C·I·R·P·É·E

Centre Interuniversitaire sur le Risque,
les Politiques Économiques et l'Emploi

Stock Returns and Monetary Policy: Are There Any Ties ?

Hafedh Bouakez

Badye Omar Essid

Michel Normandin

Bouakez: Department of Economics, HEC Montréal and CIRPÉE, 3000 Chemin de la Côte-Sainte-Catherine, Montréal, Québec, Canada H3T 2A7
hafedh.bouakez@hec.ca

Essid: Department of Economics, HEC Montréal and CIRPÉE, 3000 Chemin de la Côte-Sainte-Catherine, Montréal Québec, Canada H3T 2A7
badye-omar.essid@hec.ca

Normandin : Corresponding author. Department of Economics, HEC Montréal and CIRPÉE, 3000 Chemin de la Côte-Sainte-Catherine, Montréal, Québec, Canada H3T 2A7; Phone number: 514 340-6841; Fax number: 514 340-6469
michel.normandin@hec.ca

Abstract:
This paper empirically investigates the following three questions: (*i*) Do stock returns respond to monetary policy shocks? (*ii*) Do stock returns alter the transmission mechanism of monetary policy? and (*iii*) Does monetary policy systematically react to stock returns? Existing research based on event studies and Structural Vector Auto-Regressions (SVAR) documents that stock returns increase significantly following an unanticipated monetary policy expansion. However, this literature did not explore whether or not stock returns matter for the choice of monetary policy or its propagation mechanism. In this paper, we use a SVAR that relaxes the restrictions commonly imposed in earlier studies and identify monetary policy shocks by exploiting the conditional heteroscedasticity of the structural innovations. Applying this method to U.S. data, we reach a surprising and puzzling conclusion: the answers to the three questions above are No, No, and No!

1. Introduction

This paper empirically investigates the following three questions using monthly U.S. data: (*i*) Do stock returns respond to monetary policy shocks? *ii*) Do stock returns alter the transmission mechanism of monetary policy? and (*iii*) Does monetary policy systematically react to stock returns? We reach a surprising and puzzling conclusion: the answers to the three questions above are No, No, and No!

The interdependence between asset prices and monetary policy is a central issue in financial economics, in which interest has been rekindled in light of the latest global financial crisis. Yet, among the various aspects of this interdependence, only the responsiveness of stock returns to monetary policy shocks has received significant attention in the empirical literature. In contrast, the questions of whether stock returns matter for the choice of monetary policy or whether they affect its propagation mechanism have remained largely unexplored from an empirical standpoint, despite being highly controversial among academics and policy-makers.

Earlier research that focused on measuring the responsiveness of stock returns to monetary policy shocks can be grouped into two strands: event studies, which rely on a narrative approach to isolate exogenous and unanticipated changes in monetary policy, and those based on estimating Structural Vector Auto-Regressions (SVAR). By and large, this literature finds that stock returns increase significantly following an unanticipated monetary policy expansion. Both approaches, however, need to impose strong and sometimes dubious identifying assumptions, which, as we show in this paper, are not innocuous. Event studies implicitly assume that monetary policy shocks swamp any other structural shocks during periods where a decision about monetary policy is to be taken (e.g. Cook and Hahn 1989; Kuttner 2001; Bernanke and Kuttner 2005), whereas SVAR-based studies impose some exclusion restrictions that limit the interaction of economic variables in way that is not necessarily consistent with the data. These restrictions can be of two types: those that define the policy indicator and those that determine the way in which mone-

tary shocks propagate. Regarding the former, existing SVAR studies invariably define the federal funds rate as being the relevant and unique indicator of U.S. monetary policy. As for the latter, two different schemes are found in the literature: a recursive scheme, which assumes that the federal funds rate is predetermined with respect to stock returns (e.g. Thorbecke 1997; Petalis 1997; Bernake and Kuttner 2005; and Gilchrist, Yankov, and Zakrajsek 2009), and a simultaneous scheme, which allows for contemporaneous interactions between these two variables but which restricts their interactions with remaining economic variables (e.g. Bjørnland and Leitemo 2009). Under the usually maintained assumption that the structural shocks are conditionally homoscedastic, none of these identification schemes is testable.

In this paper, we estimate the interdependence between stock returns and monetary policy using a methodology that relaxes the identifying assumptions commonly used in earlier studies. Instead, monetary policy shocks and their effects are identified by exploiting the conditional heteroscedasticity of the innovations to the variables included in the SVAR, as in Normandin and Phaneuf (2004) and Bouakez and Normandin (2009). The idea behind this approach is that time variation in the conditional volatilities of the structural innovations provides additional information that allows to identify more parameters (relative to the conventional conditionally homoscedastic case). As a result, no arbitrary restrictions need to be imposed on the contemporaneous interactions between policy instruments and the variables of interest, thus leaving unrestricted both the policy indicator and the propagation mechanism of shocks.

Interestingly, the flexible system estimated in this paper nests, and hence allows to test, the various specifications proposed in existing SVAR studies. This in turn allows us to gauge the consequences of imposing counterfactual identifying restrictions and to determine the extent to which they are responsible for the established results. An additional advantage of our empirical methodology is that it allows us to address the two remaining questions (*ii* and *iii*) that have been overlooked by the empirical literature.

We start by showing that the identifying restrictions commonly used in the literature are not supported by the data. We also show that the responses of output, the price level, and the short-term interest rates implied by the flexible system are empirically plausible and do not exhibit the anomalies (such as the price puzzle) generated by the restricted systems used in previous studies. We then proceed to analyze the response of stock returns to an expansionary monetary policy shock. We find this response to be negative on impact but statistically insignificant at all horizons and we show that this lack of responsiveness does not stem from aggregating individual stocks into a broad portfolio. This result is puzzling given that standard theoretical models suggest that asset prices, and thus stock returns, should increase following a monetary policy expansion, owing to an increase in firm's expected future cash flows and a decline in the rate at which those cash flows are discounted. Importantly, this result overturns the findings of earlier empirical studies, thus forcefully demonstrating that imposing invalid identifying restrictions can lead to substantial mismeasurements and ultimately to erroneous conclusions about the effects of monetary policy.

Our analysis also indicates that asset prices play essentially no role in the transmission mechanism of monetary policy. We establish this result by comparing the unrestricted responses of key macroeconomic aggregates with the responses computed by shutting down all contemporaneous and dynamic interactions between stock returns and the other variables in the system. Specifically, we find that the unrestricted responses of output, consumption, investment, and the price level are virtually identical to those obtained from a system in which stock returns do not interact with any other variable. This result contrasts with the conventional wisdom that asset prices affect consumption through a wealth channel, and investment through a Tobin's Q effect (higher expected profits) and a credit channel (improvement in the firms' balance sheet).

Finally, we find that stock returns do not influence the Federal Reserve's policy. The parameter estimates of the monetary authority's feedback rule imply that the policy indi-

cator is not significantly affected by current changes in stock returns. In addition, the more stringent exercise that eliminates all contemporaneous and dynamic interactions between stock returns and all the other variables leads to responses of the policy variables, such as the federal funds rate, the non-borrowed and total reserves, that are very similar to those obtained from the unrestricted system. This result implies that the Federal Reserve is not reacting explicitly to asset prices neither in a proactive nor in a reactive way.

Our paper is closely related to the work of Rigobon and Sack (2003, 2004), who assume that the *unconditional* volatilities of the structural innovations change across pre-selected regimes.[1] Two important differences distinguish our approach from theirs. First, in their work, the relations between stock prices and monetary policy are sequentially analyzed from two distinct definitions of regimes. On the one hand, the impact response of stock prices to a monetary policy shock is analyzed by assuming that this shock is larger on days of Federal Open Market Committee meetings and of the Chairman's semi-annual monetary policy testimony to Congress, while the variance of the stock market innovation remains constant. On the other hand, the contemporaneous effect of stock prices on the monetary policy indicator is measured by assuming that the variance of the stock market shock is larger when the 30-day rolling variances of the reduced-form residuals of the interest rate and stock returns are more than one standard deviation above their averages, whereas the monetary policy shock is homoscedastic. In contrast, our methodology allows us to assess the bidirectional relations between stock returns and monetary policy simultaneously. Second, the Rigobon-Sack definitions of the various regimes require the use of high-frequency data. This in turn impedes the analysis of the role of asset returns in the propagation

---

[1] Alternatively, the volatilities of the structural innovations may be estimated within a Markov switching framework, without pre-selecting the regimes. Lanne, Lütkepohl, and Maciejowska (2010) derive the conditions under which identification can be achieved in this context. Lanne and Lütkepohl (2008) use this methodology to assess the effects of monetary policy shocks on macroeconomic aggregates.

mechanism of monetary policy, since data on output and the price level are not available at high frequencies. In contrast, our method can be applied to monthly data, for which measures of output and the price level exist.

This paper is organized as follows. Section 2 presents the flexible system and popular alternative specifications. Section 3 explains the empirical method to identify monetary policy shocks and estimate the system. Section 4 reports some preliminary results. Section 5 studies the interdependence between stock returns and monetary policy. Section 6 concludes.

2. Econometric Framework

In this section, we present the flexible system that will be used to study the interdependence between stock returns and monetary policy. Then, we lay out the restrictions under which this system nests alternative specifications used in previous work.

2.1 Flexible System

We start with the following SVAR:

$$Az_t = \sum_{k=1}^{\tau} A_k z_{t-k} + \epsilon_t. \tag{1}$$

The vector z_t includes the variables of interest, which can be divided into three categories: the goods variables, the reserve variables, and the financial variables. The goods variables are total output, y_t, the price level, p_t, and the commodity price, cp_t. The reserve variables are the nonborrowed reserves, nbr_t, total reserves, tr_t, and the federal funds rate, ffr_t. The financial variables are the treasury bill rate, tbr_t, and stock returns, sr_t. The vector ϵ_t incorporates mutually uncorrelated structural innovations and, in particular, the monetary policy shock. The matrix $A = [a_{ij}]$ contains the parameters capturing the contempora-

neous interactions among the variables. The matrices $A_k = [a_{k,ij}]$ reflect the dynamic feedbacks between these variables.

