, we make note of these in our results section.
\end{itemize}
time-series methods allow identification of structural breaks and other economic instabilities in the sample. Structural breaks are now very commonly appreciated concepts and hence when a steady state is taken to be simply the mean level of inflation and the interest rate, it is clear any possible breaks are not considered in the estimation of Muscatelli et al. Demeaning variables such as inflation, which averaged over 10% in the 1970s but below 2% in the 1990s and 2000s, will provide only a scaled version of inflation and not deviations from a steady state because one has not existed over the sample length considered by Muscatelli et al.

A balance must be struck between adherence to economic theory considerations and to econometric theory strictures. Too much of the former and it is unclear how well the econometric results can be trusted, yet too much of the latter and the result may be simply numbers without any economic interpretation. In our paper we attempt to strike a balance by recognising the possibility of non-stationary, and by modelling the variables relevant to the economic modelling of monetary and fiscal policy in a manner that best allows the data to speak. Such an approach naturally has some shortcomings. Our estimation will not be as tightly knit to any economic theory model and hence very tight model predictions are less feasible. In particular, many of the structural parameters in Muscatelli et al’s model are not specified in our model because they are not estimable. This is an ever-present problem in empirical macroeconomics: Tighter assumptions give more precise model predictions, but if those tight assumptions are non-credible then those precise model predictions are in danger of being precisely wrong and hence of little value. Our approach is perhaps best expressed in Hendry (1995) and described as general-to-specific.

Part of the general initial econometric estimation is ensuring that the model is well specified. This means ensuring that as much as possible, all systematic variation in the dependent variables can be explained by those explanatory variables included in the model, and is not left in the residuals — that bit which we are ignorant about. This has particular value in that it enables confidence to be taken in any statistical procedures undertaken since these procedures are tried, tested and reliable when the assumptions of the statistical model are satisfied.

By starting general, restrictions such as those implied by rational expectations can be tested, adding considerable value to the process of learning about the macroeconomy. Perhaps more importantly, the steady state of the macroeconomy being modelled can be found from the estimation, and not by filtering each variable separately. A macroeconomic steady state must reflect overall conditions in the macroeconomy, and individually detrending/demeaning variables cannot do that.

When appropriate care is taken for the econometric features of the economic data as well as the economic theory that provides the rationale for modelling, standard theoretical results are not necessarily supported. Juselius (2007) devotes much attention to this discord. Nonetheless, the reduced-form results that we can produce using econometrics can help shape and form the stylised facts that macroeconomic theories must attempt to replicate.

Finally we should note one concern with previous attempts to estimate monetary and fiscal interactions that is not addressed in this paper, notably that of revised data. In most of these studies the most recent data available are used, which often entail numerous data revisions by statistical authorities. An alternative strategy to this might be to try to use the data available to the policymaker at the time of the policy decision. Orphanides (2001) has argued that this provides a more accurate reflection of the decision process of monetary and/or fiscal policy, and has also shown, using real-time data on estimates of monetary-policy rules, that estimated reaction coefficients fall, with possible violation of the Taylor principle. Such parameter shrinkage might be expected with the greater uncertainty policymakers face in real-time (Brainard, 1967). Real-time databases exist (for example Croushore and Stark, 2001), but a production-function-based output-gap measure has not yet been constructed. Implementing real-time variants of empirical models, as with any alternative approach, is not a panacea; it would appear to neglect important factors such as measurement error, which will likely induce serial correlation in residuals. Additionally, while the response in real-time is of interest, also equally important is what the actual response was to; more accurate, revised data gives a better idea of exactly what monetary or fiscal policy reacted to. As such, the data used in this paper are revised and not real time.
We turn now to the results from estimating our cointegrated VAR model.  

5 Econometric Output

We split this section on our econometric output into two sections to aid readability. The first part, Econometric Details, describes how we arrived at our model and hence discusses issues such as lag-length selection and model specification more generally. The second part of the section, Econometric Results, reports the actual model results and discusses them.

