Do expectations matter? The Great Moderation revisited

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Abstract

We examine the role of expectations in the Great Moderation. We derive theoretical restrictions in a simple New-Keynesian model and test them using measures of expectations obtained from survey data, the Greenbook and bond markets. Expectations explain the dynamics of inflation and of interest rates but their importance is roughly unchanged over time. Systems with and without expectations display similar reduced form characteristics. Including or excluding expectations does not change the explanation of the Great Moderation. Results are robust to changes in the structure of the empirical model.

JEL classification: C11, E12, E32, E62

Key Words: Indeterminacy, Expectations, Term structure, Structural VARs, Sunspot shocks.

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1 Introduction

Many authors have examined the "Great Moderation" episode in the US (see Clarida, et. al. (2000), Blanchard and Simon (2001), Cogley and Sargent (2001) (2005), Stock and Watson (2002), Gambetti et. al. (2005), Gordon (2005) Primiceri (2005), Arias, et. al. (2006), Sims and Zha (2006) among others) and its international features are currently under investigation (see Stock and Watson (2004), Benati and Mumtaz (2006) or Canova, et. al. (2007)). Most analyses agree on the observation that the volatility and the persistence of output and inflation have declined since the late 1970s but explanations differ. The literature is mainly divided into two fronts - those who support the "bad policy" hypothesis (failure of the Fed to appropriately respond to inflation) and those who lean toward the "bad luck" hypothesis (shocks are drawn from a distribution with time varying features) - with a few authors claiming that changes in the private sector (see e.g. McConnell and Perez Quiroz (2001), Canova (2005), Campbell and Herkovitz (2006)) or reduced activism combined with decreased missperceptions (Orphanides (2004), Orphanides and Williams (2005)) may be responsible for the phenomenon. The division appears to be linked, in part, to the type of data one uses (real time vs. historical) and, in part, to the type of empirical analysis one conducts: while narrative and reduced form approaches consistently point to "bad policy" as key to explain the facts, structural VARs favor the "bad luck" conclusion. Given the strong prior of many commentators, some have questioned the ability of structural VARs to detect true sources of variations in the data (see Benati and Surico (2006)).

The most convincing formalization of the " bad policy" hypothesis appears in Lubik and Schorfheide (LS) (2004) who, building on the work of Clarida, et. al. (2000), estimate a three equations New-Keynesian model with Bayesian methods over subsamples and find an indeterminate equilibrium in the first subsample (up to the end of the 1970s) but not in the second one (from the beginning of 1980s up today). Boivin and Giannoni (2006) confirm this conclusion with an alternative estimation technique. One important consequence of this finding is that while expectations were driven by non-fundamental forces in the 1970s, they became function of fundamental factors when the Fed strenghtened reaction of the nominal rate to inflation. Despite the fact that the dynamics of expectations could be crucial to understand the facts and to assess the credibility of the explanation, no one has formally examined whether expectations fit the role that the indeterminacy-determinacy story of the Great Moderation has given to them. Leduc et. al (2005) studied how much the nominal rate moves in response to expected inflation shocks and whether there has been a change in the magnitude and the persistence of expected inflation shocks, but they do not directly examine the importance of inflation expectations in the two regimes.

In this paper we study the role of expectations in the Great Moderation episode. To start with, we derive the population implications of a simple New-Keynesian model, using a parameterization which replicates the most salient aspects of LS estimates. Three basic implications emerge. First, the indeterminate regime differs from the determinate one because a state variable is important in the former but not in the latter. If expectations play the role of this additional state variable, they should help to predict other variables in the indeterminate sample and there should be a break in the significance of predictive tests, as we move from the indeterminate to the determinate regime.

Second, changes in the policy rule imply changes in both the impact coefficients and the lagged responses to shocks. This is true when policy changes imply regime switches and when they do not. Hence, regimes can not be separated by examining the relative magnitude of the changes in the lagged dynamics and in the variance of the reduced form shocks or the standard counterfactuals performed in the literature.

Third, several explanations are "locally" indistinguishable from the indeterminacy-determinacy story. That is, it is possible to reproduce the population dynamics in response to structural shocks of the indeterminacy regime with a specification where only a determinate equilibrium exists and structural parameters are appropriately adjusted. Interestingly, while the pure "bad luck" hypothesis, where only the variance of the structural shocks is adjusted, does not display this feature, alternative specifications, where changes in the parameters of the private sector and/or the policy rule are combined with particular variations in the variances of the shocks, have such a property. Hence, regimes can not be distinguished by examining the dynamics in response to shocks either.

In our analysis we proceed as follows. We collect alternative measures of one year ahead expectations using survey data (Michigan, Professional, Livingstone), the Greenbook, and the term structure of nominal interest rates. We, then, run several VARs which include output growth, inflation, the nominal interest rate, and a proxy measure of expectations and examine whether (i) the coefficients on lagged expectations are significant and (ii) their significance changes over time. We complement this analysis by examining whether omitting expectations from the estimated system causes time varying biases in the variance of reduced form shocks. Finally, we study whether the absence of expectations from the estimated system alters the interpretation of the Great Moderation. Since expectations have been systematically excluded from empirical models examining the episode, we want to know whether conclusions are robust to this omission or not.

Our results suggest that the role of expectations differs from the one postulated by the indeterminacy-determinacy story. In particular, regardless of the specification of the empirical model and the statistics used, we find that (i) lags of expectations are either always significant or always insignificant and there is no clear switch in their importance in any equation of the system over time; (ii) reduced form variances estimated in systems with and without expectations display similar features and little evidence of time varying biases; (iii) the economic interpretation of the Great Moderation episode is largely independent of the exclusion of expectations from the empirical system. Consistent with Gambetti et. al. (2005), supply and real demand shocks are crucial to understand the time profile of output growth volatility and persistence while supply and monetary shocks drive the time variations in inflation persistence and volatility; (iv) sunspot shocks have little effects on output growth and inflation volatility and persistence and changes in their contribution over time do not line up well with the time variations in these statistics.

The rest of the paper is organized as follows. The next section examines the implications of a simple theoretical model. Section 3 describes our expectation measures. Section 4 presents the empirical evidence. Section 5 discusses the causes of the Great Moderation. Section 6 measures the importance of sunspot shocks. Section 7 concludes.

2 What does theory tells us

To set up ideas it is useful to consider a simple univariate example. Let $y_t = \frac{1}{\theta} E_t y_{t+1} + e_t$, where e_t is iid $(0, \sigma^2)$. When $\theta > 1$, $y_t = \sum_j (\frac{1}{\theta})^j E_t e_{t+j} = e_t$; when instead $\theta < 1$, $y_{t+1} = \theta y_t - \theta e_t + v_{t+1} \equiv \theta y_t + u_{t+1}$, where $v_{t+1} = y_{t+1} - E_t y_{t+1}$. Clearly, if $v_{t+1} = e_{t+1}$, $y_t = e_t$ also when $\theta < 1$. In general, the two solutions will be different. Hence, in this example, a switch in regime can be equivalently represented with a change in the value of θ or with the elimination of the expectation shock v_{t+1} from the solution.

Suppose v_{t+1} is a pure sunspot shock. In the indeterminate regime, since $E_t y_{t+1} = \theta y_t - \theta e_t$ and since y_t is independent of e_t, $E_t y_{t+1}$ helps to forecast y_{t+1}, even when y_t is available. Since this will not be true in a determinate regime, two basic conclusions emerge: first, expectations should help to predict y_{t+1} in the indeterminate regime but not in the determinate one. Second, using expectations should produce forecast errors which are smaller than those produced when expectations are disregarded.

To show that these two basic conclusions carry over to more interesting setups, consider a standard three-equation New-Keynesian model which includes a log-linearized Euler condition, a log-linearized Phillips curve, and a log-linearized policy rule. While this structure is basic, the implications it delivers about regime switches are the same as those obtained in models with additional frictions and more shocks. In deviation from a non-stochastic steady state, the equations are:

$$R_t = \phi_r R_{t-1} + (1-\phi_r)(\phi_\pi \pi_t + \phi_x (x_t - z_t)) + e_{R,t} \quad (1)$$

$$\pi_t = \beta \pi_{t+1|t} + \kappa (x_t - z_t) \quad (2)$$

$$x_t = x_{t+1|t} - \tau (R_t - \pi_{t+1|t}) + g_t \quad (3)$$

where $g_t = \rho_g g_{t-1} + e_{g,t}$, $z_t = \rho_z z_{t-1} + e_{z,t}$, x_t is the output gap, π_t the inflation rate, R_t the nominal rate, and the notation $t+1|t$ denotes conditional expectations. Here, g_t is a demand shifter, z_t exogenously shifts the marginal cost of production while $\beta, \kappa, \tau, \phi_r, \phi_\pi, \phi_x, \rho_g, \rho_x, \sigma_{eR}$, σ_g, σ_z and ρ_{gz}, the contemporaneous correlation between g_t and z_t, are parameters.

Table 1: Model Parameterization

Parameter	Regime 1 Indeterminate	Regime 2 Determinate	Regime 1 Determinate 1	Regime 1 Determinate 2
β	0.99	0.99	0.99	0.99
τ	1.45^{-1}	1.45^{-1}	1.75^{-1}	1.45^{-1}
κ	0.77	0.77	0.58	0.77
ρ_g	0.68	0.68	0.74	0.74
ρ_z	0.82	0.82	0.74	0.77
σ_g	0.27	0.27	0.29	0.33
σ_z	1.13	1.13	1.05	1.31
σ_{eR}	0.23	0.23	0.15	0.15
ϕ_π	0.77	2.19	1.75	1.51
ϕ_x	0.17	0.30	0.82	0.87
ϕ_R	0.60	0.84	0.81	0.86
ρ_{gz}	0.14	0.14	0.14	0.14

To describe the population features of this model in different regimes we use a parametrization similar in spirit to the estimates of Lubik and Schorfheide (2004) (see table 1, columns 1 and 2), which were obtained with US data and Bayesian methods over the subsamples (1960:1-1979:2, 1982:4-1997:4), although none of the points we make depend on the exact parameter selection. Note that the only change in the first two columns of table 1 involves the coefficients of the policy rule. As in the univariate example, when the reaction of the nominal rate to inflation is weak ($\phi_\pi < 1$) an indeterminate equilibrium obtains; when the reaction is strong ($\phi_\pi > 1$), a determinate equilibrium emerge.