Denote by ν_t the vector of residuals (or statistical innovations) obtained from a VAR process in which the vector z_t is projected on its own lags. These residuals are linked to the structural innovations through

$$A\nu_t = \epsilon_t. \tag{2}$$

Extracting the structural shocks from the residuals requires knowledge of the matrix A. As is well known, however, under conditional homoscedasticity of the structural shocks, projecting z_t on its own lags does not provide sufficient information to identify all the elements of A, such that some restrictions must be imposed. As discussed below, our empirical methodology relaxes the assumption that the structural shocks are conditionally homoscedastic, so that no restrictions need to be imposed to identify monetary policy shocks and their effects.

Nonetheless, our empirical approach places a minimal set of cross-equation restrictions to ensure that the estimated system is a coherent framework for the analysis of monetary policy. More explicitly, we consider the following simple formulation of the reserve market (Bernanke and Mihov 1998):

$$\nu_{nbr,t} = \phi_d \sigma_d \epsilon_{d,t} - \phi_b \sigma_b \epsilon_{b,t} + \sigma_s \epsilon_{s,t}, \tag{3.1}$$

$$\nu_{tr,t} = -\alpha \nu_{ffr,t} + \sigma_d \epsilon_{d,t}, \tag{3.2}$$

$$(\nu_{tr,t} - \nu_{nbr,t}) = \beta \nu_{ffr,t} - \sigma_b \epsilon_{b,t}. \tag{3.3}$$

The structural innovation $\epsilon_{s,t}$ is the monetary policy shock representing an unexpected exogenous policy action taken by the Federal Reserve, while $\epsilon_{d,t}$ and $\epsilon_{b,t}$ denote, respectively, shocks to demand for total reserves and to the supply of borrowed reserves by commercial

6

banks. The parameters σ_s, σ_d, and σ_b are the standard deviations scaling the structural innovations of interest, ϕ_d and ϕ_b are unrestricted parameters, and α and β are positive parameters. Equation (3.1) describes the procedure that may be used by the Federal Reserve to select its monetary policy instruments. Equation (3.2) represents the banks' demand for total reserves in innovation form. Equation (3.3) is the banks' supply of borrowed reserves in innovation form, under the assumption of a zero discount-rate innovation.

Inserting the equilibrium solution of the reserve-market formulation (3) in the SVAR (1) yields:

$$
\begin{pmatrix}
a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} & a_{17} & a_{18} \\
a_{21} & a_{22} & a_{23} & a_{24} & a_{25} & a_{26} & a_{27} & a_{28} \\
a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} & a_{37} & a_{38} \\
a_{41} & a_{42} & a_{43} & \frac{1+\phi_b}{\sigma_s} & -\frac{\phi_d+\phi_b}{\sigma_s} & \frac{\beta\phi_b-\alpha\phi_d}{\sigma_s} & a_{47} & a_{48} \\
a_{51} & a_{52} & a_{53} & 0 & \frac{1}{\sigma_d} & \frac{\alpha}{\sigma_d} & a_{57} & a_{58} \\
a_{61} & a_{62} & a_{63} & \frac{1}{\sigma_b} & -\frac{1}{\sigma_b} & \frac{\beta}{\sigma_b} & a_{67} & a_{68} \\
a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & a_{77} & a_{78} \\
a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & a_{88}
\end{pmatrix}
\begin{pmatrix}
\nu_{y,t} \\
\nu_{p,t} \\
\nu_{cp,t} \\
\nu_{nbr,t} \\
\nu_{tr,t} \\
\nu_{ffr,t} \\
\nu_{tbr,t} \\
\nu_{sr,t}
\end{pmatrix}
=
\begin{pmatrix}
\epsilon_{1,t} \\
\epsilon_{2,t} \\
\epsilon_{3,t} \\
\epsilon_{s,t} \\
\epsilon_{d,t} \\
\epsilon_{b,t} \\
\epsilon_{7,t} \\
\epsilon_{8,t}
\end{pmatrix},
\qquad (4)
$$

where the elements a_{ij} $(i,j = 1,\ldots,8)$ are unconstrained parameters.

System (4) is flexible in the sense that it allows, among other things, for a rich specification of the monetary authority's feedback rule. This can be seen be rewriting the fourth equation as:

$$
\nu_{s,t} = \rho_{41}\nu_{y,t} + \rho_{42}\nu_{p,t} + \rho_{43}\nu_{cp,t} + \rho_{47}\nu_{tbr,t} + \rho_{48}\nu_{sr,t} + \sigma_s\epsilon_{s,t}. \qquad (5)
$$

The term $\nu_{s,t} = \left[(1+\phi_b)\nu_{nbr,t} - (\phi_d+\phi_b)\nu_{tr,t} + (\beta\phi_b - \alpha\phi_d)\nu_{ffr,t}\right]$ measures the statistical innovation of the monetary policy indicator. This indicator is expressed as a linear combination of the reserve variables, reflecting the notion that the Federal Reserve might be adopting a mixed procedure whereby it targets neither the interest rate nor a monetary aggregate exclusively. The coefficients $\rho_{4j} = -a_{4j}\sigma_s$ (for $j = 1,2,3,7,8$) capture the

7

systematic responses of the Federal Reserve to changes in the non-reserve variables. More precisely, the feedback rule implies that the Federal Reserve designs its policy by taking into account current values of all goods and financial variables.

System (4) is also flexible because it leaves unrestricted the contemporaneous interactions between the terms within and across the blocks of goods, reserve, and financial variables. These simultaneous effects imply that all variables may be contemporaneously affected by all the structural innovations and, in particular, by monetary policy shocks. Hence, system (4) allows one to capture potential salient interdependences between stock returns and the monetary policy indicator.

The first interdependence that we focus on is the reaction of stock returns to monetary policy. Specifically, we verify the common view that asset prices immediately increase following an expansionary monetary policy shock. The underlying intuition is that, in the absence of asset bubbles, stocks are claims on future economic output and monetary policy has real effects (see Patelis 1997). More precisely, a surprise monetary policy easing is likely to lead to an instantaneous rise in stock prices because the expected present value of dividends increases following the induced economic growth, and the rate used to discount firms' cash flows decreases following the induced decline in market interest rates.

System (4) implies that the response of stock returns to a monetary policy shock reflects both direct and indirect effects. The direct effects are summarized by the coefficients a_{8j} (for $j = 4, 5, 6$), which directly relate stock returns to the reserve variables involved in the monetary policy indicator. The indirect effects are measured by the coefficients a_{8j} (for $j = 1, 2, 3, 7$), as the policy variables indirectly affect stock returns through their effects on the goods variables and the treasury bill rate. As will be discussed below, the evaluation of the response of stock returns to monetary policy shocks is the unique focus in most existing SVAR studies in this area.

The second interdependence of interest is the role of stock returns in the propagation of

8

monetary policy on output and the price level. In theory, asset returns play a role in the transmission of monetary policy through some components of aggregate expenditures. In particular, an unexpected expansionary monetary policy should lead to a rise in private consumption expenditures due to a positive wealth effect that arises from the increase in stock returns (e.g. Poterba 2000). Such a policy should also lead to a rise in investement expenditures owing to the increase in the shadow price of capital, i.e. Tobin's Q (e.g. Hayashi 1982), and to a financial accelerator effect associated with the increase of entrepreneurs' net worth (see Bernanke and Gertler 1989).

The importance of stock returns for the transmission of monetary policy can be gauged by purging its indirect effects on output and the price level that operate through stock returns. These effects are measured by the coefficients a_{1j} and a_{2j} (for $j = 3, 7, 8$), as the policy variables indirectly affect output and the price level through their current effects on commodity prices, the treasury bill rate, and stock returns.

The last interdependence that we analyze is the influence of stock returns on the orientation of the Federal Reserve's policy. Several arguments may be invoked to suggest that asset prices should be taken into account by Central Banks when they design their policies. For example, this should be the case if the monetary authority seeks to stabilize a broad measure of the cost of living that includes not only current prices of consumer goods but also those expected in the future, which, under certain conditions, can be proxied by current asset prices (e.g. Alchian and Klein 1973). Perhaps more concretely, current stock prices may represent a good predictor of future inflation if the effects of monetary policy are first manifested in movements in asset prices and later on in changes in the prices of consumer goods (e.g. Gilchrist and Leahy 2002). It may also be the case that the policy makers respond proactively to perceived misalignments in asset prices that could form bubbles, in order to successfully stabilize inflation and output (e.g. Cecchetti, Genberg, Lipsky, and Wadhwani 2000). Finally, the monetary authority may instead follow a reactive approach, which consists in reacting to current asset price movements only to the extent that they

affect expected inflation (e.g. Bernanke and Gertler 1999; Bernanke and Gertler 2001).

In practice, we verify whether stock returns affect the monetary indicator by comparing the responses of the policy variables to monetary shocks obtained from system (4) with those constructed by purging the feedback effect related to stock returns in the monetary rule (5). This effect is summarized by the coefficient a_{48}, or equivalently, ρ_{48}, since the endogenous component of monetary policy responds to current changes in stock returns.

2.2 Alternative Systems

We now show how system (4) nests various alternative specifications that closely resemble those used in existing studies. The alternative cases include two recursive systems, labelled $R1$ and $R2$, and one simultaneous system, labelled S. The detailed specifications of these systems are the following.

System R1

The recursive system $R1$ is specified as:

$$
\begin{pmatrix}
\tilde{a}_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\tilde{a}_{21} & \tilde{a}_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\
\tilde{a}_{31} & \tilde{a}_{32} & \tilde{a}_{33} & 0 & 0 & 0 & 0 & 0 \\
\tilde{a}_{41} & \tilde{a}_{42} & \tilde{a}_{43} & \tilde{a}_{44} & 0 & 0 & 0 & 0 \\
\tilde{a}_{51} & \tilde{a}_{52} & \tilde{a}_{53} & \tilde{a}_{54} & \tilde{a}_{55} & 0 & 0 & 0 \\
\tilde{a}_{61} & \tilde{a}_{62} & \tilde{a}_{63} & \tilde{a}_{64} & \tilde{a}_{65} & \tilde{a}_{66} & 0 & 0 \\
\tilde{a}_{71} & \tilde{a}_{72} & \tilde{a}_{73} & \tilde{a}_{74} & \tilde{a}_{75} & \tilde{a}_{76} & \tilde{a}_{77} & 0 \\
\tilde{a}_{81} & \tilde{a}_{82} & \tilde{a}_{83} & \tilde{a}_{84} & \tilde{a}_{85} & \tilde{a}_{86} & \tilde{a}_{87} & \tilde{a}_{88}
\end{pmatrix}
\begin{pmatrix}
\nu_{y,t} \\
\nu_{p,t} \\
\nu_{cp,t} \\
\nu_{ffr,t} \\
\nu_{tr,t} \\
\nu_{nbr,t} \\
\nu_{tbr,t} \\
\nu_{sr,t}
\end{pmatrix}
=
\begin{pmatrix}
\tilde{\epsilon}_{1,t} \\
\tilde{\epsilon}_{2,t} \\
\tilde{\epsilon}_{3,t} \\
\tilde{\epsilon}_{s,t} \\
\tilde{\epsilon}_{5,t} \\
\tilde{\epsilon}_{6,t} \\
\tilde{\epsilon}_{7,t} \\
\tilde{\epsilon}_{8,t}
\end{pmatrix} . \tag{6}
$$

This system assumes a specific feedback rule whereby the monetary policy indicator corresponds to the federal funds rate, and the Federal Reserve contemporaneously responds to the goods variables, but not to the financial variables. This feedback rule is nested in (5) under the restrictions $\phi_d = 1$, $\phi_b = -1$, and $a_{47} = a_{48} = 0$. To complete identification, the recursive system (6) places 24 additional exclusion restrictions, which are listed in Table

3. These restrictions are required to identify the system under the assumption that the structural innovations are conditionally homoscedastic. These restrictions affect the propagation mechanism of monetary policy shocks. In particular, the goods variables do not contemporaneously respond to these shocks, whereas the reserve and financial variables do.

