Commentary

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In their paper, Hoover and Jordá have tackled a very difficult task: the analysis of the effect of systematic monetary policy. As the paper's critical review of the literature outlines, during the last several decades the literature has focused almost exclusively on the effects of unanticipated monetary shocks rather than on the effects of systematic monetary policy. Hoover and Jordá argue that this exclusive focus should be altered, that monetary analysis should also study the effects of systematic monetary policy.

The second half of the paper offers new methods and results for the analysis of monetary effects. Hoover and Jordá propose a new way to identify the relative effects of anticipated versus unanticipated monetary policy in the context of Cochrane's (1998) mixed model. They then use the estimates to analyze the implications for systematic monetary policy.

This paper deals with many subtle issues of identifying monetary policy. Because an understanding of the subtleties is essential for appreciating the contribution of this paper, I will first review the identification issues involved. I will then expand on Hoover and Jordá's arguments for why we should study the effects of systematic monetary policy. Focusing on the second half of their paper, I will analyze Hoover and Jordá's new procedure and then finish by assessing its strengths and weaknesses.

IDENTIFYING THE SEPARATE EFFECTS OF ANTICIPATED VERSES UNANTICIPATED MONETARY POLICY

Sargent (1976) first pointed out that without additional information, one cannot separately identify the effects of anticipated versus unanticipated monetary policy. The problem is that many different theories of the effects of monetary policy are consistent with the history of monetary policy, as captured by a vector autoregression (VAR). Thus, without further identifying assumptions, a VAR can only reveal the effect of a monetary shock *if it is followed by the usual policy actions*.

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It is useful to consider two polar cases and an intermediate case:

- **Polar Case 1: Only unanticipated money matters.**
  This is the case usually assumed (implicitly) in the VAR literature. If only unanticipated money matters, the impulse response function (IRF) reveals the structural coefficients of the model. Furthermore, the impulse response function is invariant to changes in monetary regimes. Why is this the case? Because none of the propagation of a monetary shock to output operates through the subsequent effect on anticipated money, the effects do not depend on the coefficients of the monetary feedback rule.
- **Polar Case 2: All money matters equally.**
  In this case, the coefficients in the regression of output, y, on money, m, and its lags are invariant to changes in the policy rule. This result occurs because a unit increase in money always has a certain effect on output, regardless of whether the increase was caused by a monetary shock or a systematic increase in money. The impulse response function, however, is not invariant to changes in the policy rule. If policy changes so that movements in money become more persistent, the response of output will be different.
- **Intermediate Case: Anticipated and unanticipated money matter differently.**
  This middle case is the most difficult case to analyze because nothing from the VAR is invariant to policy. Without further identifying information, it is hopeless to try to distinguish the two types of effects.

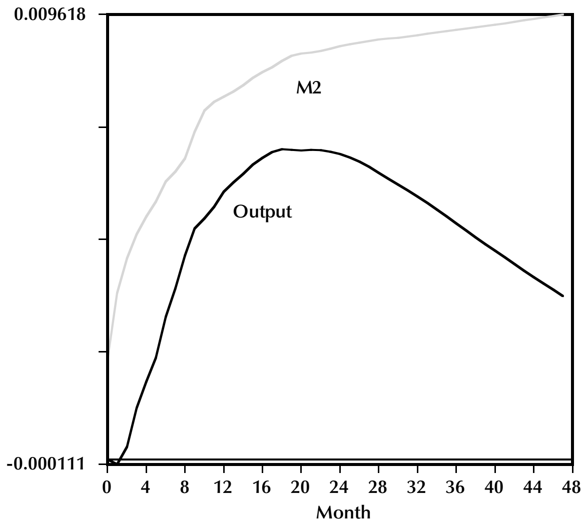
WHY STUDY THE EFFECTS OF SYSTEMATIC MONETARY POLICY?

Until recently, most researchers were content to examine only the effects of unanticipated monetary shocks because they assumed that systematic monetary policy does not matter. As pointed out above, impulse response functions from the VAR are the natural method for analyzing these effects because they are invariant to changes in policy regimes.

Why have Hoover and Jordá, as well as a few papers in the recent literature, decided to tackle the very difficult problem of analyzing systematic policy? I would argue that there are four key reasons.