5.1 Econometric Details

We turn now to the results from estimating our cointegrated VAR model.\(^{17}\) A first important step is to account for outliers corresponding to well-known periods of economic stability; such a strategy is somewhat controversial yet it is statistically harmless (Hendry et al., 2008) and economically meaningful: We can concentrate on uncovering the true data generating process by removing the noisy impact of outlying observations. We thus add three outliers, relating to the Great Recession of 2008–2010, in 2008q2 and 2008q4, and also the recession that followed the dot.com bust (2001q3). With these outliers we are able to estimate a model over the time period beginning 1983q2 and ending 2010q2.\(^{18}\) Five lags are chosen to ensure the absence of residual autocorrelation and a well-specified model, as can be seen in Table 2 (see next paragraph for a discussion of this Table).\(^{19}\) Thus each equation of the 6-variable VAR has 34 parameters and 109 observations.

We initially model an unrestricted VAR to ensure that it is a well specified representation of the data before imposing cointegrating restrictions on our model. To ascertain whether the model is indeed well specified, it is subject to a battery of misspecification tests. The tests are provided in Table 2 where the test and test distribution are described in the first two columns, and in the remaining columns a larger font number is the test statistic, with its associated p-value in parentheses below. An asterisk denotes a test rejection at the 5% level, and two asterisks denotes a rejection at the 1% level. An ideal model will fail very few tests indeed, given statistical limits. It is wise to test at the 1% level given the number of tests being carried out, as the tests are near-independent, as this limits the probability of making at least one error in the 24 tests reported. Given this significance level it can be seen that there is just one borderline test failure, for Normality in the interest rate equation. Although we are able thus to attribute this one test failure to statistical chance, further investigation of the test failure reveals a small amount of excess skewness present in the residual distribution; such a symptom can cause problems with the trace test and hence we make use of additional information related to our model as mentioned in the previous section when determining the rank of the system.

Having selected the appropriate VAR model specification, a trace test is carried out for rank determination. Table 3 gives the outcome of the trace test. We follow the Johansen (1995) procedure and begin testing from a rank of zero, and we continue to test for a rank one higher if a test is rejected, stopping when we find a test non-rejection. Table 3 suggests the rank of our system is three; the decision between rank two

Table 2: Misspecification testing on the estimated VAR model.

<table>
<thead>
<tr>
<th>Test</th>
<th>Distribution</th>
<th>(y_t^{gap})</th>
<th>(\pi_t)</th>
<th>(\pi_t^e)</th>
<th>(pby_t)</th>
<th>(dy_t)</th>
<th>(r_t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR 1-5 test</td>
<td>F(5,70)</td>
<td>1.78</td>
<td>1.35</td>
<td>2.32</td>
<td>1.43</td>
<td>1.88</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.13)</td>
<td>(0.25)</td>
<td>(0.05)</td>
<td>(0.22)</td>
<td>(0.11)</td>
<td>(0.49)</td>
</tr>
<tr>
<td>ARCH 1-4 test</td>
<td>F(4,101)</td>
<td>0.83</td>
<td>1.74</td>
<td>0.22</td>
<td>0.98</td>
<td>0.80</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.51)</td>
<td>(0.15)</td>
<td>(0.93)</td>
<td>(0.42)</td>
<td>(0.53)</td>
<td>(0.84)</td>
</tr>
<tr>
<td>Normality test</td>
<td>(\chi^2(2))</td>
<td>0.26</td>
<td>0.41</td>
<td>2.05</td>
<td>1.45</td>
<td>1.15</td>
<td>9.93**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.88)</td>
<td>(0.81)</td>
<td>(0.36)</td>
<td>(0.48)</td>
<td>(0.56)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Hetero test</td>
<td>F(60,45)</td>
<td>0.96</td>
<td>1.38</td>
<td>0.96</td>
<td>0.76</td>
<td>1.68*</td>
<td>1.55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.57)</td>
<td>(0.13)</td>
<td>(0.57)</td>
<td>(0.85)</td>
<td>(0.04)</td>
<td>(0.06)</td>
</tr>
</tbody>
</table>

\(^{17}\)The empirical output in this paper is carried out using OxMetrics6 (Doornik, 2007).