The recursive system (6) is identical to the one used by Thorebecke (1997). Note that this specification does not stem from a particular theory and, as such, may be subject to the criticisms leveled at traditional SVAR analyses by Cooley and LeRoy (1985). For example, the assumption that the goods variables do not react at impact to monetary policy shocks is at odds with the predictions of many theories, and in particular, the Dynamic New Keynesian (DNK) model. Carlstrom, Fuerst, and Paustian (2009) show that the omission of these contemporaneous effects severely distort the dynamic responses of the goods variables obtained from recursive systems similar to $R1$, when the DNK model is the data-generating process. Specifically, the recursive systems yield dynamic responses of the price level that display the wrong sign, and under-estimate the effects of monetary policy shocks on output and inflation.

In our case, system $R1$ limits the analysis of the interactions between stock returns and monetary policy. That is, although this specification admits an impact response of stock returns to monetary policy shocks, the ad hoc restrictions involved in $R1$ imply that stock returns do not influence contemporaneously the monetary policy indicator or its transmission mechanism.

System R2

The recursive system $R2$ is given by:

$$
\begin{pmatrix}
\tilde{a}_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\tilde{a}_{21} & \tilde{a}_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\
\tilde{a}_{31} & \tilde{a}_{32} & \tilde{a}_{33} & 0 & 0 & 0 & 0 & 0 \\
\tilde{a}_{41} & \tilde{a}_{42} & \tilde{a}_{43} & \tilde{a}_{44} & 0 & 0 & 0 & 0 \\
\tilde{a}_{51} & \tilde{a}_{52} & \tilde{a}_{53} & \tilde{a}_{54} & \tilde{a}_{55} & 0 & 0 & 0 \\
\tilde{a}_{61} & \tilde{a}_{62} & \tilde{a}_{63} & \tilde{a}_{64} & \tilde{a}_{65} & \tilde{a}_{66} & 0 & 0 \\
\tilde{a}_{71} & \tilde{a}_{72} & \tilde{a}_{73} & \tilde{a}_{74} & \tilde{a}_{75} & \tilde{a}_{76} & \tilde{a}_{77} & 0 \\
\tilde{a}_{81} & \tilde{a}_{82} & \tilde{a}_{83} & \tilde{a}_{84} & \tilde{a}_{85} & \tilde{a}_{86} & \tilde{a}_{87} & \tilde{a}_{88}
\end{pmatrix}
\begin{pmatrix}
\nu_{ffr,t} \\
\nu_{y,t} \\
\nu_{p,t} \\
\nu_{cp,t} \\
\nu_{tr,t} \\
\nu_{nbr,t} \\
\nu_{tbr,t} \\
\nu_{sr,t}
\end{pmatrix}
=
\begin{pmatrix}
\tilde{\epsilon}_{s,t} \\
\tilde{\epsilon}_{2,t} \\
\tilde{\epsilon}_{3,t} \\
\tilde{\epsilon}_{4,t} \\
\tilde{\epsilon}_{5,t} \\
\tilde{\epsilon}_{6,t} \\
\tilde{\epsilon}_{7,t} \\
\tilde{\epsilon}_{8,t}
\end{pmatrix}.
\tag{7}
$$

This system exhibits two important features. First, it implies a feedback rule that states that the monetary policy indicator corresponds to the federal funds rate and that the Federal Reserve conducts its policy without exploiting the information contained in current goods and financial variables. These assumptions are embedded in (4) by imposing the restrictions $\phi_d = 1$, $\phi_b = -1$, and $a_{47} = a_{48} = 0$. Second, the system implies a propagation mechanism in which monetary policy shocks contemporaneously affect all variables. For identification purposes, system (7) places 21 extra exclusion restrictions, which alter the transmission mechanism of the other structural innovations.

System (7) preserves the key characteristics of the SVAR frequently used in empirical macroeconomics and finance. For example, in a seminal paper, Sims (1992) uses a recursive system in which the federal funds rate, which defines the monetary policy indicator, precedes all the other variables (i.e. output, the price level, commodity prices, a monetary aggregate, and the foreign exchange value of domestic currency). Paletis (1997) adopts a similar specification, in which the non-policy variables are the real one-month treasury bill rate, the term spread between the ten-year government bond and one-month Treasury bill rates, the dividend yield, and stock returns. More recently, Bernanke and Kuttner (2005) include federal funds rate surprises, which are meant to measure monetary policy shocks, as an additional exogenous variable in an SVAR. This orthogonalization procedure is conceptually equivalent to ordering the federal funds rate first, as in system (7).[2]

---

[2] Bernanke and Kuttner (2005) construct monetary policy shocks from the federal funds futures data.

As in the case with *R1*, *R2* involves restrictions that preclude stock returns from contemporaneously influencing the conduct of monetary policy, and that constrain its effects on output and the price level.

System S

The simultaneous system S takes the form:

$$
\begin{pmatrix}
\tilde{a}_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\tilde{a}_{21} & \tilde{a}_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\
\tilde{a}_{31} & \tilde{a}_{32} & \tilde{a}_{33} & 0 & 0 & 0 & 0 & 0 \\
\tilde{a}_{41} & \tilde{a}_{42} & \tilde{a}_{43} & \tilde{a}_{44} & \tilde{a}_{45} & 0 & 0 & 0 \\
\tilde{a}_{51} & \tilde{a}_{52} & \tilde{a}_{53} & \tilde{a}_{54} & \tilde{a}_{55} & 0 & 0 & 0 \\
\tilde{a}_{61} & \tilde{a}_{62} & \tilde{a}_{63} & \tilde{a}_{64} & \tilde{a}_{65} & \tilde{a}_{66} & 0 & 0 \\
\tilde{a}_{71} & \tilde{a}_{72} & \tilde{a}_{73} & \tilde{a}_{74} & \tilde{a}_{75} & \tilde{a}_{76} & \tilde{a}_{77} & 0 \\
\tilde{a}_{81} & \tilde{a}_{82} & \tilde{a}_{83} & \tilde{a}_{84} & \tilde{a}_{85} & \tilde{a}_{86} & \tilde{a}_{87} & \tilde{a}_{88}
\end{pmatrix}
\begin{pmatrix}
\nu_{y,t} \\
\nu_{p,t} \\
\nu_{cp,t} \\
\nu_{sr,t} \\
\nu_{ffr,t} \\
\nu_{tr,t} \\
\nu_{nbr,t} \\
\nu_{tbr,t}
\end{pmatrix}
=
\begin{pmatrix}
\tilde{\epsilon}_{1,t} \\
\tilde{\epsilon}_{2,t} \\
\tilde{\epsilon}_{3,t} \\
\tilde{\epsilon}_{4,t} \\
\tilde{\epsilon}_{s,t} \\
\tilde{\epsilon}_{6,t} \\
\tilde{\epsilon}_{7,t} \\
\tilde{\epsilon}_{8,t}
\end{pmatrix}.
\tag{8}
$$

As system *R1*, the specification above implies that the monetary policy indicator corresponds to the federal funds rate, that the monetary authority does not react to current changes in the treasury bill rate, and that the goods variables do not respond contemporaneously to monetary policy shocks. Unlike *R1*, however, S allows for simultaneous short-run interactions between the federal funds rate and stock returns, while imposing that monetary policy shocks have no long-run effect on real stock prices. Specifically, the cumulative responses of real stock returns are forced to be nil through the long-run restriction $b_{84} = 0$, where $B = [b_{ij}] = \left[I - A^{-1} \sum_{k=1}^{\tau} A_k \right]^{-1} A^{-1}$.

System (8) is obtained from (4) by imposing the restrictions $\phi_d = 1$, $\phi_b = -1$, and $a_{47} = 0$ on the feedback rule, the long-run restriction $b_{84} = 0$, as well as 24 additional exclusion restrictions on the short-run effects of the structural innovations to complete identification. This specification therefore permits to evaluate whether the conduct of monetary policy is influenced by current movements in stock returns. However, it does not allow to capture

13

their contributions to the propagation of monetary policy on the goods variables. In contrast to the recursive systems, specification S permits to evaluate whether the conduct of monetary policy is influenced by current movements in stock returns. System (8) is closely related to that estimated by Bjørnland and Leitemo (2009), who, however, only focus on the first five variables involved in (8).

In sum, the recursive and simultaneous systems commonly used in the literature invariably impose that the policy indicator is the federal funds rate, but impose different assumptions regarding the information available to the Federal Reserve as well as the propagation mechanism of the structural innovations, and in particular, monetary policy shocks. In both cases, these assumptions are rather arbitrary.

3. Methodology

This section explains the conditions under which the flexible and alternative systems are identified. We also describe the strategy used to estimate each system.

3.1 Identification

Under conditional heteroscedasticity of the structural innovations, the flexible system (4), and in particular, monetary policy shocks and their effects on the various variables can be identified (see Sentana and Fiorentini 2001). The sufficient (rank) condition for identification states that the conditional variances of the structural innovations are linearly independent. That is, $\lambda = 0$ is the only solution to $\Gamma\lambda = 0$, such that $(\Gamma'\Gamma)$ is invertible — where Γ stacks by column the conditional volatilities (for $t = (\tau+1), \ldots, T$) associated with each structural innovation. The necessary (order) condition requires that the conditional variances of (at least) all, but one, structural innovations are time-varying.