Figure 1

Response of Output and M2 to an M2 Shock



The first reason is the realization in the last decade that shocks to monetary policy do not explain much of the variance of output (e.g., Cochrane, 1994). Many researchers have strong prior beliefs that money matters a lot. In order to reconcile that belief with the small role of shocks, one must naturally turn to systematic monetary policy as a candidate.

The second reason is the realization of the potential role of systematic monetary policy as a propagation mechanism. By ignoring the possible systematic effects of monetary policy we may be inappropriately attributing its effects to other variables. For example, Bernanke, Gertler, and Watson (1997) argue that many of the observed effects of oil on the economy may be due to the endogenous response of monetary policy to oil shocks.

The third reason that the literature has become more open to the idea that systematic monetary policy is important is the great amount of recent research on the importance of monetary policy rules. If systematic monetary policy has no effects, then there is little point in debating the merits of various rules, except for the central bank's role in price stabilization.

Finally, as Cochrane (1998) points out, if only unanticipated monetary policy matters, then "the striking similarity of the output and monetary responses is a pure and unlikely coincidence" (p. 295). Figure 1 shows the response of the log of industrial production and the log of M2 to a shock to M2.[1] Output and money follow very similar paths in the first few years after a shock. If we believe that only unanticipated money matters, then we should not expect such similarities in the path. The similarities displayed offer incriminating evidence that part of the impact of money on output is propagated through the endogenous response of money.

HOOVER-JORDÁ IDENTIFICATION METHOD

Hoover and Jordá offer a very clever idea for distinguishing the effects of anticipated versus unanticipated money. They begin with Cochrane's hybrid model, which is a "structural" model that allows anticipated money to matter. The hybrid equation is as follows:

$$y_t = \lambda A(L)\, E(m_t|\Omega_{t-1}) + A(L)[m_t - E(m_t|\Omega_{t-1})] + \boldsymbol{B}(L)\varepsilon_{wt},$$

where ε_{wt} is a vector of orthogonalized nonmonetary innovations, which includes the output innovation. The first term captures the effect of anticipated money and the second term captures the effect of unanticipated money. If $\lambda = 0$, then only unanticipated money matters. If $\lambda = 1$, there is no distinction between anticipated and unanticipated money. If λ is between 0 and unity, then unanticipated and anticipated money matter, but they matter differently.

Cochrane gives no economic interpretation of λ, but Hoover and Jordá suggest one. They suggest that λ be interpreted as the fraction of nonrational agents in the economy, much as Campbell and Mankiw (1989) interpreted a comparable coefficient in their study of consumption behavior. I will discuss the plausibility of this interpretation below.

The identification problem is best seen by considering the relationship between the structural parameters λ and the parameters of $A(L)$ on the one hand and the coefficients from the reduced-form moving-average representation (MAR) of the VAR on the other. The MAR is given by equations (18) and (19) of the paper, which are shown here:

[1] The impulse response functions are computed from a VAR with industrial production, the consumer price deflator, and M2, all in logarithms. The VAR has 12 lags and is estimated over the period 1960:1–1999:12.

(18) $$y_t = C_{ym}(L)\varepsilon_{mt} + \boldsymbol{C}_{yw}(L)\varepsilon_{wt}$$

and

(19) $$m_t = C_{mm}(L)\varepsilon_{mt} + \boldsymbol{C}_{mw}(L)\varepsilon_{wt}\,.$$

The relationship between the structural coefficients and the MAR coefficients is given by equation (26) of the paper. Here is the first set of equations in equation (26):

(26) $$\begin{aligned} c_{ym0} &= a_0 c_{mm0} \\ c_{ym1} &= a_0 \lambda c_{mm1} + a_1 c_{mm0} \\ &\vdots \\ c_{ymk} &= a_0 \lambda c_{mmk} + \ldots + a_{k-1} \lambda c_{mm1} + a_k c_{mm0} \\ &\vdots \end{aligned}$$

(The rest of the equations in equation (26) involve the coefficients such as c_{yy0}, c_{yw0}, etc. and the b's from the polynomial $\boldsymbol{B}(L)$.) Consider the algebra behind the identification problem. The c coefficients are estimated from the MAR of the VAR and thus can be treated as "known" for the purposes of identification. Given the c's, can we back out the λ and a's? No. Inspection of the equations shows that the number of equations is greater than the number of unknowns: there are $k+1$ equations in $k+2$ unknowns. Adding the remaining equations in the system does not solve the problem.