The log-linearized decision rules for the nominal rate, the inflation rate and the output gap are as follows. For the indeterminate regime, the continuity solution (see Lubik and Schorfheide (2003)) produces:

$$\begin{bmatrix} \widehat{R}_t \\ \widehat{\pi}_t \\ \widehat{x}_t \end{bmatrix} = \begin{bmatrix} -0.24 & -0.41 & -0.33 & -0.28 \\ 0.23 & -0.19 & -0.59 & -0.15 \\ 0.19 & -0.45 & 0.07 & 0.19 \end{bmatrix} \begin{bmatrix} \widehat{R}_{t-1} \\ \widehat{\pi}_{t-1} \\ \widehat{x}_{t-1} \\ \widehat{y}_{t-1} \end{bmatrix} + \begin{bmatrix} \widehat{u}_{1t} \\ \widehat{u}_{2t} \\ \widehat{u}_{3t} \end{bmatrix}, \Sigma_u = \begin{bmatrix} 0.31 & & \\ 0.96 & 3.39 & \\ -0.15 & -0.42 & 0.40 \end{bmatrix}$$

where y_t could be either expected inflation, expected output or a combination of the two, while the orthogonality solution (see Lubik and Schorfheide (2003)) delivers:

$$\begin{bmatrix} \widehat{R}_t \\ \widehat{\pi}_t \\ \widehat{x}_t \end{bmatrix} = \begin{bmatrix} 0.62 & 0.03 & -0.17 & 0.01 \\ 0.27 & -0.18 & -0.58 & -0.14 \\ 0.13 & -0.48 & 0.06 & 0.17 \end{bmatrix} \begin{bmatrix} \widehat{R}_{t-1} \\ \widehat{\pi}_{t-1} \\ \widehat{x}_{t-1} \\ \widehat{y}_{t-1} \end{bmatrix} + \begin{bmatrix} \widehat{u}_{1t} \\ \widehat{u}_{2t} \\ \widehat{u}_{3t} \end{bmatrix}, \Sigma_u = \begin{bmatrix} 0.05 & & \\ 0.03 & 0.17 & \\ -0.08 & -0.41 & 0.98 \end{bmatrix}$$

On the other hand, in the determinate regime we have:

$$\begin{bmatrix} \widehat{R}_t \\ \widehat{\pi}_t \\ \widehat{x}_t \end{bmatrix} = \begin{bmatrix} -0.39 & -0.31 & 0.11 \\ -0.15 & 0.30 & -0.12 \\ -0.23 & -0.16 & 0.44 \end{bmatrix} \begin{bmatrix} \widehat{R}_{t-1} \\ \widehat{\pi}_{t-1} \\ \widehat{y}_{t-1} \end{bmatrix} + \begin{bmatrix} \widehat{u}_{1t} \\ \widehat{u}_{2t} \\ \widehat{u}_{3t} \end{bmatrix}, \Sigma_u = \begin{bmatrix} 0.09 & & \\ 0.24 & 0.98 & \\ -0.21 & -0.55 & 0.89 \end{bmatrix}$$

As these expressions show, there is an additional state variable under indeterminacy - and the choice of solution is unimportant. Moreover, if parameters would change within a regime, either of determinate or indeterminate type, the role of this state variable would be unaltered. Omitting this additional state variable from an estimated system has two implications. Reduced form errors in the indeterminate regime will combine structural shocks, forecast errors and lags of the omitted state variable. To the extent that this omitted variable is correlated with the included ones, standard techniques will give inconsistent estimates of the reduced form shocks and the estimated structural dynamics will be different from those obtained in the true system. Moreover, the variance of the reduced form shocks will be larger than the true one in the indeterminate but not in the determinate regime.

Interestingly, while the structural model differs across regimes only in the coefficients of the policy equation, the solution is such that lagged dynamics as well as the variance of the reduced form shocks change. Hence, standard counterfactuals exercises, conducted assuming that there are switches only in the variance or in the coefficients of two samples, can not be used to assess whether a regime change has occurred (as suggested by Benati and Surico (2006)). In addition, since changes within a regime imply changes in the lagged coefficients and in the variances of reduced form shocks of roughly the same magnitude as changes across regimes, it is impossible to use the relative magnitude of the variations in the reduced form (or structural) coefficients and in the variances to determine the nature of the regime and/or whether it has changed.

Figure 1 presents the conditional dynamics in response to shocks in the two regimes where, in the case of indeterminacy, we plot both the continuity and the orthogonality solutions. Three interesting features are present. First, the impact coefficients are quantitatively different in the two regimes - this mirrors the fact that reduced form variances change. Second, there are quantitative differences in the dynamics, but they die out relatively quickly. Third, the sign and the shape of the responses are similar across regimes. Hence, when faced with an infinite sample of data from this model, methods focussing on the dynamics induced by structural shocks will find it hard to detect regime switches.

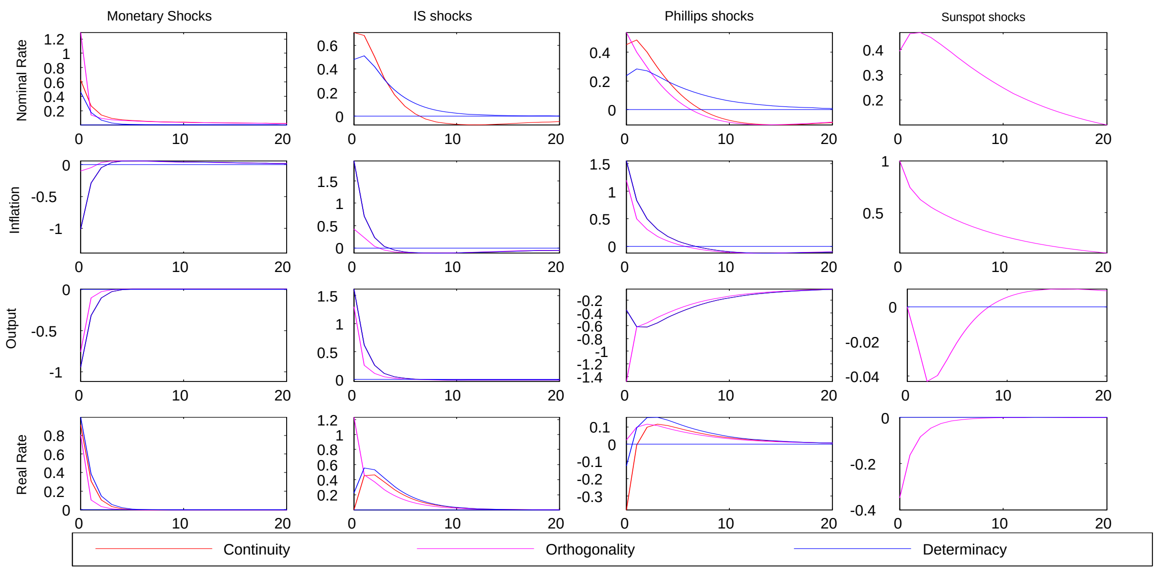

Figure 1: Impulse responses, Determinacy and Indeterminacy

It is often presumed that structural estimation methods have an edge in detecting regimes, because they take expectation formation into account. This is not the case here precisely because the conditional autocorrelation function of the three endogenous variables is similar across regimes. To illustrate this point, we take the population dynamics generated by the model under indeterminacy (the continuity solution) as given and ask: are there parameter values which make the dynamics under determinacy "close" to those produced under indeterminacy? Figure 2 shows that the match is imperfect, but the serial correlation properties of nominal and real rates, output, inflation in response to the three structural shocks are closely reproduced. If rather than taking one parameterization, we take estimated uncertainty seriously and construct response bands for the indeterminate regime using Monte Carlo simulations, these bands would always include the point estimate of the responses under determinacy.

The parameters generating the responses in figure 2 are in the third column of table 1. Note that, it is impossible to simply change the variance of the shocks to match the dynamics of the indeterminate solution; that is, the "bad luck" hypothesis is not local to the indeterminacy/determinacy story. However, alternative explanations in which the private sector parameters change together with the structural variances or in which the parameters of the policy rule change together with the structural variance (keeping private sector parameters fixed, see last column of table 1) have this feature.

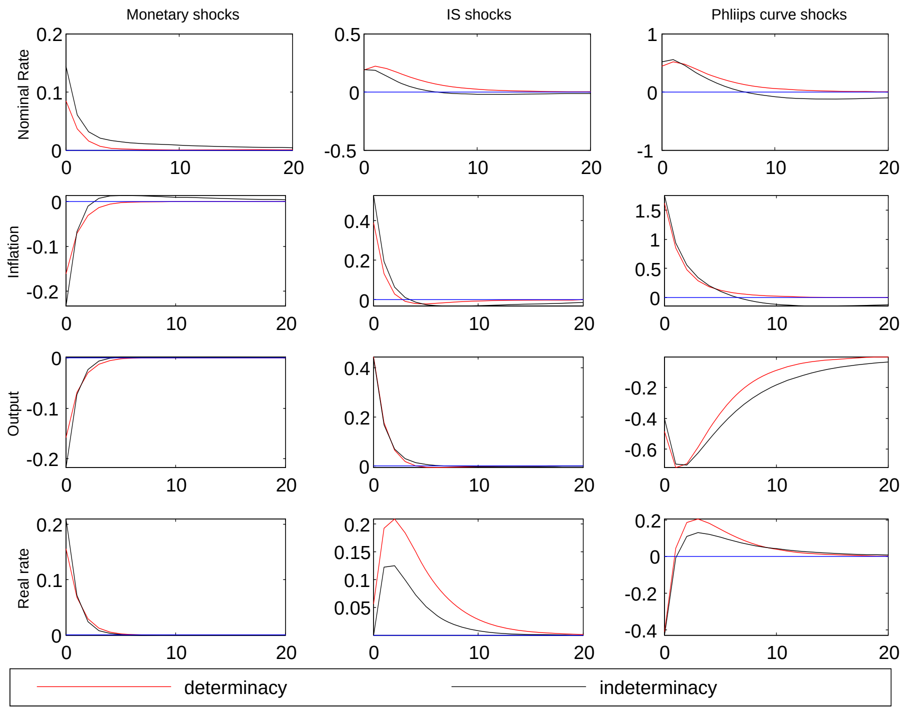

Figure 2: Alternative dynamics for regime 1

The last column of figure 1 presents responses to a sunspot shock, when the orthogonality solution is chosen. The dynamics induced by a sunspot shock look, qualitatively, like those induced by a Phillips curve shock and only the sign of the response of the real rate after the impact period allows to separate them.

In sum, regime changes are hard to detect with standard methods. Both structural VARs and impulse-response-matching methods are unlikely to succeed in separating indeterminate from determinate samples using the dynamics or the variances of the shocks. However, if the indeterminacy/determinacy story is correct expected inflation, expected output, or a combination of the two must be a state variable up to the end of the 1970s but not afterwards, that is, lags of these variables must help in predicting output, inflation, and interest rates up to the end of the 1970s but not afterwards and the change should be a permanent one. Furthermore, omitting expectations from the system should change the variance of reduced form shocks only for samples up to the end of the 1970s. Finally, the interpretation of the evidence should be affected if expectations are excluded from the empirical system.

In what follows, we will focus attentions on the role of inflation expectations as a state variable. Later, we examine how our conclusions change if a measure of output expectations is used in place or in addition to an inflation expectation measure.

3 Measures of expectations

Expectations are not observable but there are a number of proxies one could use. Since they differ in the time coverage and in their reliability as predictor of future variables, we dedicate this section to describe their properties and motivate our selection of proxy measures.

The Michigan survey reports average expected changes in consumer prices for the incoming year and is available quarterly since 1960:1. This survey has 100 respondents each period, covers primarily households, and is conducted before the inflation figures of the middle month of the quarter are available. We assign the forecast to the end of the quarter, giving the survey a bit more information than it actually has. We use the mean forecast as our measure, since median estimates are available only since 1978, despite the fact that Kilian and Inoue (2005) have raised doubts about its reliability.

The Survey of Professional Forecasters, constructed by the Federal Reserve Bank of Philadelphia, has data on the implicit price deflator and real GDP expected yearly changes since 1970:1 (1968:1 for real GDP growth) while CPI forecasts are available only since 1981. The number of respondents changes somewhat with the quarter and the year in which the survey is run, and respondents are primarily members of the business community. As the Michigan survey, it is conducted in the middle of each quarter, but we assign the reported value to the end of the quarter. In this case, we use median forecast as our measure.

The Livingstone survey is biannual - it is conducted in April and October since 1955:1 - and reports eight months ahead level of the non-seasonally adjusted CPI. The number of respondents is smaller than the other two surveys (it covers about 50 economists from industry, government and academia per time period) and this may produce larger or more persistent biases. To make it comparable to the other survey measures the 8 months expected rate of change is annualized. The median value of the survey is used as our estimate.

The Greenbook contains projections of inflation and real GDP growth produced by the staff at the Federal Reserve Board for FOMC meetings. The projections measure the annualized quarter-on-quarter changes of the implicit price deflation and real GDP up to 1996 and of the chain-weighted indices after that date. One year ahead forecasts are available only since 1975:1. Irregularly sparsed annualized two and three quarter ahead forecasts are available since 1968:1 and annualized one quarter ahead forecasts since 1965:4. We fill in missing data using regression methods and use annualized three quarters ahead projections as our basic measure. Also since FOMC meetings do not occur regularly, quarterly data are constructed using the projections produced by the report which is closest to the middle of each quarter. As with survey measures, we assign this value to the end of the quarter.