To understand this identification strategy, first note that the unconditional and conditional

scedastic structures of system (4) are, respectively:

$$\Sigma = A^{-1}A^{-1\prime}, \tag{9.1}$$

$$\Sigma_t = A^{-1}\Gamma_t A^{-1\prime}. \tag{9.2}$$

Here, $\Sigma = E(\nu_t \nu_t')$ represents the unconditional non-diagonal covariance matrix of the non-orthogonal statistical innovations, whereas $\Sigma_t = E_{t-1}(\nu_t \nu_t')$ is the conditional non-diagonal covariance matrix. Also, $I = \Gamma = E(\epsilon_t \epsilon_t')$ normalizes (without loss of generality) the unconditional variances of the orthogonal structural innovations, while $\Gamma_t = E_{t-1}(\epsilon_t \epsilon_t')$ is the conditional diagonal covariance matrix.

In the context of an n-variable system, the unconditional scedastic structure (9.1) implies that the estimates of the distinct elements of Σ allow to identify $\frac{n(n+1)}{2}$ of the n^2 elements of A, leaving $\frac{n(n-1)}{2}$ elements to be identified. Moreover, the conditional scedastic structure (9.2) implies that:

$$\left(\Sigma_t - \Sigma_{t-1}\right) = A^{-1}\left(\Gamma_t - \Gamma_{t-1}\right)A^{-1\prime}. \tag{10}$$

This set of equations allows to identify $\frac{k(k+1)}{2}$ additional parameters of A, where k is the rank of the matrix $\left(\Gamma_t - \Gamma_{t-1}\right)$. Hence, if $\left(\Gamma_t - \Gamma_{t-1}\right)$ has a rank of at least $(n-1)$, identification can be achieved. In our context, a necessary condition for this is that the conditional variances of at least $(n-1)$ structural innovations are time-varying.

To gain some economic intuition for identification through heteroscedasticity, consider a stripped-down version of (3) in which we set $\phi_d = \phi_b = \sigma_b = 0$. This yields:

$$\nu_{tr,t} = -\alpha\nu_{ff,t} + \sigma_d\epsilon_{d,t}, \tag{11.1}$$

$$\nu_{tr,t} = \beta\nu_{ff,t} + \sigma_s\epsilon_{s,t}. \tag{11.2}$$

This system consists of a downward-sloping demand curve (11.1) and an upward-sloping supply curve (11.2) for total reserves, and contains 4 unknown parameters: α, β, σ_d, and σ_s. As is well known, the structural parameters of equilibrium models such as (11) are generally not identifiable. More specifically, since realizations of total reserves and the federal funds rate are determined by the intersection of the two curves above, these realizations are not informative about the slope of either curve. Now assume, without loss of generality, that only the monetary policy shock, $\epsilon_{s,t}$, has a time-varying conditional variance. Then, these changes in volatility act as an additional shifter to the supply curve, thus allowing to identify the slope of the demand curve, $-\alpha$. The remaining parameters can then be recovered from the estimation of the unconditional covariance matrix, Σ, of the statistical innovations of a bi-variate VAR that includes total reserves and the federal funds rate.

Under conditional homoscedasticity, equations (9.1) and (9.2) coincide, so that condition (10) becomes non-informative. Consequently, $\frac{n(n-1)}{2}$ arbitrary restrictions need to be imposed on the elements of A in order to achieve identification. This is why each alternative system places a total of 28 restrictions, given that for specifications *R1*, *R2*, and *S* the conventional assumption of conditional homoscedasticity of the structural innovations is systematically invoked. As stated above, these restrictions are not dictated by the data, but rather reflect the econometrician's judgement about the monetary policy indicator and its transmission mechanism.

3.2 Estimation Strategy and Data

The flexible and alternative systems are estimated using a two-step procedure. The first step extracts the estimates of the statistical innovations ν_t, for $t = (\tau + 1), \ldots, T$. To do so, we apply the ordinary least squares (OLS) to τ-order VAR processes. For the flexible system and both recursive specifications, the VAR include the levels of output, the price index, the commodity price, nonborrowed reserves, total reserves, as well as nominal re-

turns on the federal funds, treasury bills, and stocks. For the simultaneous system, S, there are two distinctions that are in line with the empirical analysis of Bjørnland and Leitemo (2009). First, the VAR includes the changes of output, price index, commodity price, non-borrowed reserves, and total reserves — rather than their levels. These transformations ensure that the system is stationary, which is a condition required to implement the long-run restriction reflecting the neutrality of monetary policy. Second, the VAR involves real rather than nominal stock returns. This makes easier to implement the long-run neutrality of monetary policy on real stock prices.

The second step consists in estimating the SVAR parameters as well as those of the conditional heteroscedastic processes. For this purpose, we specify the dynamics of the conditional variances of the structural innovations as:

$$\Gamma_t = (I - \Delta_1 - \Delta_2) + \Delta_1 \bullet (\epsilon_{t-1}\epsilon'_{t-1}) + \Delta_2 \bullet \Gamma_{t-1}. \tag{12}$$

The operator $\bullet$ denotes the element-by-element matrix multiplication, while Δ_1 and Δ_2 are diagonal matrices of parameters. Equation (12) involves intercepts that are consistent with the normalisation $I = E(\epsilon_t\epsilon'_t)$. It also implies that all the structural innovations are conditionally homoscedastic if Δ_1 and Δ_2 are null. On the other hand, some structural innovations display time-varying conditional variances characterized by univariate generalized autoregressive conditional heteroscedastic [GARCH(1,1)] processes if Δ_1 and Δ_2 — which contain the ARCH and GARCH coefficients, respectively — are positive semi-definite and $(I - \Delta_1 - \Delta_2)$ is positive definite. Furthermore, all the conditional variances follow GARCH(1,1) processes if Δ_1, Δ_2, and $(I - \Delta_1 - \Delta_2)$ are positive definite.

For the flexible system, we estimate the (non-zero) elements of the matrices A, Δ_1, and Δ_2 by maximum likelihood (ML). This method assumes that the statistical innovations are conditionally normally distributed. In this context, the empirical likelihood function is constructed from the estimates of the statistical innovations, obtained in the first step, and the estimates of the conditional covariance matrix Σ_t. This matrix is computed recursively,

for given values of the elements of A, Δ_1, and Δ_2, by using equations (9.2) and (12) and the initialization $\Gamma_\tau = \left(\epsilon_\tau \epsilon'_\tau\right) = I$. For the alternative systems, we estimate the elements of A, but set $\Delta_1 = \Delta_2 = 0$ to impose the standard assumption that the structural innovations are conditionally homoscedastic.

Our empirical analysis is based on monthly U.S. data covering the 1982:11 to 2007:11 period. As is common practice, the starting date of the sample is selected so as to avoid the atypical Federal Reserve operating procedures pursued under the 1979:10 to 1982:10 episode, where little effort, if any, went into stabilizing either the federal funds rate or the borrowing reserves (see Strongin 1995). The series used in the analysis are constructed as follows: y_t is measured by the industrial-production index; p_t is the all-item, all-urban-consumer, price index; cp_t is the world-export commodity-price index; nbr_t denotes the non-borrowed reserves; tr_t denotes the total reserves adjusted for changes in reserve requirements; ffr_t is the nominal rate on the federal funds; tbr_t is the nominal rate on the one-month treasury bills; and sr_t is the nominal value-weighted return (including dividends) associated with the global index of the NYSE, NASDAQ, and AMEX markets. The series y_t, nbr_t, tr_t, and ffr_t are released by the Federal Reserve Board of Governors, tbr_t and sr_t are taken from the Center for Research in Security Prices, while p_t and cp_t are collected from the U.S. Bureau of Labor Statistics and the International Financial Statistics. All data are seasonally adjusted and expressed in logarithms, except for the federal funds rate, treasury bill rate, and stock returns. Throughout the analysis, we include six lags ($\tau = 6$) in the flexible and alternative systems, in accordance with the standard practice of SVAR analyses on monetary policy.

4. Estimation Results and Preliminary Diagnostics

The objective of our preliminary analysis is twofold. First, we assess whether the flexible system produces reliable measures of monetary policy shocks and provides plausible estimates of the associated dynamic effects. Second, we compare these findings to those

obtained from the alternative systems.

4.1 Parameter Estimates and Test Results

Table 1 reports estimates of the GARCH(1,1) parameters of the flexible system. These estimates indicate that five structural innovations, including the monetary policy shock, display highly persistent conditional variances, as the sums of the ARCH and GARCH coefficients exceed 0.90. In contrast, two structural innovations exhibit moderately persistent conditional variances, and one structural innovation is characterized by a constant conditional variance. These estimates imply that the order condition for identification is satisfied, since seven of the eight structural innovations are conditionally heteroscedastic. Likewise, the rank condition is satisfied given that $(\Gamma'\Gamma)$ is invertible. These results confirm that monetary policy shocks can be identified through the conditional heteroscedasticity of the structural innovations.[3]

Table 2 presents estimates of the reserve-market parameters of the flexible system. The estimates of ϕ_d and ϕ_b reveal that the Federal Reserve offsets almost entirely shocks to demand for total reserves, but accommodates only modestly shocks to the supply of borrowing reserves. The estimates of the slope of the demand for total reserves, $-\alpha$, and that of the supply of borrowed reserves, β, display the predicted signs, but are imprecise.

Next, we test the validity of the restrictions imposed in the flexible and alternative systems using a Wald test. Table 3 shows the results. For the flexible system, recall that evaluating the reserve-market specification (3) at equilibrium imposes the linear restrictions

---

[3] Unfortunately, a joint test of the significance of the ARCH and GARCH coefficients cannot be performed because conventional critical values are invalid under the null hypothesis of conditional homoscedasticity given that the system becomes under-identified. However, the fact that our maximum-likelihood estimation procedure converges ensures that the identification conditions are satisfied.

$a_{54} = 0$ and $a_{64} = -a_{65}$. These restrictions are never rejected either jointly or individually at any conventional level of significance, thus suggesting that the flexible system provides an empirically plausible description of the reserve market. In sharp contrast, the joint identifying restrictions associated with the alternative systems $R1$, $R2$, and S are overwhelmingly rejected. In particular, the feedback rule is misspecified because the federal funds rate is an invalid measure of the monetary policy indicator, given that it erroneously imposes that the monetary authority fully offsets shocks to the supply of borrowing reserves. Similarly, the additional short-run restrictions required to complete identification are systematically rejected. Finally, the assumption that the conditional variances of the structural innovations are constant is always rejected.