Because the system is not identified without further assumptions, Cochrane only analyzes what the effects of monetary policy would be if λ took on various values. Hoover and Jordá, in contrast, tackle the identification problem head-on.

Hoover and Jordá solve the identification problem by making assumptions that allow them to convert this system of algebraic equations into a system of regressions. Rather than solve algebraically for the λ, a's, and b's, they instead figure a way to *estimate* them. The required assumptions are as follows:

1. The monetary policy regime switches at least once during the sample, so there are at least two sets of MAR coefficients (the c's).
2. λ is invariant to switches in monetary policy regimes.
3. $A(L)$ and $\boldsymbol{B}(L)$ are invariant to switches in monetary policy regime.
4. Anticipated and unanticipated shocks are propagated by the same mechanism: $A(L)$.

To see how these assumptions solve the identification problem, rewrite the equations in system (26) as a system of *regressions* rather than algebraic equations:

$$\begin{aligned} c_{ym0,t} &= a_0 c_{mm0,t} + \mu_{0,t} \\ c_{ym1,t} &= a_0 \lambda c_{mm1,t} + a_1 c_{mm0,t} + \mu_{1,t} \\ &\vdots \\ c_{ymk,t} &= a_0 \lambda c_{mmk,t} + \ldots + a_{k-1} \lambda c_{mm1,t} + a_k c_{mm0,t} + \mu_{k,t} \\ &\vdots \end{aligned}$$

I have added t subscripts on the c coefficients because now they are treated as variables (with at least two observations). I have also added error terms, μ, which I will discuss shortly.

Now, identification becomes much easier. In fact, the system is recursive. The first equation regresses $c_{ym0,t}$ on $c_{mm0,t}$ and produces a regression coefficient estimate for a_0. With an estimate of a_0 from the first equation, one can then use the regression given in the second equation to estimate λ and a_1. One can estimate each of the a's recursively. In short, Hoover and Jordá identify the structural parameters by turning a system of algebraic equations into a system of regressions.

To implement the idea, Hoover and Jordá use the following procedure. They begin with the Christiano, Eichenbaum, and Evans (1996) VAR to describe monetary policy and its effect on the economy. Hoover and Jordá use Bai-Perron tests for structural breaks on the monetary reactions function (the federal funds rate [FFR] equation in a Christiano et al. system). The test statistics favor two breaks, but they choose five breaks since the test statistic is almost as high and it gives more observations for each c in the system above. In the next step, they estimate the entire VAR separately on each regime, taking regime breaks as given. This step yields six sets of estimates of the MAR coefficients.

They then treat each MAR coefficient as a variable with six observations to create the set of regressions outlined above. They use a minimum-distance estimator to estimate λ and the parameters of $A(L)$ and $\boldsymbol{B}(L)$, imposing the nonlinear cross-equation restrictions.

This procedure yields several surprising results. First, λ is estimated to be 0.57 with a standard error of 0.14! This estimate of λ is eerily similar to Campbell and Mankiw's (1989) estimate of the fraction of rule-of-thumb consumers. Are we to believe that Hoover and Jordá's nonrational agents and Campbell and Mankiw's rule-of-thumb consumers are one and the same?

A second result, which is not so surprising, is that the response of money to a shock depends significantly on the value of λ. This result confirms what Cochrane found when he analyzed monetary policy under different assumptions about λ. The response of output to an unanticipated shock becomes smaller as λ rises because we attribute more and more of the subsequent response of output to lagged anticipated money, which also changes in response to the initial unanticipated shock.

Perhaps the most surprising result is the analysis of monetary policy over the various regimes. Hoover and Jordá find a wide variety of responses of monetary policy to real shocks over the different regimes. Among the more curious results found are the estimates that imply that Volcker was much more of an inflation dove than Burns-Miller and Greenspan. These results are difficult to interpret.

CRITIQUE

While I think that the Hoover and Jordá identification method is a clever device that can probably be used in a variety of contexts, I think that there are several weaknesses of this particular implementation. These weaknesses lead me to question the robustness of the empirical results.