The term structure of nominal interest rates also provides an implicit measure of inflation expectations we could use. To construct it, we employ a standard decomposition. Let $f_{t,4,k-4} \equiv \frac{R_{t,4}}{R_{t,k}}$ be the forward rate quoted at t for one year maturity on a bond that has settlement period k. This rate, which can be computed using the returns on one year and any k years nominal bonds, can be decomposed as:

$$f_{t,4,k-4} = r^e_{t,4,k-4} + \pi^e_{t,4,k-4} + [f_{t,4,k-4} - E_t \ln R_{4,t+k-4}] + [E_t \ln R_{4,t+k-4}] - r^e_{t,4,k-4} - \pi^e_{t,4,k-4}] \tag{4}$$

where the first term represents the expected one year real rate, the second the one year expected inflation, the third the nominal term premium (the difference between the forward rate and the expected future nominal rate) and the last the real excess return of the expected nominal rate over the expected real rate. While it is typical to assume that the first, the third and the fourth terms of the expression are roughly time invariant - this would allow us to identify the dynamics of expected inflation with those of the forward rate - such an assumption is too heroic for the sample we consider to be credible. As an alternative, we use the rational expectation assumption, regress realized inflation on a constant and the forward rate and take the predicted value as a measure of inflation expectations. This procedure is relatively common in the literature (see e.g. Svensson (1994), or Soderlin (1995)) and make the resulting expectations close to actual inflation. To take into account potential breaks in the path of inflation the regression is actually run on two separate subsamples (up to 1980:2, after 1980:2). An alternative signal extraction approach, where expected inflation is treated as unobservable random walk while the other components in (4) have stationary AR(1) dynamics, produces similar results.

Data on the term structure of the nominal interest rates is available at the FRED databank of the Fed of Saint Louis. However, the data reports rates for non-zero coupon bonds. We have managed to recover a comparable data set for zero coupon bonds but only for the period 1974:1-2001:4, which makes it too short for our purposes. It turns out that the forward rates implied by the two term structures are very similar in the overlapping sample (contemporaneous correlation 0.98) and the measures of expectations we obtain from the two different series are practically indistinguishable. To maximize the length of the sample, we work with inflation expectations obtained from non-zero coupon bonds even though the above decomposition is only approximately valid.

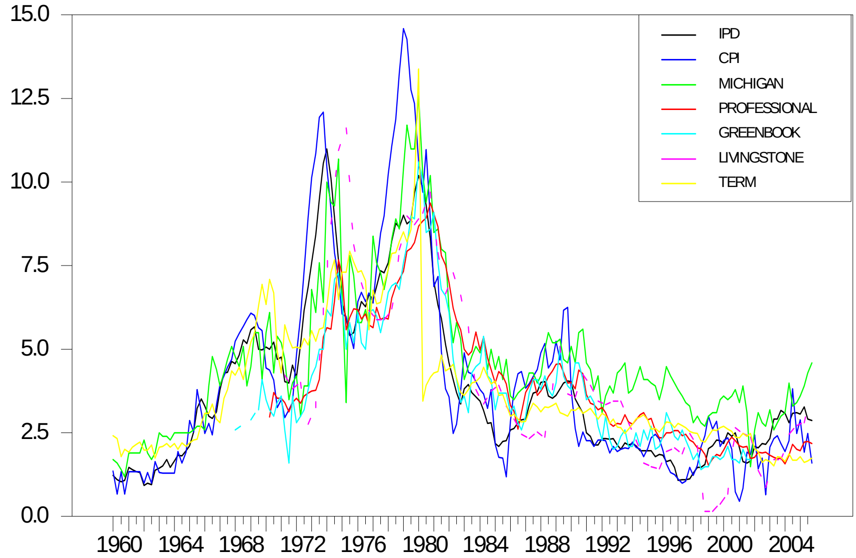

Figure 3: Actual and expected inflation.

While inflation expectations backed out from financial market data are probably more reliable, survey data are publicly available and do not require any statistical model or possibly controversial assumption to back them out. To compare their properties, we plot in figure 3 the time path of the five expected inflation series together with actual inflation computed using the implicit price deflator (IPD) and the CPI (measured here by the seasonally adjusted CPI for all items). Confirming Merha (2002), Michigan expectations are a good predictor of actual inflation up to 1980. The tracking performance deteriorates somewhat over the 1980s, and over the 1990s the reported mean systematically overestimates actual inflation. Professional expectations are better over the whole sample, but in particular episodes (for example, the beginning of the 1980s), they are less reliable than Michigan expectations. Livingstone expectations appear to be free of large or persistent biases, except perhaps in the latest part of the sample. Greenbook projections closely track IPD dynamics and are highly correlated with Professional forecasts and term structure expectations replicate actual inflation well, except for the early 1980s.

Table 2 shows that Michigan and Term structure expectations are the ones which are most highly correlated with actual inflation (regardless of whether it is measured by IPD or CPI) and with each other. In terms of moments of the empirical distribution, Term structure expectations closely replicate those of actual inflation. Given these results, we initially focus on Michigan and Term structure expectations and use the other measures for robustness checks [1].

Table 2: Statistics and contemporaneous correlations

	Correlations						Statistics			
	Professional	Livingstone	Greenbook	Term	IPD	CPI	Mean	St. Err.	Min	Max
Michigan	0.78	0.50	0.77	0.79	0.86	0.82	4.66	2.20	1.2	12.60
Professional		0.63	0.88	0.70	0.73	0.69	4.05	1.97	1.54	9.37
Livingstone			0.54	0.47	0.50	0.46	4.12	2.66	0.15	11.62
Greenbook				0.60	0.75	0.71	4.04	2.03	1.40	10.60
Term					0.83	0.80	3.80	2.20	0.95	13.07
IPD							3.80	2.39	0.94	10.99
CPI							4.05	3.06	0.45	14.59

4 The evidence

We estimate reduced form VAR models and examine whether lags of inflation expectations matter in a system including real output growth (ΔGDP), the inflation rate (π), a short term nominal rate (R). Data is from the FRED data bank. Output growth is measured by the year-to-year change in GDP, inflation by the year to year change in CPI, all items and the interest rate by the Federal funds rate. While the implications we have derived in section 2 hold for a system where real activity is proxied by the output gap, it can be easily shown that they also hold when output growth is used, so long as potential output is either a linear trend or a unit root process.

To start with, we use the traditional device of breaking the sample in two even if such approach is problematic for two reasons: since inflation and the nominal interest rate display an inverted U-shaped pattern, it is not clear which break date should be used and whether a subset of the data (the 1979-1982 period) should be omitted or not; using subsamples

[1] When comparing survey measures to actual inflation data one should be aware that they are not measuring the same thing. First, the reported expected rate is an average over quarters rather than an end of the period measure. Second, apart from profesional forecasts, it is not clear if agents forecast CPI levels/changes or headline CPI level/changes. Third, it is not clear if simple or compounded rates are used to construct yearly measures. Fourth, forecasts are typically for non-seasonally adjusted data, while seasonally adjusted data will be used in the exercise. Ang et. al. (2006) have shown that these measurement biases are small and account for none of their forecasting comparison results.

forces a simultaneous break in all the relationships while the moments of these variables display breaks at different dates.

Table 3: F-tests, p-values

	With Michigan expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.73	0.70	0.81	0.91	0.70	0.55	0.99	0.92
π	0.00	0.01	0.01	0.00	0.02	0.00	0.04	0.05
R	0.12	0.00	0.11	0.24	0.00	0.01	0.10	0.05
	With term structure expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.69	0.82	0.52	0.29	0.02	0.03	0.10	0.67
π	0.58	0.51	0.10	0.00	0.00	0.00	0.59	0.24
R	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.02

Table 3 reports the p-value of an F-test for the exclusion of lags of inflation expectations for a number of subsamples in a VAR with 4 lags. When Michigan expectations are employed, lags of inflation expectations are never important in the output growth equation, always important in the inflation equation and usually important in the nominal rate equation (the exceptions are the samples 1960:1-1981:2 and 1960:1-1982:1).

When term structure expectations are used, lags of inflation expectations are always significant in the nominal rate equation; significant in the output growth equation in the samples 1979-2005 and 1980-2005, and significant in the inflation equation, if the years 1979-1980-1981 are jointly included.

Table 4, which reports the estimated variance of the residuals in a number of subsamples when the two proxies for expectations are used and when inflation expectations are excluded from the system, confirms the outcomes of table 3. For appropriately selected samples, the variances of reduced form shocks in a system where inflation expectations are included decreases over time and a system which excludes inflation expectations tends to have reduced form shocks with marginally higher variability. More importantly, a system where inflation expectations are excluded displays the same qualitative features as systems which include them: for appropriately chosen samples, the variance of all shocks declines.

Table 4: Variances of reduced form shocks

	With Michigan expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.80	0.81	0.86	1.06	0.60	0.58	0.56	0.34
π	0.07	0.08	0.09	0.10	0.05	0.04	0.03	0.03
R	0.50	0.75	1.47	1.96	0.93	0.92	0.46	0.15
	With term structure expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.80	0.81	0.83	1.00	0.55	0.53	0.51	0.34
π	0.10	0.10	0.10	0.10	0.04	0.04	0.04	0.03
R	0.43	0.52	1.03	1.35	0.64	0.64	0.46	0.15
	Without inflation expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.83	0.83	0.88	1.07	0.62	0.60	0.56	0.35
π	0.10	0.10	0.11	0.13	0.06	0.05	0.04	0.04
R	0.57	0.89	1.65	2.12	1.15	1.06	0.50	0.17

Hence, tables 3 and 4 do not support the main implication of the theory: in the model of section 2 inflation expectations should be initially relevant and later irrelevant and the break in the relationships should be a permanent one. The data tells us that if inflation expectations matter, they matter for the whole sample and when it is not the case, changes are temporary in nature and primarily related to the Volker experiment of the late 1970s.

5 Is the empirical evidence reliable?

There could many reasons for why the evidence fails to conform with the theory. First, we may be unable to detect a permanent break in the importance of inflation expectations because the lag length of the VAR is inappropriately chosen. Two opposing reasons may produce this outcome. Given overlapping nature of all expectations measures, a generous lag length is needed to make VAR residuals a white noise. However, if too many lags are included, lags of the other variables could proxy for lags of inflation expectations, making our tests weak. Since the model of section 2 has a VAR(2) representation and since inflation expectation measures induce MA component of order three, a lag length of 4 strikes a balance between the two opposing forces. In tables A.1 and A.2 we show that changing the lag length from 2 to 8 has no effect on the conclusions one reaches.

Second, our tests may fail because the proxies for expected inflations we employ are plagued by measurement or estimation errors. Since Thomas (1999), Merha (2002), and Ang, et. al. (2006)) have shown that these proxies capture important information about future developments of inflation, it is hard to believe that this is the case. Nevertheless. Faust and Wright (2006) have shown that Greenbook projections are superior to other expectation measures, while Leduc et. al. (2005) claim that Livingstone expectations contain information which is relevant to capture shocks to expectations. We have repeated estimation using Greenbook forecasts - in this case the sample starts in 1968:4 - and Livingstone survey data - in this case data for output growth, inflation and the nominal rate is sampled bi-annually. Tables A.3-A.6 show that the same conclusions obtain. If anything, the evidence for a structural break is even weaker with Livingstone data, while Greenbook projections become more important for output growth and inflation after 1982.

One can also think that our inflation expectation measures are not really forward looking and therefore unsuited for the analysis. To check for this possibility we have constructed an expected inflation measure using the VAR. This measure, which is internally consistent but completely backward looking, is correlated with survey and term structure measures, but not perfectly (roughly 0.6). Therefore, inflation expectations measures do contain an important forward looking component.

Third, one can easily argue that a four equation VAR is misspecified. If a large scale model were the true data generating process and a four variable system was used, many important variables would be omitted and their presence in VAR residuals could make the detection of regime changes hard. We therefore repeated estimation using a eight variable VAR which includes, in addition to the previous four variables, consumption growth, investment growth, hours and the growth rate of money. Consumption growth is measured by the year-to-year change in real nondurable private consumption, investment by the year to year change in fixed private investments, hours by total hours in the non-farm business sector and money growth by the year to year change in M2. Two lags are sufficient to whiten the residuals of this system. Tables A.7 and A.8 indicate that in this system inflation expectations have an even smaller predictive role in the first part of the sample. Hence, it is harder to find a break in the importance of inflation expectations over time.