4.2 Monetary Policy Shocks

We compare the measures of unanticipated, exogenous changes in U.S. monetary policy extracted from the flexible system with those implied by the alternative systems. Figure 1 displays the smoothed series of monetary policy shocks, computed as five-month centered moving averages. A negative (positive) value of the smoothed measure represents an unanticipated contractionary (expansionary) policy by the Federal Reserve.

The flexible system implies that there was an episode of very large negative monetary policy shocks from the middle of 1984 to the beginning of 1985. This episode coincides with the period in which the Federal Reserve decreased substantially its nonborrowed reserves in order to sterilize the effects of its extensive lending to the Continental Illinois Bank on total reserves (see Benston, Eisenbeis, Horvitz, Kane, and Kaufman 1986). Similarly, there was a sequence of contractionary monetary policy shocks at the end of 1988. This accords with the unpredicted, exogenous policy tightening in December 1988 that Romer and Romer (1994) have identified based on their narrative analysis of the minutes of the Federal Open

Market Committee meetings. Contractionary monetary policy shocks were also observed before the 1991 economic contraction, while expansionary ones preceded the 2001 economic contraction. However, the shocks were fairly small during both episodes. Likewise, the size of these shocks remained quite modest when the financial markets came under stress in the summer of 2007. More generally, U.S. monetary policy shocks were substantially less volatile in the 1990s and 2000s than in the 1980s. This observation is consistent with the view that monetary policy has become more effective in stabilizing the economy in recent years (e.g. Clarida, Galí and Gertler 2000; Lubik and Schorfheide 2004; Boivin and Giannoni 2006).

The alternative systems $R1$, $R2$, and S imply almost identical measures of monetary policy shocks, which, on the other hand, exibit important distortions relative to the monetary policy shocks extracted from the flexible system. More explicitly, the measures extracted from the restricted systems often display the wrong sign and are characterized by a greater volatility, which does not decrease much during the post-1990 episode.

4.3 Dynamic Responses of Selected Variables

We now turn to the analysis of the dynamic effects of U.S. monetary policy shocks on output, the price level, and the nominal interest rates. The aim of this exercise is to demonstrate that our approach yields sensible results regarding the effects of monetary policy on U.S. economic activity.

Figure 2 depicts the dynamic responses of selected variables following a positive, one unconditional standard deviation, monetary policy shock. The flexible system yields an output response that is positive and hump shaped, reaching its peak around 15 months after the monetary policy shock. Interestingly, such a pattern has often been documented in ear-

lier SVAR studies relying on various identification schemes (e.g. Christiano, Eichenbaum, and Evans 1999). The price level exhibits a fairly muted response in the first months, but eventually increases to reach a plateau. This initial inertia of the price level has also been highlighted in previous empirical studies (e.g. Christiano, Eichenbaum, and Evans 1999). The federal funds rate declines during the first five months, before returning to its pre-shock level. The response of the treasury bill rate is similar in shape to that of the federal funds rate, except that the impact response is slightly positive. Note that the responses of the federal funds and treasury bill rates are indicative of a short-lived liquidity effect, which lends support to the so-called vanishing-liquidity-effect hypothesis, according to which the fall in interest rates following an unexpected monetary expansion has become smaller in the post-1982 period (e.g. Christiano 1995; Pagan and Robertson 1995). In sum, we conclude that the responses generated by the flexible system reflect plausible dynamic effects of a monetary policy shock on aggregate quantities and prices.

In comparison, the alternative systems lead to output responses that are in general slightly negative for the first six months after the monetary policy shock, and positive thereafter. However, a noticeable difference between the alternative systems is that the impact response of output is restricted to be nil under specifications *R1* and *S*, whereas it is left unrestricted under *R2*. The responses of the price level are systematically negative at all horizons, except on impact. Again, the impact response of the price level is forced to be nil for specifications *R1* and *S*, while it is negative in *R2*. Finally, the responses of the federal funds and treasury bill rates are negative on impact and remain negative for at least 20 months after the shock. Overall, the responses obtained from the alternative systems are at odds with well-accepted beliefs about the aggregate effects of monetary policy. In particular, these responses exibit the price puzzle documented in several empirical studies (e.g. Sims 1992). Note that Bjørnland and Leitemo (2009) highlight the existence of

the price puzzle in a simultaneous system like S. Unfortunately, Thorbecke (1997) does not report the responses of the price level associated with a recursive system identical to $R1$, whereas Bernanke and Kuttner (2005) cannot report these responses given that their recursive system does not include the price level.

This preliminary analysis has revealed that the flexible system leads to plausible estimates of monetary policy shocks and their dynamic effects on output, the price level, and interest rates. In contrast, the alternative systems assume incorrectly that the monetary indicator corresponds to the ferderal funds rate, which leads to severe mismeasurements of monetary policy shocks. The alternative systems also impose invalid restrictions associated with the propagation mechanism of monetary policy, which leads to incorrect dynamic responses of key macroeconomic aggregates.

5. Stock Returns and Monetary Policy

In this section, we study the relation between stock returns and monetary policy. First, we measure the extent to which stock returns react to monetary policy shocks. Second, we determine the role played by the stock market in the transmission of monetary policy. Finally, we investigate whether the Federal Reserve conducts its policy by taking into account stock returns. Throughout the analysis, we compare the results obtained from the flexible system with those implied by existing approaches.

5.1 Do Stock Returns React to Monetary Policy Shocks?

We assess the reaction of the stock market to monetary policy by evaluating its effects on nominal stock returns, sr_t, excess stock returns, $e_t = (sr_t - tbr_t)$, and real stock returns, $h_t = (sr_t - \pi_t)$, where $\pi_t = (p_t - p_{t-1})$ is the inflation rate. Figure 3 presents the dynamic responses of each of these variables to a positive monetary policy shock. It is

23

straightforward to construct these responses from the flexible and alternative systems.

For the flexible system, the response of nominal stock returns is negative at impact, oscillates during the subsequent 10 months, and becomes nil afterwards. The response is much larger than those of the price level and treasury bill rate. Consequently, the responses of nominal, real, and excess stock returns are numerically almost identical. However, these responses are imprecisely estimated, and, as a result, none of them is statistically significant.

To gain further insights into the reaction of stock returns to monetray policy shocks, we resort to the following decomposition:

$$e_t - E_{t-1}e_t = (E_t - E_{t-1})\left[\sum_{j=0}^{\infty}\rho^j\Delta d_{t+j} - \sum_{j=0}^{\infty}\rho^j r_{t+j} - \sum_{j=1}^{\infty}\rho^j e_{t+j}\right], \qquad (13)$$

where E_t denotes the expectation operator conditional on the information available up to period t, Δ represents the first difference operator, d_t is the real dividend, $r_t = (tbr_t - \pi_t)$ is the real interest rate, and ρ is a discount factor given by the steady-state ratio of the stock price to the stock price plus dividend. Expression (13) is obtained by linearizing the expected gross nominal stock return around the logarithms of the current stock price and dividend (Campbell and Shiller 1988). This linearization expresses the news in excess stock returns as a linear combination of revisions in expectations of the dividend, discount, and premium components. The dividend component corresponds to the present value of current and future changes in real dividends. The discount component is defined as the present value of current and future real interest rates. The premium component is the discounted sum of future excess stock returns.

Empirically, we evaluate the terms involved in (13) by applying the procedure outlined in Campbell (1991) and Campbell and Ammer (1993). Specifically, we construct the conditional expectations of excess stock returns and the real interest rate from the forecasts of the variables in the VAR. We then use these expressions and set ρ at 0.9893 to evaluate

the news in excess stock returns and the revisions in expectations of the discount and premium components. The revisions in expectations of the dividend component is then backed out from (13). Note that the dividend component is not constructed directly from the VAR forecasts because our system does not include the dividend as one of the variables.

Table 4 presents the impact responses of the news in excess stock returns and of the revisions in expectations of the various components following an unanticipated monetary expansion.[4] The flexible system implies that a positive monetary policy shock leads to downward revisions in expectations of the premium and dividend components, and to upward adjustments in expectations of the discount component. However, these effects are imprecisely estimated, so that none of them is statistically significant. These results are at odds with the belief that a surprise monetary policy easing should imply a contemporaneous increase in stock returns because it produces an economic expansion that leads to upward revisions of expected dividends, as well as a decline in market interest rates that leads to downward adjustments in expectations of the discount rate.

The alternative systems, $R1$, $R2$, and S, yield similar responses of stock returns, which are positive for the first three months, negative for the next two months, and positive again for the subsequent two months, before dying out (see Figure 3). Again, the responses of nominal, real, and excess stock returns are almost identical. These responses are positive at impact and negative for the fourth and fifth months after the monetary policy shock. These findings are in line with those reported in earlier work relying on recursive and simultaneous systems similar to $R1$, $R2$, and S: A surprise monetary easing produces a significant current increase in stock returns (e.g. Bjørnland and Leitemo 2009; Bernanke and Kuttner 2005; Thorbecke 1997).

---

[4] By construction, the impact response of the news in excess stock returns coincides with the impact response of excess stock returns. Also, the dynamic responses of the news in excess stock returns and of the revisions in expectations of the various components are nil.

Also, specifications S and $R2$ imply that an unexpected monetary expansion triggers downward revisions of the forecasts of stock premia, whereas specification $R1$ leads to the opposite result (see Table 4). On the other hand, all three specifications imply downward adjustments in expectations of the discount component and upward revisions in forecasts of dividends, some of which are significant. Bernanke and Kuttner (2005) find similar effects from a recursive system similar to $R2$, although the effect on the dividend component largely dominates that on the discount component.

So far, the results indicate that once one relaxes the commonly used identifying restrictions, the effect of monetary policy shocks on stock returns becomes statistically insignificant. An interesting question, however, is whether the lack of responsiveness of the global-index of stock returns is a robust empirical fact or just an artifact of aggregating individual stocks into one coarse portfolio. Indeed, it could be the case that stock returns exhibit strong positive responses in some sectors of the economy, which are offset by negative responses in other sectors.