\(^{18}\)We are only able to get debt data up to 2010q2, and the Haubrich expectations begin only in January 1982 (Michigan expectations start in January 1979 yielding only a few additional observations).

\(^{19}\)Hence our data sample actually begins in 1982q1 but we lose five observations.
<table>
<thead>
<tr>
<th>rank</th>
<th>eigenvalue</th>
<th>Trace test</th>
<th>p-value</th>
</tr>
</thead>
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<tr>
<td>0</td>
<td>180.9</td>
<td>0.00**</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.50</td>
<td>104.9</td>
<td>0.00**</td>
</tr>
<tr>
<td>2</td>
<td>0.33</td>
<td>61.52</td>
<td>0.01**</td>
</tr>
<tr>
<td>3</td>
<td>0.24</td>
<td>32.12</td>
<td>0.10</td>
</tr>
<tr>
<td>4</td>
<td>0.15</td>
<td>14.08</td>
<td>0.29</td>
</tr>
<tr>
<td>5</td>
<td>0.12</td>
<td>0.233</td>
<td>0.99</td>
</tr>
<tr>
<td>6</td>
<td>0.00</td>
<td></td>
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</tr>
</tbody>
</table>

Table 3: Trace test results

and three, which could be viewed as mildly borderline at a 1% significance level, can be settled by considering the next largest root of the system when the different ranks are imposed. When we imposed a rank of two, the next largest root of the system is 0.97, whereas when we impose rank three the next largest root is at just 0.91. This suggests that we should choose a rank of three.

5.2 Econometric Results

Thus having chosen a rank of three, we can proceed to estimate a cointegrated VAR model, and identify it. We attempt to identify the three cointegrating vectors as a monetary policy rule, a fiscal policy rule and an expectations-augmented Phillips Curve. Hence as discussed earlier we must restrict the primary balance and debt to be equal to zero for the monetary policy rule, the interest rate and inflation/inflation expectations equal to zero in the fiscal policy rule, and we restrict the two policy tools to be zero in the Phillips Curve. Once these restrictions are imposed and the system identified, standard errors can be calculated and the significance of other variables assessed. At this point, we found that whichever of inflation or inflation expectations had not been restricted in the fiscal policy rule was insignificant, thus meaning that our identification choice was irrelevant between these two variables. Of more surprise was to find that in the Taylor Rule for monetary policy, the output gap term was very insignificant, albeit of the right sign. In a rank two system, the output gap term would have been significant and of the right sign, suggesting that the presence of a third, Phillips Curve, steady state relationship takes this term out of the Taylor rule. We will return later to interest rate behaviour in relation to the output gap when we discuss adjustments to the Phillips Curve.

The adjustment factors, the $α$ matrix coefficients, are simply reported as they are, to give an idea of their significance, instead of being restricted to zero and hence not reported. The model we report is thus, written in simplified form as $\Delta X_t = \hat{\alpha} \beta' X_{t-1}$ to aid interpretation:

$$
\begin{pmatrix}
\Delta r_t \\
\Delta pby_t \\
\Delta \pi_t \\
\Delta \pi_{t}^{e} \\
\Delta y_{t}^{gap} \\
\Delta dy_t
\end{pmatrix} =
\begin{pmatrix}
-0.50 \\
-0.22 \\
-0.04 \\
0.10 \\
-0.02 \\
0.22
\end{pmatrix}
\begin{pmatrix}
0.11 & (0.07) \\
0.05 & (0.24) \\
0.02 & (0.16) \\
0.01 & (0.09) \\
0.21 & (0.09) \\
-0.48 & (0.30)
\end{pmatrix}
\begin{pmatrix}
\pi_{t-1} - 3.87 \pi_{t-1} - 8.26 \pi_{t-1} + 0.08 \\
\pi_{t-1} - 0.70 \pi_{t-1} - 0.59 \pi_{t-1} + 0.05 \pi_{t-1} + 0.02 \\
\pi_{t-1} - 0.59 \pi_{t-1} - 0.15 \pi_{t-1} + 0.12 \\
\pi_{t-1} - 0.15 \pi_{t-1} + 0.05 \pi_{t-1} + 0.02 \\
\pi_{t-1} - 0.05 \pi_{t-1} + 0.00 \pi_{t-1} + 0.00
\end{pmatrix}.
$$