Fourth, as argued in section 2, the theory implies that there is a state variable missing in the first sample. So far we have associated this variable with inflation expectations, but in principle, any variable which is correlated with sunspot shocks may do the job. We have repeated estimation using a VAR where output growth expectations are used in place of, or jointly with, inflation expectations - since measures of output growth expectations start only in the mid-late 1960's, the size of the first subsamples is now shorter. Tables A9 and A10 shows that the addition of output growth expectations or the substitution of inflation expectations with output growth expectations leaves the conclusions unchanged.

Fifth, it may be that our tests have low power in small sample. Despite our attempts to maximize the size of the samples, we have only about 80 data points on each side of the potential break date. To check whether small samples may be responsible for our results, we have simulated data from each of the two regimes, using the parameter values reported in table 1, employing either the continuity or the orthogonality solution when generating data from the indeterminate regime. We then constructed two samples of 160 data points (one with 80 data from the continuity regime and 80 from the determinate regime, the other with 80 data from the orthogonality regime and 80 from the determinate regime) and applied our tests to simulated data. Tables A11 and A12 show that our tests would be able to detect a regime change with this DGP and this sample size. Inflation expectations would be significant in some equations when up to the first 80 data points are used but not if either more data is included or estimation starts at a later date; the variance of the reduced form shocks in a system without inflation expectations would be larger than in a system which includes them if the first 80 data points are used, but not if the last 80 data point are employed. Benati and Surico (2006) have argued that VARs may be unable to correctly capture regime switches with this DGP for the data. Tables A11 and A12 show that such a claim is generally invalid.

Sixth, Orphanides (2004) and Orphanides and Williams (2005) have forcefully pointed out that policy decisions are typically taken when preliminary estimates of the relevant quantities are available while empirical analyses typically employ final estimates and that this discrepancy may lead researchers astray when trying to understand how policymakers historically behaved. For our exercises this is a relevant concern since the presence of measurement errors could reduce the ability of out tests to detect breaks. To examine the relevance of this problem we have simulated data from the model of section 2 assuming that private agents take decisions using the correct data while the central bank rule is

$$R_t = \phi_r R_{t-1} + (1 - \phi_r)[\phi_\pi(\pi_t + u_{1t}) + \phi_x(x_t - z_t + u_{2t})] + e_{R,t}$$

where u_{1t} and u_{2t} are measurement errors. With the same parametrization we have used in tables A11 and A12, we have simulated two samples with 160 data points (one with 80 data from the continuity regime and 80 from the determinate regime, the other with 80 data from the orthogonality regime and 80 from the determinate regime) and applied our tests to the simulated data. We have considered two situations: classical iid and highly serially correlated measurement errors. Clearly, if measurement error is large anything can happen. Therefore, it is important to appropriately calibrate the variance and the persistence of these errors to make the simulations realistic. The size of the revision error between initial and final estimates of output growth and inflation over the last 40 years shows a small declining trend and its standard error around this trend never exceeds 10 percent of the standard error of series. Therefore, it is conservative to assume that an upper bound for the standard deviations of the two measurement errors is 10 percent of the standard errors of the largest structural shocks. Tables A13 and A14 show that measurement error of both types can not cover up structural changes if they were present.

Finally, we have argued that arbitrarily splitting the sample and forcing the break to be common in all equations is less than ideal to examine the role of expectations over time. Time varying coefficient models are particularly suited for our purpose because they avoid strong restrictions on the nature of the breaks and because they can track the evolution of the relationships well. A time varying coefficient specification also allows us to examine the weaker hypothesis that the importance of expectations has declined as we move from the 1970s to the later part of the sample. The model we consider is

$$w_t = X_t' \theta_t + \varepsilon_t \tag{5}$$

where w_t is a 4×1 vector, X_t is a matrix including lags of w_t and a constant, θ_t is a $4(4p+1) \times 1$ vector, p is the number of lags and $\varepsilon_t \sim (0, \Sigma_t)$. We assume that

$$\theta_t = \theta_{t-1} + u_t \tag{6}$$

where u_t is a $4(4p+1) \times 1$ white noise with zero mean, covariance Ω, and paths for θ_t which produce non-converging paths for y_t are discarded. We assume that $\Sigma_t = L\Omega_t L'$, where L is a lower triangular matrix, that $\Omega = diag\{\omega_{it}\}$ and that

$$\log \omega_{it} = \log \omega_{it-1} + \eta_{it}, \quad i = 1, \ldots, n \tag{7}$$

where $\eta_{it} \sim N(0, \sigma_\eta^2)$ and $\eta_{it}, u_t\ \varepsilon_t$ are independent.

We estimate (5)-(7) with Bayesian techniques and non-informative but proper priors setting $p = 2$. Since both θ_t and Σ_t are time varying rather than using classical F-tests for the significance of lags of inflation expectations at each date, we present the evolution of the median and of the 68% central posterior credible interval for the statistics of interest.

Figures 4 and 5, which plot the evolution of the median and the posterior credible intervals for the lags of inflation expectations and for their long run value in each equation, when Michigan and Term expectations are used, broadly agree with table 3. When Michigan expectations are used, inflation expectations are practically never significant in the output growth equation, and almost always significant in the inflation equation, at least in the long run. The significance of inflation expectations in the interest rate equation depends on the sample, but changes over time in the long run effects are not statistically significant.

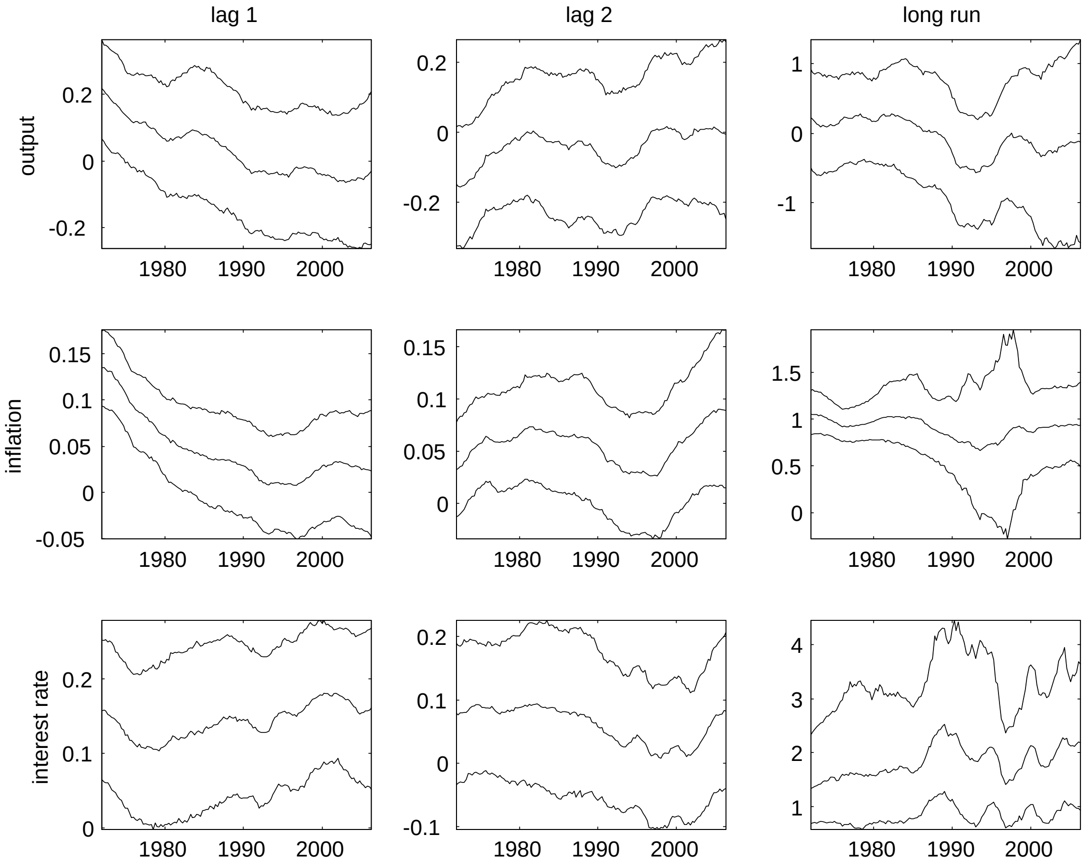

Figure 4: 68 percent posterior intervals for coefficients on lagged inflation (Michigan) expectations.

When Term expectations are used the evidence is more mixed. Nevertheless, it is still true that the importance of inflation expectations in the output growth equation is small and somewhat increasing since the early 1980s while for the other two equations the effect is time varying but inconsistent with the hypothesis of interest. For example, decreases in the median of the coefficient of the first lag in the interest rate equation are compensated by increases in the coefficient of the second lag. Overall, inflation expectations are more important after 1982 than in the 1970s.

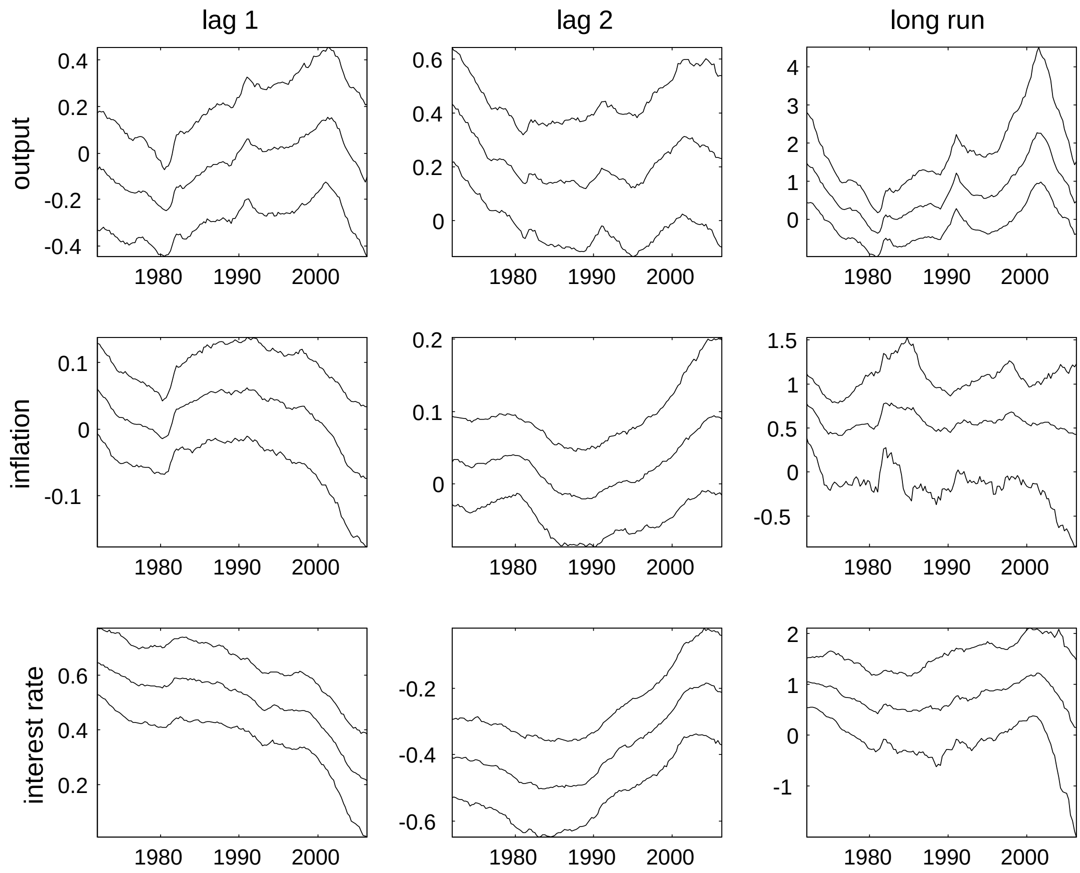

Figure 5: 68 percent posterior intervals for coefficients on lagged inflation (Term) expectations.