To verify this conjecture, we estimate the responses of stock returns associated with portfolios sorted by industries, size, and book-to-market. The dynamic response of each portfolio return is computed from the flexible system, where the global-index stock return is replaced by the portfolio return of interest. For all portfolios, the monthly nominal value-weighted returns (including dividends) are constructed for the NYSE, NASDAQ, and AMEX markets and cover the 1982:11 to 2007:11 period.

Figure 4 displays the dynamic responses of stock returns for various industry portfolios. The first two columns depict the results for 10 industry portfolios constructed by sorting firms based on their four-digit Standard Industrial Classification (SIC) codes, as in Fama

26

and French (1988).[5] The third column corresponds to the industry classification using the input-output accounts of the National Income and Product Accounts (NIPA), as recently proposed by Gomes, Kogan, and Yogo (2009). This classification identifies each SIC industry by its primary contribution to final demand in order to form portfolios representing the three broad categories of personal consumption expenditures (i.e. durable goods, non-durable goods, and services), and investment expenditures. Accordingly, the NIPA-based portfolios have cash flows that are economically tied to aggregate consumption so that they are closely related to systematic consumption risk.

The responses associated with the various industry portolios exhibit patterns that are quite similar to that found using the broad equity index. In particular, the contemporaneous responses are always negative (except for utilities) and never statistically different from zero. The dynamic responses tend to oscillate in a window of 5 to 10 months after the monetary policy shock and eventually die out, but are rarely statistically significant over the various horizons. In contrast, using a recursive system similar to $R1$, Thorbecke (1997) finds that the impact responses of stock returns associated with 22 industry portfolios sorted from the two-digit SIC codes are systematically positive following an expansionary monetary policy shock. Likewise, Bernanke and Kuttner (2005) report that stock returns of the 10 industry portfolios constructed as in Fama and French always exhibit a positive response.

Figure 5 exhibits the dynamic responses of stock returns associated with portfolios sorted by size and book-to-market. The size criterion sorts firms based on their market-value equity (i.e. the number of shares outstanding times the price per share). The first quintile ($S1$) is a proxy of the smallest firms, whereas the fifth quintile ($S5$) corresponds to the

---

[5] The Fama-French portfolio data are available from French's web page (mba.tuck.dartmouth.edu/pages/faculty/ken.french).

largest firms. The book-to-market criterion sorts firms based on their ratio of book-value equity to market-value equity. The first quintile ($G1$) is a proxy of firms experiencing the strongest growth, while the fifth quintile ($G5$) corresponds to firms facing the most important financial distresses. Finally, the size and book-to-market criteria are combined to select firms with specific size characteristics and growth phases. These data are collected from the Fama-French data library.

The responses associated with the various size and book-to-market portfolios resemble the one obtained using the global equity index, being negative but statistically insignificant on impact and oscillating for a few months before dying away. Interestingly, the responses tend to be more pronounced for small firms than for large ones, indicating that unanticipated policy actions affect more stock returns for small firms. Moreover, the responses seem quite similar regardless of the growth phases of firms, suggesting that monetary policy shocks have almost the same effects on stock returns whether firms exhibit pronounced growth or face financial distresses.

Thorbecke (1997) also finds for ten portfolios sorted by size that monetary policy shocks exert a stronger contemporaneous effect on the stock returns of small firms than on those of large firms. In contrast to our results, however, the increase in the stock returns of small firms is statistically significant. In the same vein, Gertler and Gilchrist (1994) argue that small firms are less well collateralized than large firms, and thus more likely to be subject to binding credit constraints. In particular, a monetary easing, by decreasing interest rates, improves more the small firms' cash flows net of interests and thus their balance-sheet positions. Such an increase in net worth raises the small firms' ability to borrow and therefore to spend and invest.

In sum, our results indicate that the unresponsiveness of stock returns to monetary policy

is robust to considering various portfolio compositions and does not stem from aggregation. However, imposing invalid restrictions implies that stock returns increase following an unanticipated monetary expansion, whether we consider a broad equity index or disaggregated portfolios.

5.2 Do Stock Returns Influence the Propagation of Monetary Policy?

We now turn to the question of whether stock returns alter the transmission mechanism of monetary policy. For this purpose, we focus on specifications that involve the global-index stock returns, rather than portfolio returns. Occasionally, we consider specifications in which output is replaced by a selected component of aggregate expenditure. The components of interest are private consumption of durable goods, and nondurable goods and services, as well as investment expenditures. Private consumption is measured by monthly real personal expenditures, released by the U.S. Department of Commerce. Investment is measured by monthly total construction spending, published by the U.S. Census Bureau. Consumption and investment data are seasonally adjusted and expressed in logarithms.

To evaluate the role of stock returns as a propagation channel of monetary policy, we compare the unrestricted responses of the price level, output, and the components of aggregate expenditure with the responses obtained by excluding the indirect effects associated with stock returns. These indirect effects are eliminated by shutting down all contemporaneous and dynamic interactions between stock returns and the other variables of the system: $a_{ij} = a_{k,ij} = 0$ for $k = 1, \ldots, \tau$, $i = 1, \ldots, 7$ and $j = 8$ as well as for $i = 8$ and $j = 1, \ldots, 7$. Note that these restrictions imply, among other things, that stock returns do not react to monetary policy shocks at any horizon. Also, it is easy to show that these restrictions lead to a reduced form that is composed of two independent subsystems: i) an unrestricted τ-order VAR for all variables except stock returns, and ii) an unrestricted τ-order univari-

ate AR process for stock returns. In practice, we estimate by OLS the coefficients of the VAR and AR processes, extract the implied residuals, and estimate by ML the relevant contemporaneous interactions involved in A.

Figure 6 confronts the responses of the selected variables with and without the indirect effects associated with stock returns. For the flexible system, the unrestricted responses of the price level, consumption of durables and nondurables, and investment are very close to those obtained by imposing the requirement that current and future stock returns are unaffected by monetary policy. This result is at odds with the conventional wisdom that asset prices affect consumption through a wealth channel, and investment through both a Tobin's Q effect and a credit channel. The response of output is actually smaller when the effects related to stock returns are accounted for. This runs against the belief that the effects of monetary policy shocks on output should be magnified by the adjustment of the stock market.

For the recursive systems $R1$ and $R2$, the responses of the price level, output, consumption of durables and nondurables, and investment are virtually identical to those obtained when the indirect effects are ignored. For the simultaneous system S, the responses of output, consumption of durables, and investment are fairly larger in magnitude when the indirect effects are taken into account, whereas the response of the price level changes sign. The latter observation might suggest that the price puzzle is induced by the adjustment of the stock market. However, this conjecture is difficult to reconcile with the view that the reaction of asset prices magnifies the effects of monetary policy shocks on both output and the price level.

To summarize, using the flexible system, we find that stock returns do not alter the transmission mechanism of monetary policy. This result also holds when using recursive iden-

tification schemes.

5.3 Do Stock Returns Influence the Conduct of Monetary Policy?

Finally, we investigate whether monetary policy systematically reacts to stock returns. To this end, we evaluate the endogeneous adjustments of the monetary policy indicator to current changes in asset prices. For the flexible system, the sensitivities of the policy indicator to nominal stock returns, excess stock returns, and real stock returns are respectively summarized by the coefficients ρ_{48}, $(\rho_{48} - \rho_{47})$, and $(\rho_{48} - \rho_{42})$ of the monetary authority's feedback rule (5). Recall that for the flexible system, the indicator corresponds to a linear combination of all the reserve variables (i.e. nonborrowed reserves, total reserves, and the federal funds rate). In contrast, for all the alternative systems, the monetary policy indicator is exclusively summarized by the federal funds rate. The identifying restrictions imply that the federal funds rate may be affected by nominal stock returns in the simultaneous specification S, but not in the recursive cases.

Table 5 reports estimates of the feedback rule. For the flexible system, none of the estimates is significant, so that there is no endogenous response of monetary policy to stock returns, whether these returns are measured in nominal or real terms, or as a deviation from the treasury bill rate. For system $R1$, the identifying restrictions imply that the coefficients ρ_{48}, $(\rho_{48} - \rho_{47})$, and $(\rho_{48} - \rho_{42})$ are set to zero. In system $R2$, $\rho_{48} = (\rho_{48} - \rho_{47}) = 0$ by construction, and the estimate of the coefficient $(\rho_{48} - \rho_{42})$ is not statistically different from zero. In contrast, in system S, all coefficients are statistically significant.

To complete the analysis of the importance of stock returns in the determination of the monetary policy indicator, we compare the unrestricted responses of the policy variables with those obtained by shutting down all contemporaneous and dynamic interactions be-

tween stock returns and the other variables of the system. Figure 7 presents these responses computed from the flexible and alternative systems following an unanticipated monetary policy expansion. Figure 8 displays the responses computed by evaluating the flexible system with and without the indirect effects associated with stock returns conditional on the remaining structural shocks.

Following a positive monetary policy shock, the flexible system yields unrestricted responses of nonborrowed reserves, total reserves, and the federal funds rate that are almost identical to those obtained under the requirement that stock returns do not react to monetary policy shocks at all horizons. Likewise, the alternative systems imply that the federal funds rate responds similarly under the two scenarios. Following any other shock, the flexible system leads to responses that almost perfectly coincide whether the indirect effects related to stock returns are considered or not. To the extent that one of these shocks bears the interpretation of a "stock price" shock, our results suggest that monetary policy does not systematically react to financial disturbances. In contrast, Bjørnland and Leitemo (2009) find using an SVAR similar to system S that a positive stock price shock leads to a significant, persistent, increase of the federal funds rate.

Overall, our findings indicate that stock returns do not influence the Federal Reserve's policy. These empirical results are in line with the normative implications of the model developed by Gilchrist and Leahy (2002), who do not find a strong case for including asset prices in monetary policy rules. This occurs because asset price movements tend to be positively correlated with movements in output and inflation, and thus, monetary policies that focus only on these two variables subsume most of the gains from reacting to asset prices.

6. Conclusion

In this paper, we have estimated the interdependence between stock returns and monetary policy from a flexible SVAR. Our approach identifies monetary policy shocks and their effects by exploiting the conditional heteroscedasticity of the innovations to the variables included in the system. This allows to leave unrestricted both the policy indicator and the propagation mechanism of structural shocks. In turn, this permits to relax and test the arbitrary identifying restrictions that have been commonly used in previous studies.