Here, the $\hat{\alpha}$ matrix is of dimension $6 \times 3$ reflecting the six variables in our model and the three cointegrating vectors, while the $3 \times 1 \hat{\beta}$ matrix contains those three cointegrating vectors; they are on the top row the monetary policy vector, on the second row the fiscal policy vector and on the final row the Phillips Curve. A bold face coefficient in the $\hat{\alpha}$ matrix denotes a strongly significant coefficient; all are reported, whether significant or not.
Considering first the monetary policy rule, we can write it rearranged in terms of the interest rate, for better exposition:\(^\text{20}\)

\[ r_t = -3.87 \pi_t + 8.26 \pi_t^2 - 0.08 + e^{cm1}_t. \]  

At first glance, this looks little like the standard Taylor Rule because the inflation term is of the wrong sign, and the output gap term is insignificant and hence omitted.\(^\text{21}\) However, what this policy rule does display is strong forward-lookingness: The coefficient on the inflation expectations term is of the right sign (positive) and large at 8.26; taken on its own or in combination with the contemporaneous inflation term, the Taylor Principle, that the real interest rate should rise in response to an increase in inflation (anticipated or otherwise) is satisfied.\(^\text{22}\) Hence it would appear that monetary policy has been set over this sample period (since 1982) in a forward-looking manner, a conclusion that while in line with the literature (e.g. Clarida et al., 2000) is novel in that it is found using expectations data.

The next surprise when considering the monetary policy rule is found when considering the adjustments to the vector: the interest rate insignificantly adjusts and with a small coefficient relative to its adjustments to other vectors. It was mentioned earlier that we should expect to find a policy tool adjusting to its own policy rule; if not the policy regime is characterised as active as opposed to passive. Hence it might appear from here that policy is active, although we should consider whether the policy tool responds to other policy rules or macroeconomic relationships before concluding in that manner. As mentioned also earlier, we would expect to find target macroeconomic variables adjusting to the policy rule, and so we now consider these other variables; both inflation and inflation expectations adjust to disequilibrium in this relationship and correct any disequilibrium suggesting that monetary policy is effective in influencing both inflation and expected inflation, two important objectives of policy. It would seem that monetary policy has minimal impact on output via the output gap; nonetheless, this ought to be somewhat expected since economic theory implies that neither monetary nor fiscal policy ought to be able to permanently impact economic growth. Finally, debt appears to react significantly to this policy vector, although given that debt does not enter the relationship, it is somewhat difficult to interpret this coefficient. We will continue to interpret this vector and its implications for policy as we discuss the other two cointegrating vectors and the adjustments to them.

Turning to the second cointegrating vector, that for fiscal policy, again it is written below in terms of the fiscal policy tool for exposition:

\[ pby_t = 2.03 y_t^{gap} + 0.15 dy_t - 0.12 + e^{cm2}_t. \]  

The fiscal policy rule has a counter-cyclical output gap term, and a debt correction term. The size of the output gap term is somewhat at odds with the theory prescribed earlier in that it is quite large, and larger than the insignificant output gap term for the monetary policy vector. If we used the cyclically adjusted primary balance, this reduces the output-gap coefficient down to 1.7 and leaves all else unaffected since we merely take a linear combination of variables within our system. Hence controlling for cyclical movements in the primary balance does not reduce the size of the counter-cyclical term particularly much. Additionally, both inflation and inflation expectations are found to be insignificant in this policy vector, the former against the theory expectations but the latter in line with them. However, it does seem somewhat more realistic that fiscal policy is set with regard to the output gap as opposed to inflation or its expectations; justifications for fiscal stimuli in the context of the Great Recession made no reference to levels of inflation but instead to the output gap, and referring back to our monetary policy rule, although the Federal Reserve does not explicitly inflation target and has instead a more general mandate for setting policy, it has been noted that the control of inflation is often deemed paramount by Federal Reserve officials [citations??]. The debt

\(^{20}\) Also changing the time subscripts from \( t - 1 \) to \( t \) since in the context of discussing the cointegrating vector, the time period is relative as opposed to absolute.