Figure 6, which reports the posterior median of the variance of the reduced form shocks with inflation expectations (Michigan solid line, Term dashed line) and without them (dotted line), also broadly agrees with table 4. For instance, there is a general decline in the variability of the reduced form shocks over time which is similar in magnitude and timing across measures of inflation expectations; including or excluding inflation expectations from the system hardly changes the time path of the reduced form variances. Furthermore, given the considerable uncertainty associated with point estimates, differences in systems with and without inflation expectations are a-posteriori insignificant at any date in the sample.

To conclude, regardless of the measure of employed, of the specification of the VAR and the horizon where we measure the effect, of whether we allow coefficients to be time varying or not, and of other specification choices, the importance of expectations does not decline as we move from the 1970s to the end of the sample, neither in the sense of a structural break nor in the sense of a slow moving but continuous change.

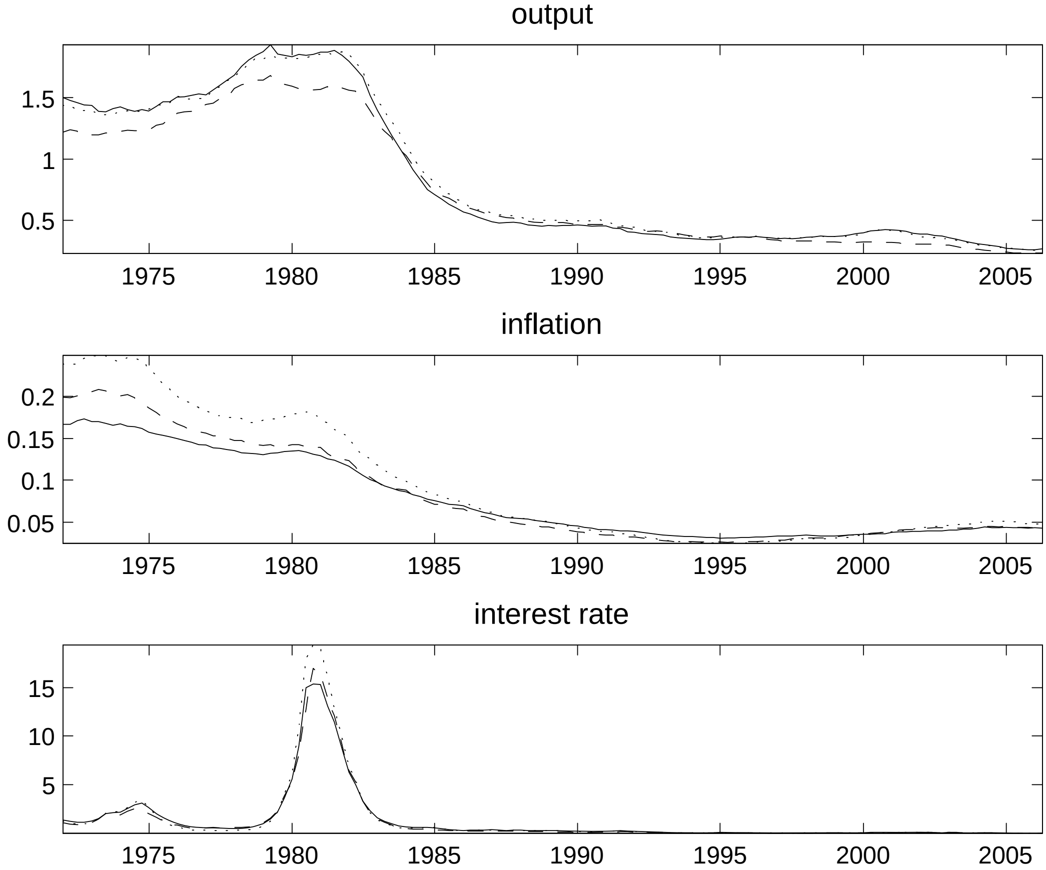

Figure 6: Variances of VAR shocks, solid Michigan, dashed Term, dotted no expectations.

6 Explaining the Great Moderation

The statistical analysis we have presented so far is silent as to whether the absence of inflation expectations from an empirical model alters our understanding of the Great Moderation episode. If inflation expectations truly mattered up to a certain date, the majority of existing analyses, which systematically exclude them from the empirical system, are likely to be flawed.

To study the sources of the Great Moderation we need to identify structural shocks. The restrictions we use are in table 5. Gambetti et. al. (2005) have shown how they can be obtained from a DSGE model featuring monopolistic competitive firms, rational consumers and rules for monetary and fiscal policy, and that they are robust, in the sense that they hold as the structural parameters drift within a reasonable range. These restrictions are satisfied in the model of section 2.

Table 5: Identification restrictions

	GDP	π	R
Supply/sunspot	≥ 0	≤ 0	≤ 0
Real Demand	≥ 0	≥ 0	≥ 0
Monetary	≥ 0	≥ 0	≤ 0

The restrictions in table 5 are robust not only to the parameterization of the model but also to the horizon at which the analysis is conducted. Following Gambetti et. al. (2005), we impose restrictions at horizons zero and one.

In the introduction we have characterized the "Great Moderation" phenomena as a considerable fall in the volatility and the persistence of output growth and inflation. We measure persistence as the height of the structural spectrum of output growth and inflation at frequency zero and volatility as the area under the structural spectrum of the two variables. These statistics, computed in a four variables TVC-VAR(2) when Michigan expectations are used, are reported as continuous lines in figure 7. They display two sharp peaks, around 1974 and 1981; a considerable decline after the second peak; and since 1985, the persistence and the volatility of both output and inflation have been stable and low relative to the 1970s. Figure 7 also presents the individual contribution of the three identified shocks: starred lines represent the contribution of supply/sunspot shocks, dotted lines the contribution of real demand shocks and dashed lines the contribution of monetary shocks. These lines report the persistence and volatility of output growth and inflation that would emerge if only that type of structural shocks was present at each date.

Supply/sunspot shocks are the largest contributors to both the 1974 and 1981 peaks in the persistence and volatility in output growth. Monetary shocks contribute little to the 1974 peak, but become more important for the 1981 peak. Supply/sunspot shocks contribute most to the peaks in inflation persistence and volatility in 1974, while monetary shocks are the sole contributor to the 1981 peak - the contributions of supply/sunspot and real demand shocks consistently decline since 1975 for both statistics. Hence, our structural model indicates that i) inflation volatility (and persistence) would have been lower since the mid 1970s, hadn't not been for the Volker experiment and ii) the fall in inflation volatility (and persistence) predates the adoption of a more aggressive monetary policy stance.

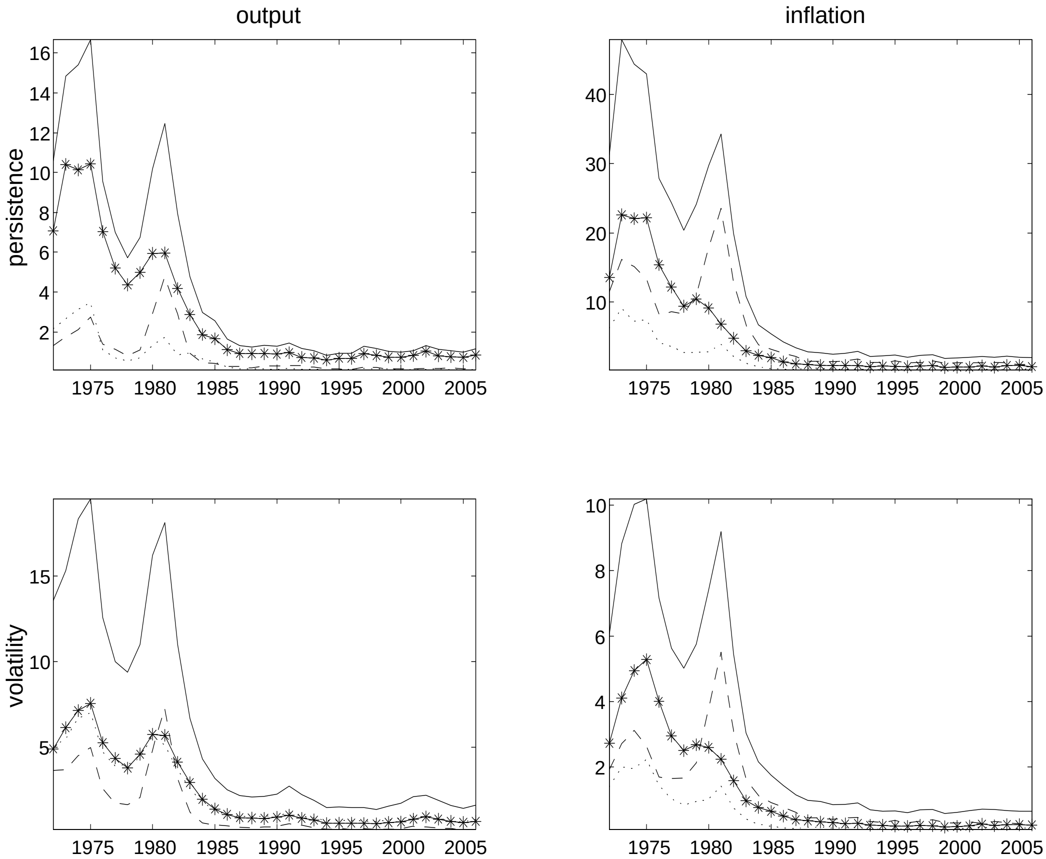

Figure 7: Contribution of supply (stars), real demand (dotted), and monetary (dashed) shocks to inflation and output growth persistence and volatility.

Would our conclusions change if we exclude inflation expectations from the VAR? Figure 8 reports the proportion of inflation and output growth volatility and persistence explained by the three identified shocks at each date in the sample in a TVC-VAR with Michigan expectations (first column), Term expectations (second column) and no expectations (third column). Most of our conclusions are unchanged if we inflation expectations are absent from the system. For example, supply and real demand shocks are crucial to characterize the time profile of output growth volatility and persistence while monetary shocks are important to understand only the 1981 peaks. However, when inflation expectations are excluded, monetary shocks become the most important driver of inflation persistence and volatility thought the sample. Notice that the timing of the changes in the three columns is very similar. Hence, even in an economic sense, inflation expectations fail to conform to the role that the indeterminacy/determinacy story has given to them.

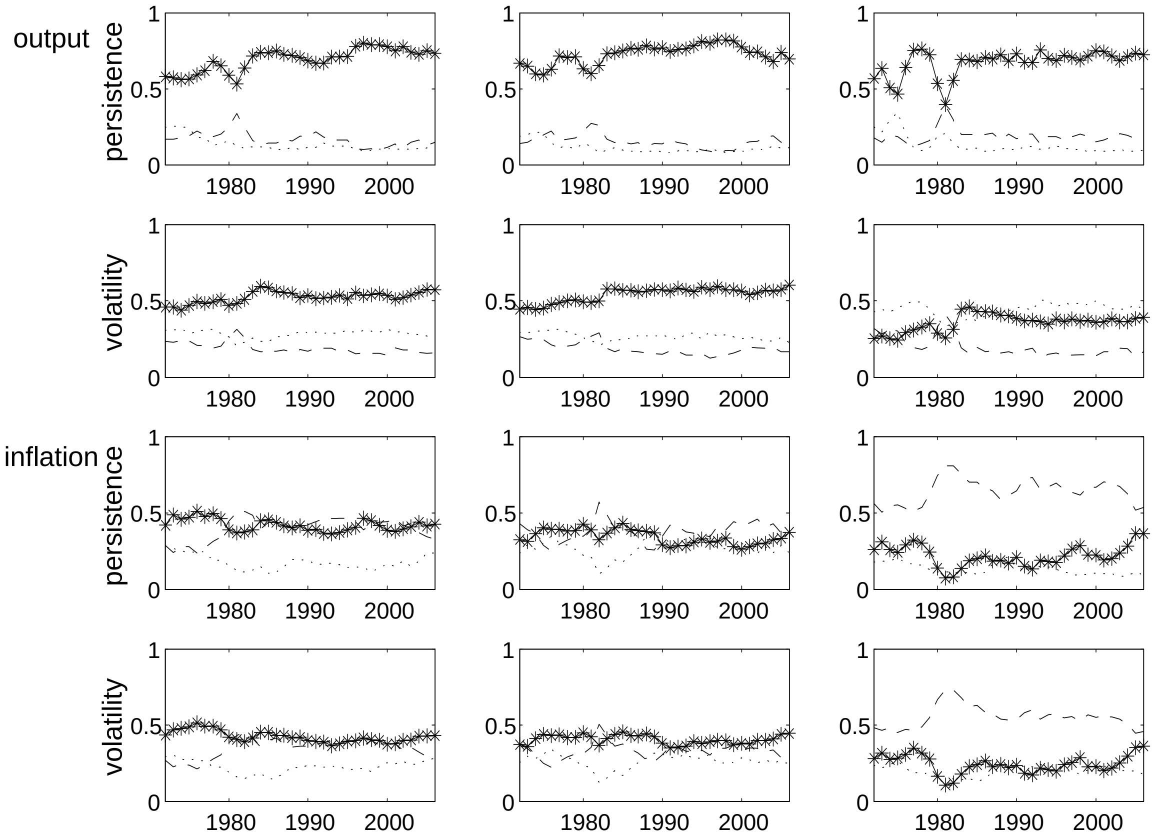

Figure 8: Share contribution of shocks: star supply shocks, dotted real demand shocks, dashed monetary shocks; colomn 1 Michigan, colomn 2 term, colomn 3 no expectations.