My first concern is that the authors are applying a very clever idea to a very shaky foundation. I am uncomfortable with their interpretation of the Cochrane hybrid model as a model with a certain fraction of nonrational agents. Abandoning Lucas's idea that only unanticipated money matters does not mean we must abandon rigorous methodology as well. We should be serious about deviations from rational expectations. There is an important area of literature that studies learning and adaptive behavior. Some of the more realistic models are those with agents that have bounded rationality but which display active cognition.

In a serious model of bounded rationality, we would expect λ to change when the monetary regime changes. In particular, we might expect λ (the fraction of nonrational agents) to rise immediately after the shift in a monetary regime because it is difficult to form rational expectations when the structure of the economy has suddenly shifted.

I am also concerned about the plausibility of some of the other identifying assumptions. One key assumption is that the lag structure coefficients for both anticipated and unanticipated money are the same, even though they are assumed to have different effects on the economy. Why would we expect them to have the same lag structure in the propagation mechanism? In short, a better structural model would help us assess the reasonableness of the identifying assumptions.

Identifying assumptions aside, there are other aspects of the implementation that cast some doubt on the precision of the results. First, as acknowledged by Hoover and Jordá, the true standard error on λ is probably much higher than 0.14. That standard error is based on an estimation method that assumes that the c's are known, rather than estimated. In fact, they are estimated. Moreover, some of the sets of c's are estimated over sample periods with very few observations. For example, for the monetary regime from 1978:6 to 1982:3, they use 46 observations to estimate 25 VAR parameters. It's no wonder that monetary policy looks so different across regimes: the sampling error must be very large. A related concern is the source of the error terms introduced into the system when it is converted from an algebraic system to a regression system. The authors talk about "computational errors," but can we be certain that these errors have the properties required for consistency of the estimates?

Another reason we might not have much confidence in the results is that there are no tests of over-identifying restrictions. It seems it would be preferable to incorporate the notion of regime changes directly in the structural model in order to derive the implications. One could then estimate the six sets of MAR coefficients jointly with λ, $A(L)$, and $\boldsymbol{B}(L)$, using the theoretical restrictions.

A final quibble is the point that finding five breaks using the Bai-Perron test does not imply six different regimes. In principle, monetary policy could be switching back and forth between two distinct regimes.

Given these potential concerns, it seems that it would be good for the authors to test a more straightforward implication of their model—one that does not require so many identifying restrictions. As discussed above, if λ is equal to unity, meaning that there is no distinction between anticipated and unanticipated money, the coefficients on money in the output equation are invariant to regime shifts. The advantage of setting λ equal to unity as the null hypothesis is that in this case it is natural to believe that the $A(L)$ coefficients are the same across anticipated and unanticipated money.

Thus, as a first pass, one could use the following

Table 1

Results of Chow Tests (*p* values)

Regimes compared	Money equation	Output equation
1 versus 2	0.000	0.470
2 versus 3	0.003	0.377

procedure. First, test the set of coefficients in the money equation for stability. If stability is rejected, then there is evidence of monetary regime shifts. Conditional on the regime switch, a test of the stability of the coefficients on money in the output equation is a test of λ equal to unity.

In order to illustrate this procedure, I estimated a VAR with the log of employment, log of M2, and log of the consumption deflator. The VAR contains seven lags. I use two breaks, which implies three regimes, because this is the result with the highest sup F in the Bai-Perron test. The first regime extends from 1960:1 to 1978:5, the second from 1978:6 to 1982:3, and the third from 1982:4 to 1999:1.

The results of Chow tests on the coefficients in the money equation versus the output equation are given in Table 1. Table 1 shows that the Chow test supports the Bai-Perron test of a structural break in the monetary policy reaction function. In contrast, one cannot reject stability of the coefficients on money in the output equation. These results suggest that the data are not at odds with the assumption that anticipated and unanticipated money matter equally. Of course, these results need to be tested in more complicated systems, but, if they hold up, they have important implications for the analysis of monetary policy.

CONCLUSIONS

Hoover and Jordá set their sights on an ambitious goal when they decided to analyze the effects of systematic monetary policy. In trying to analyze this problem, they have introduced a clever new identification technique. While I have raised concerns about several aspects of the implementation, the paper nonetheless makes two important contributions. First, it provides further support for the importance of shifting the research agenda to analyzing systematic monetary policy. Second, the potential contribution of their new technique is not limited to this particular implementation.

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