\(^{21}\) If retained, it had a coefficient of 0.23 and standard error of 0.37.

\(^{22}\) If we only run a backward-looking model, the inflation term fulfils the Taylor principle. The coefficient on the inflation term in the monetary policy rule in a rank 2 system, where the primary balance and debt are excluded due to insignificance, is -2.23, satisfying the Taylor principle.
adjustment term does suggest that fiscal policy is set with regard to the overall level of debt, and the small coefficient is consistent with the theory set out earlier.

Turning to the adjustments to this vector, the primary balance itself does adjust to this vector which suggests that fiscal policy is passive in that it follows its own rule. The primary balance corrects 22% of any disequilibrium each quarter. The debt ratio also adjusts strongly to this policy rule, correcting up to half of the disequilibrium, suggesting that debt ‘works harder’ to correct fiscal imbalances. Economic growth also responds and corrects disequilibrium: If growth is too low given the values of the debt and deficit ratios, then growth will increase to close 21% of the disequilibrium. It is also worth noting that if the primary balance is too high for equilibrium, hence the balance is higher than is optimal given the economic conditions (which could be interpreted as an austerity position), that the output gap will adjust upwards to re-establish equilibrium; it appears that fiscal retrenchment can be expansionary. This is, of course, an analysis that takes into account more than just fiscal policy in isolation however, and is an analysis based entirely on data movements in the past thirty years in the US.

Shedding more light on this finding, we can consider both the monetary and fiscal cointegrating vectors plotted the left panel of Figure 4. When either cointegrating vector is positive, this implies that the tool is higher than economic conditions imply, and hence we can describe this as a tight policy. Hence we can plot whether the two policies move in tandem or act against each other using Figure 4; we say policies are complementary if both yield opposing effects and hence are used to offset each other, and substitutionary if policies can be substituted for each other to achieve the same effect and hence have been used in the same direction in the data. The clear implication from Figure 4 is that the two policies actually act as complements: When fiscal policy is loose (negative), monetary policy is tight (positive), and vice versa. This contracts a little to the finding of Muscatelli et al, who found the policies to be asymmetric complements: Both tighten at the same time although fiscal policy loosens when monetary policy tightens. Starting in the mid-1980s where fiscal policy was tight and monetary policy loose, we see continually that the two policy spheres take opposing positions in the tightness spectrum. Particularly post 2002 we see the unravelling of the tight fiscal policy of the Clinton years into the Bush tax cuts and a much looser fiscal position, yet this is juxtaposed against a gradually tightening monetary policy after the very loose years in the early 1990s surrounding the dot.com boom and bust (which has been noted by amongst others Taylor and Press (2009) who cite this as a prime cause of the financial crisis). During the current downturn initially fiscal policy was loose in 2007 and 2008 but then entered into neutral territory after this, while monetary policy appears to have been notably tight throughout, supporting the claims by many that the Federal Reserve is not doing enough to combat the recession and the negative impact on inflation expectations (see, for example, Sumner, 2009). This analysis though does abstract from quantitative easing, the strategy of the Fed purchasing long-dated bills to influence long-term interest rates.

These findings are relevant for the unprecedented peacetime levels of government budget deficits built up off the back of large fiscal stimuli since the financial crisis of 2007–08. Firstly, the significant adjustment coefficient for the output gap to the fiscal policy relationship of 0.21 suggests that fiscal policy does impact output and suggests that Ricardian equivalence is not supported in the data: Debt and deficit levels do have real impacts on the economy. However, the direction of that impact is negative in the sense that a higher primary balance surplus increases growth, and a higher primary balance deficit inhibits growth.23 Thus an initial reading would hence suggest that indeed fiscal austerity is expansionary. Nonetheless, a Keynesian slant is possible here: if a negative shock takes place to output, then the cointegrating vector will be in positive disequilibrium, and while output will adjust as will the other variables, if the weakly exogenous fiscal policy tool happens to be stimulative (i.e. goes more negative) then it can help re-establish equilibrium more quickly. This would appear to be quite a coherent understanding of fiscal policy; indefinite stimulative policy and budget deficits will lead to a low (or negative) growth path, but short, sharp bursts of fiscal stimulus could be beneficial in ‘setting the economy back on track’, so to speak. Secondly, although the primary balance itself will not move to ensure debt sustainability according to the model, other variables will: The output gap, inflation (marginally) and the interest rate all adjust to disequilibrium to ensure fiscal sustainability, and hence a number of possible scenarios can be envisaged in the months and years ahead:

---

23 This positive correlation between the output gap and the primary balance was noted in Figure 2.
A high growth recovery helping ensure debt sustainability, high inflation eroding the real value of the debt hence making it more manageable and potentially interest rates reacting to ensure sustainability, perhaps staying low to help keep the cost of debt servicing low.

Furthermore, it is clear that throughout our sample the two policies have been complementary in that one is tight when the other is loose; hence clearly for austerity to be expansionary, a loose monetary policy would be required (in the context of zero interest rates one might speculatively argue in favour of quantitative easing here). As mentioned in Section 4, we are also able to investigate the adjustments to this steady-state relationship in order to think more about the dynamics of the output gap-primary balance relationship. The adjustment coefficients of the two variables are significant and of similar size (0.22 and 0.21), and both variables correct disequilibrium that appears in the relationship. However, since the coefficient on the output gap in the cointegrating vector is 2.03 then the output gap has to move half as much as the primary balance to re-establish equilibrium, suggesting it is the output gap that reacts more quickly to disequilibria than the primary balance; this might be expected given the time lags involved with the implementation of fiscal policy. This would appear to hint in the direction that it is the primary balance driving the output gap and hence that fiscal retrenchment, allied with monetary easing, could be expansionary.

This fiscal policy rule accords fairly well to what Bohn (1998) found for the US over numerous periods; Bohn also finds that the primary balance and output gap move together, and finds a positive, albeit smaller coefficient on his debt term. It is perhaps even more surprising that Bohn’s coefficient is substantially smaller than ours given also that his data is annual. Nonetheless, it ought to be emphasised that our estimation procedure differs considerably from Bohn’s, and this may drive some of the divergence. A potentially important difference is that we model the endogeneity between the data series relating to fiscal policy and debt sustainability.

Our final cointegrating vector is our Phillips Curve relationship, augmented by inflation expectations. We can write it as:

\[ \pi^e_t = 0.70\pi_t + 0.59y_{gap}t + 0.05d_{yt} - 0.02 + ecm3_t. \] (18)

Writing making expectations the subject of the equation appears to make most economic sense in terms of coefficients, although we should emphasise that no causality can be inferred from the right-hand side of (18) to the left, as is commonly attempted in estimated regression models. We should interpret this relationship as describing how variables move together in equilibrium: It describes a stationary linear combination of economic variables. We see that actual inflation feeds into the formation of inflation expectations, as does the level of the output gap and also debt. The higher is actual inflation, the output gap and debt, the higher are expectations of future inflation. Interestingly, considering the adjustments to this cointegrating vector, we note that both policy vectors adjust to this vector. Thus if inflation or the output gap are too high (negative disturbance to the cointegrating vector), interest rates will rise and hence we perhaps see the wider Fed mandate in how the monetary policymaking tool reacts to inflationary pressures in the wider economy. Also of interest is that inflation and inflation expectations do not actually adjust to this relationship but instead drive it — although of course both adjust to the monetary policymaking vector, hence we might interpret this as suggesting that inflation and inflation expectations are important in driving where the economy is moving, yet both are influenced by the monetary policymaker via its interest rate tool (and plausibly via quantitative easing also). Debt adjusts to the Phillips Curve relationship also: If output is too high for equilibrium then the debt ratio falls (since GDP is the denominator), and if inflation is too high again debt falls as it is inflated away.