7 Do sunspot shocks matter?

The analysis of section 2 has shown that sunspot shocks produce dynamics which are qualitatively similar to those of supply shocks and the analysis of section 6 has not tried to distinguish them. Could it be that what we call supply shocks are really shocks to expectations? Could it be that even if absence of inflation expectations causes little changes to the interpretation of the Great Moderation, sunspot shocks matter for output and inflation volatility and persistence up to a certain date but not afterwards? Since Figure 7 shows that supply/sunspot shocks have an important role in explaining the volatility and persistence bursts of 1974 and 1981 and that the time path of the volatility and persistence due to these shocks is declining over time, it is worth trying to distinguish the two types of disturbances.

Evidence on the role of sunspot shocks is difficult to obtain in general because changes in the model specification lead to change in the dynamics induced by these shocks. However, conditional on the model and its parameterization, the dynamics of the real rate may help to separate supply from sunspot shocks. In fact, in response to sunspot shocks, the real rate converges to zero from below, while in response to Phillips' curve shocks, convergence to zero is from above (see figure 1).

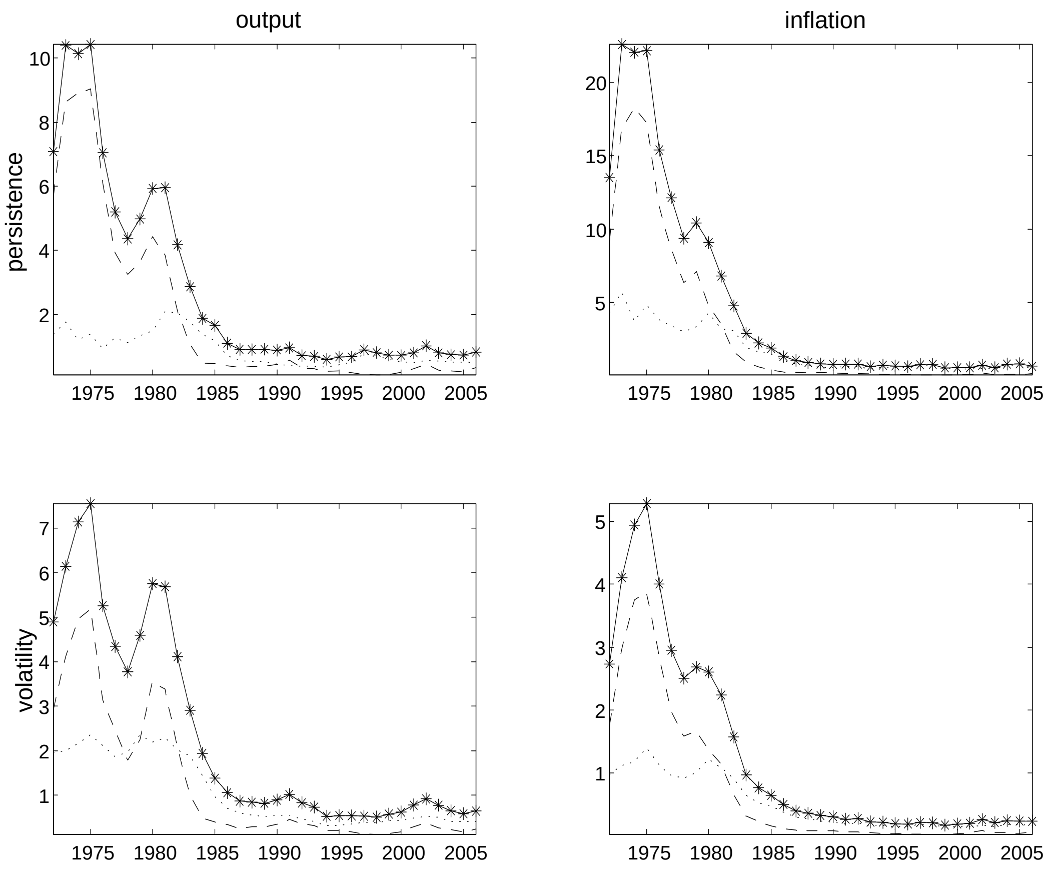

Figure 9: Contribution of sunspot (dotted) and supply (dashed) shocks to output and inflation volatility and persistence.

Given these restrictions, we ask: what is the contribution of sunspot shocks to the statistics presented in figure 7? Figure 9 reproduces the path of the statistics due to the combined effect of supply and sunspot shocks reported in figure 7 (line with stars) and shows the contribution of the two components (sunspot dotted, supply dashed) when orthogonality between structural and sunspot shocks is assumed. Output growth and inflation persistence would have been much lower in the 1970s and the change much more contained if only sunspot shocks where present. Also, the fall in output growth persistence would have occurred only since the mid-1980s. Similarly, output and inflation volatility would fail to display the two peaks in 1974 and 1981 had their been only sunspot shocks and the decline in the 1980s and 1990s would have been minor. Hence, while sunspot shocks matter - their contribution is roughly as important as the one of demand shocks, at least for inflation - the time path they induce fails to line up with the dynamics of persistence and volatility in output and inflation produced by the structural model.

We want to stress that the evidence in figure 9 is suggestive: in a three equation model it is difficult to find sharp implications to extract sunspot shocks and the restrictions on the real rate we have used are not entirely robust: there are parameter combinations which imply that sunspot shocks look like demand shocks. These parametrizations, however, have the disadvantage that sunspot shocks can not be interpreted as stagflation shocks.

We want to contrast our evidence on sunspots with what is available in the literature. Leduc et. al. (2005) identify shocks to expectations using delay restrictions and found that the response of the nominal interest rate is quite different in the 1970 and afterwards. However, the shocks they identify do not induce the same dynamics as the sunspot shocks of figure 1 and this makes the comparison difficult. Lubik and Schorfheide (2004) and Boivin and Giannoni (2006) have estimated the model of section 2 with structural methods. While their results support the idea that an indeterminate regime was in place until the end of the 1970s, they do not address the question of how much sunspots matter to explain the Great Moderation episode. Boivin and Giannoni conduct some counterfactuals but, as indicated in section 2, these are not informative about regime switches. Also, the conclusions of all three papers are based on subsample analysis, which, as we have argued, may give a distorted view about the role of sunspot over time when data display U-shaped patterns.

8 Conclusions

This paper examines whether the restrictions imposed by a simple indeterminacy-determinacy story of the Great Moderation are satisfied. Using a New-Keynesian model, we show that there is an additional state variable in the indeterminate regime which fail to appear in the determinate one; that regimes can not be separated using the relative magnitude of changes in the lagged dynamics and in the variance of the reduced form shocks; and that several explanations are "locally" indistinguishable from the indeterminacy-determinacy story. Using several VAR models we study whether there is a change in the significance of lagged expectations coefficients over time; whether omitting expectations from the estimated system causes time varying biases in the variance of reduced form shocks; and whether the absence of expectations alters the interpretation of the Great Moderation.

We find that (i) there is no clear switch over time in importance of lags of expectations in any equation of the system; (ii) reduced form variances estimated in systems with and without expectations display similar paths and little evidence of time varying biases; (iii) the economic interpretation of the Great Moderation episode is roughly independent of the inclusion or the exclusion of expectations from the system; (iv) the contribution of sunspot shocks to output and inflation volatility and persistence over time do not line up well with the time variations in these statistics.

Why do we fail to find evidence consistent with indeterminate-determinacy story of the Great Moderation? We have shown that the empirical results are robust to a number of potential empirical problems. Therefore, if one insists on taking the bad policy hypothesis as a benchmark, one has to conclude that the model we have used is inappropriate. While the implications we use hold in larger system with additional frictions (such as habit in consumption or wage stickiness), some omitted features which could matter for the results.

First, the model of section 2 assumed that agents are completely unaware of the possibility that a regime shift may occur and when it occurs they never believe there will be a switch back. Davig and Leeper (2007) have recently studied economies where regimes change in a Markov chain fashion and agents are aware of the law of motion of the switches. In this type of economies, the equilibrium is either determinate or indeterminate for the whole sample - this is consistent with the fact that the role of expectations is unchanged over time. Moreover, even if the equilibrium is globally determinate, bad policy can contribute to volatility and persistence bursts. The fact we detect a fall in the volatility and in the explanatory power of structural shocks over time is therefore in line with an explanation of the Great Moderation where a determinate regime is in place for the whole period, the 1970s were a period of bad policy and the following decades were not,

Empirical evidence suggesting that the case for bad policy in the 1970s is overstated come from the work of Orphanides and Williams (2005), who find little evidence of violation of the Taylor principle in the 1970s, once real time data are used; and by Duca and Wu

(2007), who pointed out that the presence of regulation-Q made the effective real interest rate from 1968 up to the beginning of the 1980s very different from the ex-post real rate, and that with this rate the Taylor principle is almost never violated in the 1970s.

Second, the model neglects any form of learning which, e.g., Orphanides and Williams (2004) have found important in the explaining the experience. In learning models expectations become a state variable, regardless of the monetary regime in place. Therefore, our results are not necessarily inconsistent with a indeterminate-determinate story were agents learn over time about the changes in the economy (see Schorfheide (2005)). Furthermore, with learning the coefficients of the reduced form representation of the model will be time varying - which is what we find when we allow the coefficients to drift over time.

Third, the model assumes that there is no frictions in the flow of information. However, in models where information is sticky, like those examined in Mankiw and Reis (2006), the role of inflation expectations does not necessarily changes with the regime. This is because expected inflation is generated with information which is already contained in lags of inflation. Sticky information models, however, have one counterfactual implication: inflation expectations should be almost perfectly correlated with lagged inflation. In our data the correlation is small.

Hence, while the theoretical restrictions implied by the basic model of section 2 are rejected, it is difficult to make general statements about more sophisticated versions of the bad policy hypothesis which allow for learning, misperception or informational frictions. To examine the role of expectations in these models, one needs to refine our empirical investigation in various ways. First, a small system of equations is not the best vehicle to distinguish alternative hypotheses. A larger scale model, while more difficult to estimate and identify, could help to do this and provide a more convincingly way to separate sunspot from other shocks. Second, to better understand the experience, it is important to measure the effects of inflation expectations shocks on output and inflation volatility and persistence in other ways. One could do this with more or less structural methods. The mix of reduced form and semi-parametric analysis we use here is more robust to model mispecification but, obviously, less informative about these issues. Third, it is also crucial to examine how expectations react to structural shocks and whether there are changes in their responses over time. We leave all these refinements for future research.