Our analysis has led to three surprising and puzzling conclusions. No: Stock returns do not respond to monetary policy shocks. No: Stock returns do not alter the transmission mechanism of monetary policy. No: Monetary policy does not systematically react to stock returns. The first conclusion is in sharp contrast with the findings of previous studies, which document a strong, positive, and significant response of stock returns to an unanticipated monetary expansion by imposing erroneous identifying restrictions. The last two conclusions are novel given that the role played by the stock market on the determination of monetary policy and its propagation mechanism has largely remained unexplored in earlier empirical analyses.

This paper's conclusions are important in at least two dimensions. First, they point to important shortcomings of existing theoretical models and cast doubts on their usefulness as a framework to understand the relation between asset prices and macroeconomic policies. Second, the methodology developed in this paper will be useful for future work seeking to assess whether the interaction between stock returns and monetary policy have changed in the aftermath of the latest financial crisis. In particular, our approach could be used to evaluate the extent to which the Federal Reserve, as a lender of last resort, has taken into consideration movements in stock returns during the financial turmoil.

33

References

Alchian, A., and B. Klein (1973), "On a Correct Measure of Inflation," *Journal of Money, Credit and Banking* **5**, pp. 173–191.

Benston, G.J., R.A. Eisenbeis, P.M. Horvitz, E.J. Kane, and G.G. Kaufman (1986), *Perspectives on Safe and Sound Banking: Past, Present, and Future,* Cambridge: MIT Press.

Bernanke, B., and M. Gertler (1989), "Agency Costs, Net Worth, and Business Fluctuations," *American Economic Review* **79**, pp. 14–31.

Bernanke, B., and M. Gertler (1999), "Monetary Policy and Asset Price Volatility," *Federal Reserve Bank of Kansas City Economic Review* **84**, pp. 17-51.

Bernanke, B., and M. Gertler (2001), "Should Central Banks Respond to Movements in Asset Prices?" *American Economic Review Papers and Proceedings* **91**, pp. 253-257.

Bernanke, B.S. and K. Kuttner (2005), "What Explains the Stock Market's Reaction to Federal Reserve Policy?" *Journal of Finance* **60**, pp. 1221–1257.

Bernanke, B.S. and I. Mihov (1998), "Measuring Monetary Policy," *Quarterly Journal of Economics* **113**, pp. 869–902.

Bjørnland, H.C. and K. Leitemo (2009),"Identifying the Interdependence Between US Monetary Policy and the Stock Market," *Journal of Monetary Economics* **56**, pp. 275–282.

Boivin, J. and M. Giannoni (2003), "Has Monetary Policy Become More Effective?" *Review of Economic Statistics* **88**, pp. 445-462.

Bouakez, H. and M. Normandin (2009), "Fluctuations in the Foreign Exchange Market: How Important are Monetary Policy Shocks?" *Journal of International Economics*, forthcoming.

Campbell, J.Y. (1991), "A Variance Decomposition for Stock Returns," *Economic Journal* **101**, pp. 157–179.

Campbell, J.Y. and J. Ammer (1993), "What Moves the Stock and Bond Markets? A Variance Decomposition for Long-Term Asset Returns," *Journal of Finance* **48**, pp. 3–37.

Campbell, J.Y. and R.J. Shiller (1988), "The Dividend-Price Ratio and Expectations of Future Dividends and Discount Factors," *Review of Financial Studies* **1**, pp. 195–228.

Carlstrom, C.T., T.S. Fuerst, and M. Paustian (2009), "Monetary Policy Shocks, Choleski Identification, and DNK Models," *Journal of Monetary Economics*, forthcoming.

Cecchetti, S.G., H. Genberg, J. Lipaky, and S. Wadhwani (2000), *Asset Prices and Central Bank Policy,*, London: International Center for Monetary and Banking Studies.

Christiano, L.J. (1995), "Commentary on 'Resolving the Liquidity Effect' by Pagan and Robertson," *Federal Reserve Bank of St-Louis Review* **77**, pp. 55–61.

Christiano, L.J., M. Eichenbaum, and C.L. Evans (1999), "Monetary Shocks: What Have We Learned and to What End?" in Taylor, J.B. and M.Woodford, eds., *Handbook of Macroeconomics*, Amsterdam: North-Holland.

Clarida, R., J, Galí, and M. Gertler (2000), "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory," *Quarterly Journal of Economics* **115**, pp. 147-180.

Cook, T. and T. Hahn (1989), "The Effect of Changes in the Federal Funds Rate Target on Market Interest Rates in the 1970s," *Journal of Monetary Economics* **24**, pp. 331–351.

Cooley, T. F. and S. F. LeRoy (1985), "Atheoretical Macroeconometrics: A Critique," *Journal of Monetary Economics* **16**, pp. 283–308.

Fama, E.F. and K.R. French (1988), "Permanent and Temporary Components of Stock Prices," *Journal of Political Economy* **96**, pp. 246–273.

Gertler, M. and S. Gilchrist (1994), "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms," *Quarterly Journal of Economics* **109**, pp. 310-338.

Gilchrist, S. and J.V. Leahey (2002) "Monetary Policy and Asset Prices," *Journal of Monetary Economics* **49**, pp. 75–97.

Gilchrist, S., V. Yankov, and E. Zakrajsek (2009) "Credit Market Shocks and Economic Fluctuations: Evidence from Corporate Bond and Stock Markets," *Journal of Monetary Economics* **56**, pp. 471–493.

Gomes, J.F., L. Kogan, and M. Yogo (2009), "Durability of Output and Expected Stock Returns," *Journal of Political Economy* **117**, pp. 941–986.

Hayashi, F. (1982), "Tobin's Marginal Q and Average Q: A Neoclassical Approach," *Econometrica* **50**, pp. 213–224.

Kuttner, K. (2001), "Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market," *Journal of Monetary Economics* **47**, pp. 523–544.

Lanne, M. and H. Lütkepohl (2008), "Identifying Monetary Policy Shocks via Changes in Volatility," *Journal of Money, Credit and Banking* **40**, pp. 1131–1149.

Lanne, M., H. Lütkepohl, and K. Maciejowska (2010), "Structural Vector Autoregressions with Markov Switching," *Journal of Economic Dynamics & Control* **34**, pp. 121–131.

Lubik, T.A. and F. Schorfheide (2004), "Testing for Indeterminacy: An Application to U.S. Monetary Policy," *American Economic Review* **94**, pp. 190-217.

Normandin, M. and L. Phaneuf (2004), "Monetary Policy Shocks: Testing Identification Conditions Under Time-Varying Conditional Volatility," *Journal of Monetary Economics* **51**, pp. 1217–1243.

Pagan, A.R. and J.C. Robertson (1995), "Resolving the Liquidity Effect," *Federal Reserve Bank of St-Louis Review* **77**, pp. 33-54.

Patelis, A.D. (1997), "Stock Return Predictability and the Role of Monetary Policy," *Journal of Finance* **52**, pp. 1951–1972.

Poterba, J. (2000), "Stock Market Wealth and Consumption," *Journal of Economic Perspectives* **14**, pp. 99–118.

Rigobon R. and B. Sack (2003), "Measuring the Reaction of Monetary Policy to the Stock Market," *Quarterly Journal of Economics* **118**, pp. 639–669.

Rigobon, R. and B. Sack (2004), "The Impact of Monetary Policy on Asset Prices," *Journal of Monetary Economics* **51**, pp. 1553–1575.

Romer, C.D. and D.H. Romer (1994), "Monetary Policy Matters," *Journal of Monetary Economics* **34**, pp. 75–88.

Sentana, E. and G. Fiorentini (2001), "Identification, Estimation and Testing of Conditionally Heteroskedastic Factor Models," *Journal of Econometrics* **102**, pp. 143–164.

Sims, C. (1992), "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy," *European Economic Review* **36**, pp. 975–1000.

Sims, C. and T. Zha (1999), "Error Bands for Impulse Responses," *Econometrica* **67**, pp. 1113–1157.

Strongin, S. (1995), "The Identification of Monetary Policy Disturbances: Explaining the Liquidity Puzzle," *Journal of Monetary Economics* **35**, pp. 463–498.

Thorbecke, W. (1997), "On Stock Market Returns and Monetary Policy," *Journal of Finance* **52**, pp. 635–654.

Table 1. Estimates: GARCH(1,1) Parameters

$\epsilon_{1,t}$	—	$\epsilon_{d,t}$	0.537
			(0.166)
	—		0.388
			(0.125)
$\epsilon_{2,t}$	0.161	$\epsilon_{b,t}$	0.433
	(0.046)		(0.160)
	0.783		—
	(0.080)		
$\epsilon_{3,t}$	0.200	$\epsilon_{7,t}$	0.062
	(0.090)		(0.029)
	0.281		0.935
	(0.328)		(0.032)
$\epsilon_{s,t}$	0.234	$\epsilon_{8,t}$	0.077
	(0.049)		(0.058)
	0.763		0.889
	(0.048)		(0.084)

Note: Entries are the estimates of the parameters of the GARCH(1,1) processes for the flexible system. For each structural innovation, the first and second rows refer to the ARCH and GARCH coefficients, respectively. Numbers in parentheses are standard errors. — indicates that zero restrictions are imposed to ensure that Δ_1 and Δ_2 are non-negative definite.

Table 2. Estimates: Reserve-Market Parameters

α	0.062 (0.079)	σ_s	0.025 (0.017)
β	5.089 (2.847)	σ_d	0.022 (0.013)
ϕ_d	0.922 (0.028)	σ_b	0.073 (0.044)
ϕ_b	0.014 (0.017)		

Note: Entries are the estimates of the structural parameters of the reserve market for the flexible system. Numbers in parentheses are standard errors.