Considering again policy interactions, we noted in Figure 4 that the two policies are complements. Additionally we can consider the adjustments of the policy tools to the other policymaker’s policy rule when thinking about interactions. From the \( \hat{\alpha} \) matrix in (15) we note that the interest rate adjusts to the fiscal rule, albeit with a t-ratio of only about 1.6; the adjustment is also such that if fiscal policy is tight, the interest rate moves up and hence monetary policy tightens also. This suggests a more substitutionary nature of the policy interactions in that they both move in the same direction. However, that the extent of this movement is small it would appear to not be the dominant interaction in policies, particularly given the pronounced movements noted in Figure 4. Considering the reverse interaction, the primary balance
adjusts to the monetary policy rule with a borderline significant t-statistic of 1.8; the coefficient is positive suggesting that if monetary policy is tight (positive disequilibrium) then the fiscal policymaker tightens also by increasing the primary balance. Thus both of these borderline significant coefficients for interactions suggest that the two policy spheres are substitutes in that they both tighten or loosen at the same time, and hence given the evidence in Figure 4 suggesting that the policy spheres are complements, the evidence produced here is somewhat mixed. It may well be that the insignificant adjustment for the interest rate, and the addition of the Phillips Curve is what drives this apparent confusion. Furthermore, it may be that the shocks hitting the economy are such that they lead to one of the two policies appearing to be tight (loose), and hence policies are not responding to the intended stances of the other policy but to the outcomes of particular shocks. This seems particularly likely since the two policy rules are characterised as moving with different economic variables (we reassert here that the common variables omitted from these rules were very insignificant), and hence we can realistically think of shocks that affect inflation or expectations but not output, or vice versa. The disequilibria in the cointegrating vectors would appear to be the most clear evidence for the relative stances of the policy spheres based on our interpretation of disequilibria, and hence we propose that the two policies are complements.

Thus using a cointegrated VAR model we have conducted a data-rigorous investigation of monetary and fiscal policy interactions based on an theoretical prior. Many macroeconomic studies augment analysis with impulse response analyses and other simulation-based exercises. While the temptation is great to carry out such extensions, they are critically dependent on the estimated model being something akin to the true model, and even then heavily reliant on, and very sensitive to, particular identification strategies. Finally, an assumption of stationarity between the sample period and the future period is crucial also. The model estimated is estimated over the historical period since 1982, and while it may be useful for forecasting, much available evidence suggests that it will be subject to considerable forecast failure Hendry and Clements (2001), and hence we refrain from carrying out any out-of-sample exercises on our data, particularly given the current state of structural uncertainty in the economy. The coefficients of the $\Gamma_i$ matrices listed in (12) are not reported for brevity; they only relate to short-run movements in the data and not the long-run, and hence for the purpose of discovering long-run, systematic, equilibrium movements in monetary and fiscal policies, they are of secondary importance.

6 Conclusions

In this paper we have investigated empirically the issue of monetary and fiscal policies and their interactions. Survey data on inflation expectations have been used to circumvent the difficulty with modelling expectations historically, and the cointegrated VAR methodology is employed as this is argued to be the most
meaningful and appropriate way to model what are non-stationary economic time series. The advantage also of employing cointegration methods is that each policy realm will be expected to have its own steady state path, which should be uncoverable in the data, and responses of the policy tools and target variables can be ascertained also using the cointegrated VAR approach.

In the analysis, monetary policymaking is found to be heavily forward looking, and also borderline active in the sense that it does not respond to its reaction function, or policy rule, as embodied in a cointegrating vector. Fiscal policy on the other hand is found to be passive, responding to its policy rule and ensuring debt sustainability. There appears to be a negative impact of fiscal profligacy long-term in terms of lower than potential economic growth, but in the short-term fiscal policy does appear able to influence output relative to potential. This conclusion would appear relevant for the debate on the efficacy of fiscal stimuli; they are effective in the short term, but in the longer term should be phased out, rather akin to the traditional textbook exposition of fiscal policy. We have drawn out the interactions between the policy spheres perhaps most graphically in Figure 4, and it appears on the balance of evidence that the two policies have acted as complements in the US, moving in opposite directions.

Thus we have considered monetary and fiscal policies and their interactions in an appropriate econometric context making use of a novel strategy to capture inflation expectations, and arrived at coherent conclusions for both policy spheres, and the interactions between them.

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