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Appendices

Table A.1: F-tests, p-values

1 lags

	With Michigan expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.44	0.30	0.57	0.81	0.77	0.64	0.71	0.68
π	0.00	0.07	0.04	0.00	0.02	0.01	0.41	0.50
R	0.38	0.09	0.02	0.08	0.01	0.00	0.02	0.01

	With Term structure expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.25	0.28	0.10	0.18	0.10	0.19	0.11	0.14
π	0.44	0.52	0.37	0.01	0.00	0.00	0.44	0.06
R	0.01	0.01	0.01	0.00	0.00	0.00	0.12	0.01

2 lags

	With Michigan expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.49	0.35	0.76	0.85	0.96	0.67	0.90	0.49
π	0.01	0.08	0.01	0.00	0.00	0.00	0.36	0.49
R	0.41	0.01	0.05	0.12	0.00	0.05	0.03	0.01

	With Term structure expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.31	0.26	0.09	0.22	0.15	0.24	0.08	0.12
π	0.50	0.51	0.45	0.02	0.00	0.00	0.37	0.04
R	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00

3 lags

	With Michigan expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.62	0.55	0.95	0.98	0.69	0.72	0.97	0.91
π	0.60	0.08	0.00	0.00	0.00	0.00	0.10	0.08
R	0.16	0.07	0.20	0.18	0.00	0.01	0.05	0.02
	With Term structure expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.48	0.49	0.14	0.21	0.01	0.02	0.12	0.39
π	0.52	0.50	0.16	0.00	0.00	0.00	0.72	0.27
R	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00

8 lags

	With Michigan expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.06	0.24	0.02	0.00	0.26	0.13	0.16	0.22
π	0.00	0.03	0.01	0.02	0.02	0.00	0.00	0.01
R	0.11	0.10	0.53	0.42	0.01	0.06	0.18	0.05
	With Term structure expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.84	0.71	0.14	0.31	0.00	0.01	0.18	0.14
π	0.10	0.04	0.13	0.25	0.00	0.01	0.67	0.34
R	0.44	0.00	0.00	0.00	0.00	0.00	0.01	0.03

The table reports the P-value for the F-test that expected inflation coefficients in the equation are all equal to zero in a VAR with 4 variables and varying lags.

Table A.2: Variances of reduced form shocks

1 lags

	With Michigan expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	1.12	1.11	1.21	1.39	0.79	0.69	0.67	0.52
π	0.09	0.12	0.12	0.13	0.07	0.05	0.05	0.05
R	0.67	0.89	2.44	2.61	1.42	1.28	0.62	0.23
	With Term structure expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	1.12	1.07	1.14	1.33	0.77	0.69	0.62	0.48
π	0.12	0.12	0.14	0.14	0.06	0.06	0.05	0.04
R	0.57	0.71	1.93	2.06	1.18	1.15	0.58	0.21
	Without inflation expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	1.15	1.14	1.28	1.21	0.81	0.71	0.67	0.53
π	0.15	0.15	0.15	0.14	0.08	0.07	0.06	0.05
R	0.69	0.99	2.45	2.61	1.44	1.30	0.62	0.24

2 lags

	With Michigan expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	1.03	1.01	1.17	1.31	0.71	0.65	0.62	0.45
π	0.08	0.10	0.11	0.11	0.05	0.04	0.04	0.04
R	0.62	0.86	2.03	2.33	1.24	1.22	0.51	0.18
	With Term structure expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	1.01	1.00	1.11	1.26	0.69	0.64	0.59	0.44
π	0.10	0.11	0.12	0.12	0.05	0.05	0.04	0.03
R	0.52	0.64	1.78	1.99	1.09	1.11	0.52	0.18
	Without inflation expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	1.05	1.04	1.18	1.31	0.71	0.66	0.62	0.46
π	0.10	0.11	0.11	0.11	0.06	0.06	0.04	0.04
R	0.63	0.97	2.15	2.46	1.38	1.30	0.55	0.20

3 lags

	With Michigan expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.92	0.92	1.04	1.20	0.63	0.01	0.58	0.36
π	0.08	0.10	0.10	0.10	0.05	0.04	0.03	0.03
R	0.54	0.81	1.62	1.99	0.96	0.95	0.48	0.16
	With Term structure expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.91	0.92	0.97	1.13	0.57	0.56	0.54	0.35
π	0.10	0.10	0.11	0.11	0.05	0.04	0.04	0.03
R	0.45	0.55	1.15	1.50	0.67	0.67	0.48	0.16
	Without inflation expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.95	0.95	1.05	1.20	0.64	0.61	0.98	0.95
π	0.10	0.11	0.12	0.13	0.06	0.05	0.04	0.10
R	0.58	0.90	1.73	2.13	1.16	1.07	0.18	0.58

8 lags

	With Michigan expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.43	0.52	0.51	0.53	0.31	0.27	0.23	0.21
π	0.04	0.05	0.05	0.06	0.03	0.03	0.02	0.02
R	0.26	0.50	1.12	1.21	0.44	0.44	0.20	0.11
	With Term structure expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.56	0.59	0.58	0.71	0.26	0.24	0.23	0.20
π	0.05	0.05	0.06	0.07	0.03	0.03	0.02	0.02
R	0.30	0.41	0.72	0.79	0.36	0.35	0.18	0.11
	Without inflation expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.63	0.67	0.75	0.85	0.36	0.32	0.27	0.25
π	0.07	0.08	0.08	0.08	0.04	0.04	0.03	0.03
R	0.36	0.68	1.30	1.41	0.58	0.54	0.24	0.16

Table A.3: F-tests, p-values, Livingstone expectations

	1 lag							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	0.59	0.77	0.68	0.63	0.29	0.88	0.77	0.51
π	0.49	0.48	0.24	0.15	0.00	0.09	0.84	0.66
R	0.86	0.80	0.79	0.61	0.00	0.04	0.26	0.53
	2 lags							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	0.63	0.83	0.78	0.82	0.37	0.21	0.18	0.18
π	0.67	0.51	0.42	0.43	0.01	0.20	0.09	0.31
R	0.60	0.83	0.90	0.91	0.20	0.06	0.08	0.30

The table reports the P-value for the F-test that expected inflation coefficients in the equation are all equal to zero in a VAR with 4 variables and varying lags.

Table A.4: Variances of reduced form shocks, Livingstone expectations

	1 lags							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	1.21	1.42	1.47	1.47	0.83	0.81	0.81	0.72
π	0.27	0.27	0.31	0.33	0.11	0.10	0.09	0.09
R	1.43	2.04	2.21	2.28	1.03	0.62	0.62	0.50
	2 lags							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	0.80	1.13	1.18	1.19	0.48	0.36	0.37	0.37
π	0.21	0.20	0.19	0.19	0.08	0.08	0.07	0.07
R	1.12	1.75	1.86	2.03	0.81	0.47	0.46	0.40
	Without inflation expectations, 1 lags							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	1.26	1.44	1.51	1.50	0.88	0.81	0.82	0.72
π	0.28	0.28	0.33	0.33	0.16	0.11	0.09	0.09
R	1.44	2.07	2.24	2.34	1.15	0.72	0.66	0.52
	Without inflation expectations, 2 lags							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	0.83	1.17	1.22	1.23	0.53	0.39	0.40	0.40
π	0.22	0.22	0.20	0.20	0.09	0.09	0.08	0.08
R	1.15	1.79	1.90	2.08	0.84	0.49	0.49	0.43

Table A.5: F-tests, p-values, Greenbook expectations

sample	65:4-79:1	65:4-80:1	65:4-81:1	65:4-82:1	79:2-01:4	80:2-01:4	81:2-01:4	81:2-01.4
Δ GDP	0.54	0.25	0.01	0.00	0.82	0.10	0.21	0.10
π	0.14	0.14	0.13	0.00	0.00	0.00	0.11	0.39
R	0.71	0.04	0.38	0.33	0.36	0.60	0.12	0.19

The table reports the P-value for the F-test that expected inflation coefficients in the equation are all equal to zero in a VAR with 4 variables and two lags.

Table A.6: Variances of reduced form shocks, Greenbook expectations

	With inflation expectations							
sample	65:4-79:1	65:4-80:1	65:4-81:1	65:4-82:1	79:2-01:4	80:2-01:4	81:2-01:4	81:2-01.4
Δ GDP	0.87	0.84	0.96	1.11	0.79	0.68	0.66	0.47
π	0.09	0.12	0.13	0.13	0.04	0.04	0.03	0.03
R	0.77	1.10	2.73	3.08	1.37	1.33	0.57	0.19
	Without inflation expectations							
sample	65:4-79:1	65:4-80:1	65:4-81:1	65:4-82:1	79:2-01:4	80:2-01:4	81:2-01:4	81:2-01.4
Δ GDP	1.00	1.00	1.21	1.38	0.79	0.73	0.69	0.51
π	0.12	0.12	0.14	0.16	0.06	0.05	0.04	0.03
R	0.78	1.21	2.77	3.12	1.41	1.35	0.60	0.20

Table A.7: F-tests, p-values, Large system

	With Michigan expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.60	0.15	0.58	0.01	0.41	0.57	0.95	0.90
π	0.94	0.90	0.96	0.71	0.95	0.90	0.97	0.96
Δ C	0.43	0.31	0.50	0.93	0.42	0.30	0.16	0.24
Δ I	0.18	0.14	0.26	0.11	0.14	0.16	0.06	0.04
Hours	0.91	0.88	0.75	0.78	0.29	0.22	0.35	0.30
Δ M	0.24	0.33	0.06	0.10	0.59	0.65	0.72	0.89
R	0.21	0.39	0.05	0.08	0.44	0.31	0.48	0.01
	With Term structure expectations							
sample	60:1-79:2	60:1-80:2	60:1-81:2	60:1-82:2	79:3-05:4	80:3-05:4	81:3-05:4	82:3-05.4
Δ GDP	0.60	0.35	0.73	0.39	0.60	0.68	0.83	0.87
π	0.74	0.84	0.43	0.84	0.96	0.68	0.38	0.50
Δ C	0.20	0.58	0.61	0.37	0.07	0.69	0.59	0.53
Δ I	0.33	0.41	0.25	0.73	0.38	0.03	0.19	0.16
Hours	0.92	0.57	0.97	0.99	0.60	0.52	0.59	0.64
Δ M	0.11	0.47	0.85	0.55	0.84	0.51	0.70	0.73
R	0.50	0.33	0.38	0.06	0.19	0.10	0.22	0.19

The table reports the P-value for the F-test that expected inflation coefficients in the equation are all equal to zero in a VAR with 8 variables and two lags.

Table A.8: Variances of reduced form shocks, Large system

	With Michigan expectations							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	1.06	1.14	1.20	1.32	0.60	0.58	0.44	0.45
π	0.30	0.30	0.30	0.32	0.31	0.30	0.31	0.29
Δ C	0.48	0.59	0.61	0.62	0.32	0.21	0.21	0.21
Δ I	9.09	10.2	11.0	10.6	5.04	4.07	2.95	2.91
Hours	0.40	0.45	0.43	0.42	0.59	0.55	0.55	0.56
Δ M	362.3	371.8	371.7	370.8	142.6	135.1	118.9	112.2
R	0.16	0.18	0.19	0.22	0.24	0.20	0.18	0.18
	With Term structure expectations							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	0.33	0.46	0.99	1.14	0.63	0.61	0.47	0.47
π	0.30	0.30	0.30	0.31	0.31	0.30	0.31	0.29
Δ C	0.59	0.38	0.44	0.60	0.39	0.21	0.21	0.21
Δ I	2.09	6.02	6.78	7.80	5.26	3.91	2.99	2.92
Hours	0.22	0.31	0.44	0.42	0.59	0.55	0.54	0.56
Δ M	128.9	210.9	315.4	306.2	158.9	146.2	127.9	117.6
R	0.10	0.18	0.25	0.25	0.23	0.18	0.17	0.16
	Without inflation expectations							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	1.08	1.21	1.22	1.49	0.61	0.59	0.45	0.45
π	0.30	0.30	0.30	0.32	0.31	0.30	0.31	0.30
Δ C	0.50	0.62	0.62	0.62	0.40	0.22	0.22	0.21
Δ I	9.63	10.8	11.5	11.3	5.26	4.25	3.16	3.16
Hours	0.40	0.45	0.44	0.42	0.61	0.57	0.56	0.57
Δ M	380.3	385.3	403.7	395.8	144.3	136.5	119.8	112.5
R	0.17	0.19	0.21	0.23	0.24	0.20	0.19	0.18

Table A.9: F-tests, p-values, Using output growth expectations

	Greenbook forecasts, output and inflation expectations							
	Lags of inflation expectations							
sample	65:4-79:1	65:4-80:1	65:4-81:1	65:4-82:1	79:2-01:4	80:2-01:4	81:2-01:4	81:2-01.4
Δ GDP	0.57	0.26	0.02	0.00	0.28	0.05	0.21	0.04
π	0.00	0.14	0.16	0.02	0.00	0.00	0.06	0.30
R	0.32	0.06	0.33	0.24	0.59	0.98	0.15	0.09
	Lags of output growth expectations							
sample	65:4-79:1	65:4-80:1	65:4-81:1	65:4-82:1	79:2-01:4	80:2-01:4	81:2-01:4	81:2-01.4
Δ GDP	0.58	0.71	0.28	0.06	0.02	0.18	0.24	0.13
π	0.95	0.94	0.94	0.49	0.30	0.58	0.32	0.72
R	0.58	0.82	0.17	0.03	0.04	0.03	0.69	0.16
	Greenbook forecasts, output expectations only							
sample	65:4-79:1	65:4-80:1	65:4-81:1	65:4-82:1	79:2-01:4	80:2-01:4	81:2-01:4	81:2-01.4
Δ GDP	0.55	0.72	0.29	0.11	0.06	0.33	0.24	0.29
π	0.96	0.91	0.93	0.20	0.47	0.58	0.54	0.95
R	0.57	0.84	0.18	0.04	0.02	0.01	0.57	0.35
	Professional forecasts, output and inflation expectations							
	Lags of inflation expectations							
sample	68:1-79:1	68:1-80:1	68:1-81:1	68:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	0.48	0.49	0.09	0.04	0.00	0.00	0.30	0.11
π	0.01	0.05	0.29	0.04	0.00	0.00	0.05	0.40
R	0.40	0.64	0.53	0.49	0.00	0.00	0.00	0.00
	Lags of output growth expectations							
sample	68:1-79:1	68:1-80:1	68:1-81:1	68:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	0.00	0.03	0.03	0.00	0.02	0.00	0.05	0.22
π	0.13	0.06	0.54	0.33	0.22	0.63	0.80	0.81
R	0.77	0.19	0.60	0.34	0.02	0.03	0.06	0.71
	Professional forecasts, output expectations only							
sample	68:1-79:1	68:1-80:1	68:1-81:1	68:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	0.00	0.01	0.04	0.01	0.10	0.03	0.17	0.33
π	0.20	0.10	0.48	0.15	0.02	0.31	0.76	0.65
R	0.46	0.19	0.62	0.36	0.07	0.67	0.10	0.18

The table reports the P-value for the F-test that expected output coefficients in the equation are all equal to zero in a VAR with 4 variables and two lags.

Table A.10: Variances of reduced form shocks, systems with output growth expectations

	Greenbook forecasts, output and inflation expectations							
sample	65:4-79:1	65:4-80:1	65:4-81:1	65:4-82:1	79:2-01:4	80:2-01:4	81:2-01:4	81:2-01.4
Δ GDP	0.85	0.83	0.92	1.00	0.71	0.65	0.64	0.45
π	0.09	0.12	0.13	0.13	0.04	0.04	0.03	0.03
R	0.75	1.09	2.55	2.72	1.27	1.22	0.56	0.18
	Greenbook forecasts, output expectations only							
sample	65:4-79:1	65:4-80:1	65:4-81:1	65:4-82:1	79:2-01:4	80:2-01:4	81:2-01:4	81:2-01.4
Δ GDP	0.87	1.21	1.07	1.22	0.74	0.71	0.67	0.49
π	0.12	0.14	0.14	0.15	0.06	0.05	0.04	0.03
R	1.21	1.24	2.66	2.87	1.29	1.22	0.59	0.19
	Without expectations							
sample	65:4-79:1	65:4-80:1	65:4-81:1	65:4-82:1	79:2-01:4	80:2-01:4	81:2-01:4	81:2-01.4
Δ GDP	1.00	1.00	1.21	1.38	0.79	0.73	0.69	0.51
π	0.12	0.12	0.14	0.16	0.06	0.05	0.04	0.03
R	0.78	1.21	2.77	3.12	1.41	1.35	0.60	0.20
	Professional forecasts, output and inflation expectations							
sample	68:1-79:1	68:1-80:1	68:1-81:1	68:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	0.60	0.78	0.82	1.07	0.62	0.56	0.55	0.44
π	0.09	0.09	0.13	0.14	0.05	0.05	0.04	0.04
R	0.84	1.01	3.14	3.17	1.15	1.12	0.46	0.27
	Professional forecasts, output expectations only							
sample	68:1-79:1	68:1-80:1	68:1-81:1	68:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	0.63	0.81	0.93	1.24	0.74	0.66	0.65	0.46
π	0.12	0.11	0.13	0.16	0.06	0.05	0.04	0.04
R	0.89	1.04	3.25	3.27	1.33	1.31	0.53	0.30
	Without expectations							
sample	68:1-79:1	68:1-80:1	68:1-81:1	68:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	0.94	0.97	1.13	1.43	0.78	0.71	0.67	0.48
π	0.13	0.12	0.14	0.17	0.06	0.06	0.04	0.04
R	0.90	1.09	3.23	3.33	1.40	1.38	0.56	0.31

The table reports the P-value for the F-test that expected output coefficients in the equation are all equal to zero in a VAR with 4 variables and two lags.

Table A.11: F-tests, p-values, Simulated data

	Continuity Solution							
sample	60:1-78:4	60:1-79:4	60:1-80:4	60:1-81:4	79:1-99:4	80:1-99:4	81:1-99:4	82:1-99.4
Δ GDP	0.06	0.04	0.44	0.90	0.60	0.47	0.70	0.65
π	0.08	0.08	0.39	0.57	0.52	0.51	0.49	0.40
R	0.53	0.54	0.82	0.22	0.99	0.99	0.93	0.93
	Orthogonality Solution							
sample	60:1-78:4	60:1-79:4	60:1-80:4	60:1-81:4	79:1-99:4	80:1-99:4	81:1-99:4	82:1-99.4
Δ GDP	0.04	0.04	0.08	0.22	0.60	0.60	0.70	0.65
π	0.00	0.00	0.12	0.81	0.36	0.39	0.49	0.40
R	0.90	0.90	0.71	0.44	0.84	0.82	0.93	0.93

The table reports the P-value for the F-test that expected inflation coefficients in the equation are all equal to zero in a VAR with 4 variables and two lags. Data from 1960:1 to 1979:4 are generated from the indeterminate solution, data from 1980:1 to 1999:4 are generated from the determiante solution.

Table A.12: Variances of reduced form shocks, Simulated data

	Continuity solution							
sample	60:1-78:4	60:1-79:4	60:1-80:4	60:1-81:4	79:1-99:4	80:1-99:4	81:1-99:4	82:1-99.4
Δ GDP	3.32	3.22	3.27	3.26	1.05	0.99	0.96	0.89
π	1.63	1.58	1.56	1.54	0.38	0.36	0.37	0.34
R	0.87	0.84	0.83	0.89	1.07	1.11	1.16	1.09
	Orthogonality Solution							
sample	60:1-78:4	60:1-79:4	60:1-80:4	60:1-81:4	79:1-99:4	80:1-99:4	81:1-99:4	82:1-99.4
Δ GDP	1.01	1.02	1.04	1.15	0.99	0.93	0.96	0.89
π	0.16	0.16	0.19	0.25	0.37	0.36	0.37	0.34
R	0.08	0.08	0.08	0.17	1.08	1.12	1.16	1.09
	Without inflation expectations, Continuity solution							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	3.48	3.40	3.29	3.26	1.05	0.99	0.96	0.89
π	1.68	1.63	1.56	1.54	0.38	0.36	0.37	0.35
R	0.88	0.88	0.83	0.90	1.08	1.11	1.09	1.10
	Without inflation expectations, Orthogonality solution							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	1.04	1.04	1.06	1.12	0.98	0.87	0.93	0.84
π	0.18	0.19	0.19	0.24	0.35	0.34	0.34	0.32
R	0.09	0.09	0.08	0.17	1.00	1.04	1.08	1.04

Table A.13: F-tests, p-values, Simulated data with measurement error

	Continuity Solution, iid errors							
sample	60:1-78:4	60:1-79:4	60:1-80:4	60:1-81:4	79:1-99:4	80:1-99:4	81:1-99:4	82:1-99.4
Δ GDP	0.00	0.00	0.05	0.07	0.16	0.10	0.92	0.70
π	0.14	0.17	0.23	0.94	0.16	0.20	0.26	0.32
R	0.05	0.05	0.10	0.17	0.10	0.10	0.25	0.26
	Orthogonality Solution, iid errors							
sample	60:1-78:4	60:1-79:4	60:1-80:4	60:1-81:4	79:1-99:4	80:1-99:4	81:1-99:4	82:1-99.4
Δ GDP	0.05	0.05	0.10	0.34	0.74	0.30	0.92	0.70
π	0.36	0.28	0.60	0.05	0.23	0.25	0.26	0.32
R	0.61	0.63	0.82	0.68	0.10	0.15	0.25	0.26
	Continuity Solution, AR errors							
sample	60:1-78:4	60:1-79:4	60:1-80:4	60:1-81:4	79:1-99:4	80:1-99:4	81:1-99:4	82:1-99.4
Δ GDP	0.00	0.00	0.04	0.07	0.16	0.10	0.92	0.70
π	0.12	0.14	0.21	0.90	0.16	0.20	0.26	0.32
R	0.04	0.05	0.09	0.15	0.10	0.10	0.25	0.26

The table reports the P-value for the F-test that expected inflation coefficients in the equation are all equal to zero in a VAR with 4 variables and two lags. Data from 1960:1 to 1979:4 are generated from the indeterminate solution, data from 1980:1 to 1999:4 are generated from the determinate solution. When measurement error is serially correlated, the persistence coefficent is set to 0.9.

Table A.14: Variances of reduced form shocks, Simulated data with measurement error

	Continuity solution, iid errors							
sample	60:1-78:4	60:1-79:4	60:1-80:4	60:1-81:4	79:1-99:4	80:1-99:4	81:1-99:4	82:1-99.4
Δ GDP	3.47	3.42	3.41	3.31	0.18	0.07	0.05	0.05
π	1.67	1.66	1.72	1.70	1.65	1.64	1.62	1.70
R	1.41	1.41	1.40	1.36	0.18	0.12	0.11	0.12
	Orthogonality Solution, iid errors							
sample	60:1-78:4	60:1-79:4	60:1-80:4	60:1-81:4	79:1-99:4	80:1-99:4	81:1-99:4	82:1-99.4
Δ GDP	1.38	1.40	1.72	1.69	0.50	0.13	0.05	0.05
π	0.19	0.19	0.29	0.30	1.57	1.64	1.62	1.70
R	0.52	0.52	0.56	0.53	0.15	0.12	0.11	0.12
	Without inflation expectations, Continuity solution, iid errors							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	3.82	3.74	3.58	3.44	0.19	0.08	0.05	0.05
π	1.72	1.71	1.76	1.70	1.69	1.68	1.65	1.73
R	1.49	1.48	1.45	1.39	0.18	0.13	0.12	0.12
	Without inflation expectations, Orthogonality solution, iid errors							
sample	55:1-79:1	55:1-80:1	55:1-81:1	55:1-82:1	79:2-06:1	80:2-06:1	81:2-06:1	81:2-06.1
Δ GDP	1.35	1.37	1.66	1.61	0.47	0.12	0.05	0.05
π	0.18	0.18	0.29	0.27	1.57	1.64	1.61	1.67
R	0.53	0.52	0.56	0.54	0.15	0.11	0.11	0.11