Table 3. Test Results: Identifying Restrictions

Restrictions	Simultaneous		Recursive	
	Flexible	*S*	*R1*	*R2*
Reserve Market	0.461	—	—	—
$a_{54} = 0$	0.850	—	—	—
$a_{64} = -a_{65}$	0.217	—	—	—
Feedback Rule	—	0.000	0.000	0.000
Monetary Indicator	—	0.000	0.000	0.000
Systematic Component	—	0.295	0.576	0.947
Others	—	0.000	0.000	0.000
Short Run	—	0.001	0.000	0.000
Long Run	—	0.227	—	—
Conditional Homoscedasticity	—	0.000	0.000	0.000
Joint	—	0.000	0.000	0.000

Note: Entries are the p-values of the χ^2-distributed Wald test statistics. For the flexible case, the reserve-market restrictions are tested from the estimates of the associated unconstrained system. For the alternative cases, the various sets of restrictions are tested from the estimates of the flexible system. Specifically, the restrictions associated with the monetary indicators are $\phi_d = 1$ and $\phi_b = -1$ for systems S, $R1$, and $R2$. The restrictions related to the systematic components of the monetary authority's feedback rule are $a_{47} = 0$ for S, $a_{47} = a_{48} = 0$ for $R1$, and $a_{41} = a_{42} = a_{43} = a_{47} = a_{48} = 0$ for $R2$. The other short-run restrictions are $a_{12} = a_{13} = a_{14} = a_{15} = a_{16} = a_{17} = a_{18} = a_{23} = a_{24} = a_{25} = a_{26} = a_{27} = a_{28} = a_{34} = a_{35} = a_{36} = a_{37} = a_{38} = a_{54} = a_{57} = a_{67} = a_{84} = a_{85} = a_{87} = 0$ for S, $a_{12} = a_{13} = a_{14} = a_{15} = a_{16} = a_{17} = a_{18} = a_{23} = a_{24} = a_{25} = a_{26} = a_{27} = a_{28} = a_{34} = a_{35} = a_{36} = a_{37} = a_{38} = a_{54} = a_{57} = a_{58} = a_{67} = a_{68} = a_{78} = 0$ for $R1$, and $a_{12} = a_{13} = a_{14} = a_{15} = a_{17} = a_{18} = a_{23} = a_{24} = a_{25} = a_{27} = a_{28} = a_{34} = a_{35} = a_{37} = a_{38} = a_{54} = a_{57} = a_{58} = a_{67} = a_{68} = a_{78} = 0$ for $R2$. The long-run restriction is $b_{84} = 0$ for S, where $B = [b_{ij}] = \left[I - A^{-1} \sum_{k=1}^{\tau} A_k \right]^{-1} A^{-1}$. Finally, the restrictions that the structural innovations are conditionally homoscedastic are $\Delta_1 = \Delta_2 = 0$ for all the alternative systems.

Table 4. Responses: News in Excess Stock Returns and Various Components

News	Simultaneous		Recursive	
	Flexible	S	R1	R2
Excess Stock Returns	-0.506	1.214	0.256	0.407
	(0.888)	(0.085)	(0.216)	(0.217)
Premium Component	-1.196	-0.565	0.038	-0.068
	(1.087)	(0.074)	(0.136)	(0.197)
Discount Component	0.114	-0.502	-0.126	-0.170
	(0.126)	(0.016)	(0.009)	(0.035)
Dividend Component	-1.588	0.147	0.168	0.169
	(1.287)	(0.007)	(0.149)	(0.208)

Note: Entries are the impact responses of the news in excess returns and of the revisions in expectations of the various components. Number in parentheses are standard errors.

Table 5. Estimates: Feedback-Rule Parameters

Variables	Simultaneous		Recursive	
	Flexible	*S*	*R1*	*R2*
sr_t	-0.0001	0.0009	—	—
	(0.0001)	(0.0003)		
$e_t = (sr_t - tbr_t)$	0.0262	0.0009	—	—
	(0.0176)	(0.0003)		
$h_t = (sr_t - \pi_t)$	0.3215	-1.1841	-0.7971	—
	(0.2798)	(0.6336)	(0.5775)	

Note: Entries are the estimates of the coefficients of the monetary authority's feedback rule. Numbers in parentheses are standard errors.

Figure 1. Monetary Policy Shocks
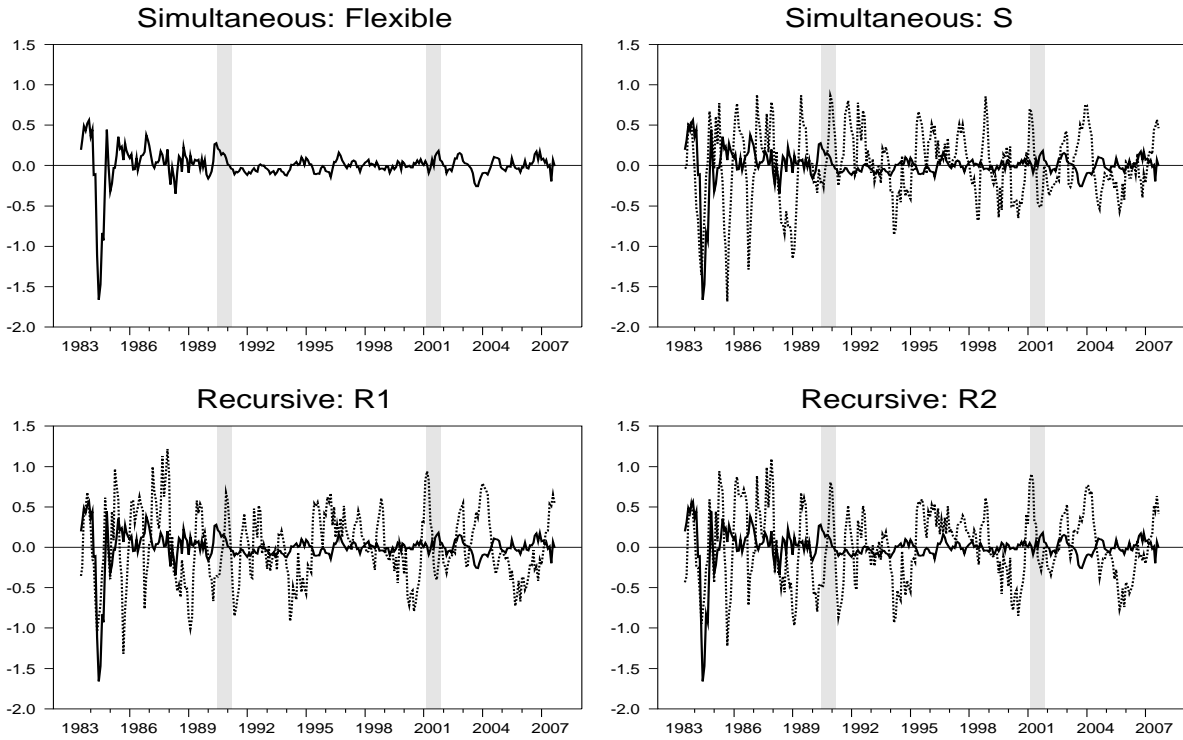
Note: The solid lines correspond to monetary policy shocks recovered from the flexible system. The dotted lines are monetary policy shocks obtained from the alternative systems. The shaded areas represent contractionary phases (i.e. peaks to troughs) reported by the National Bureau of Economic Research (NBER).
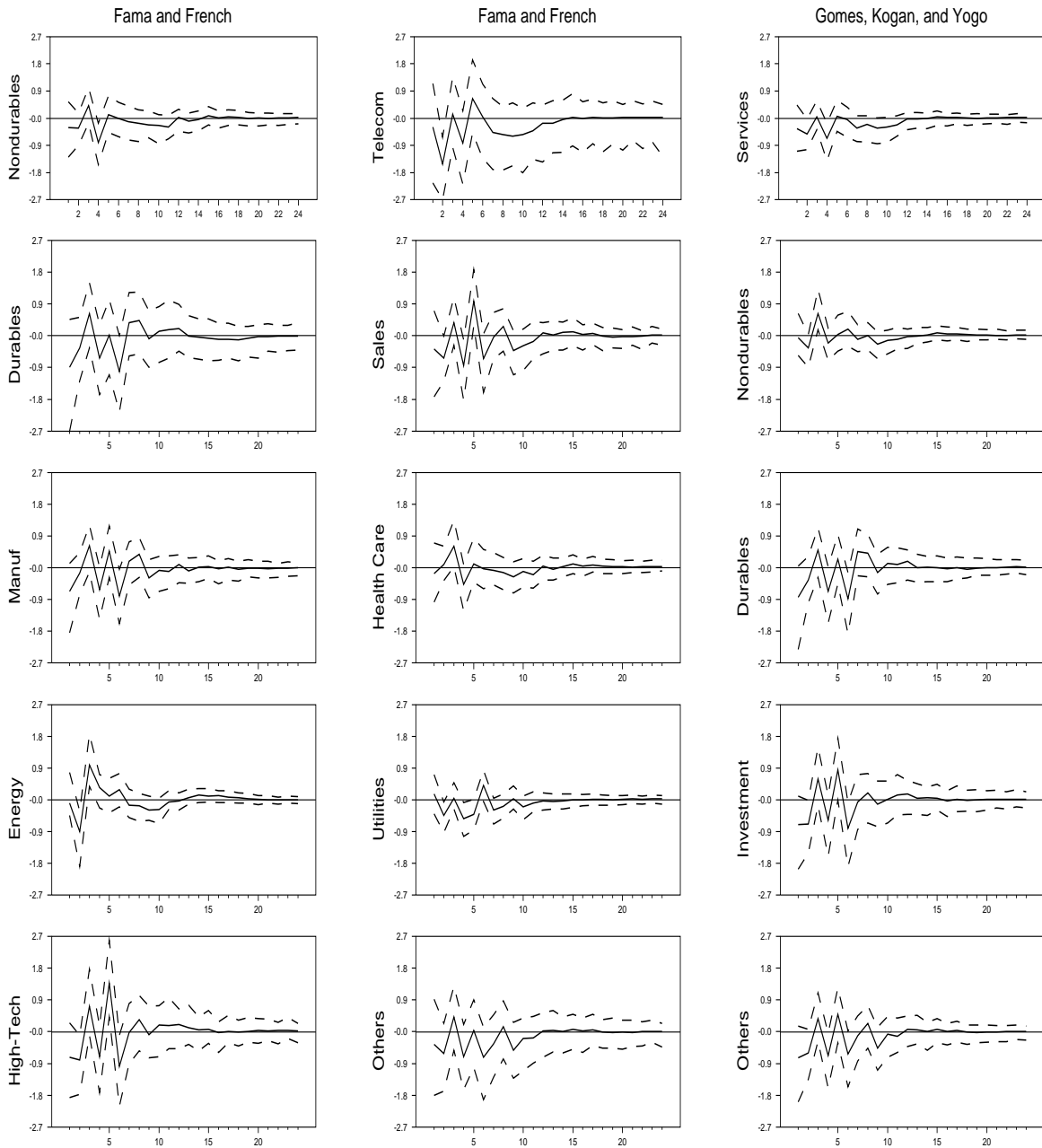
Figure 2. Responses: Selected Variables
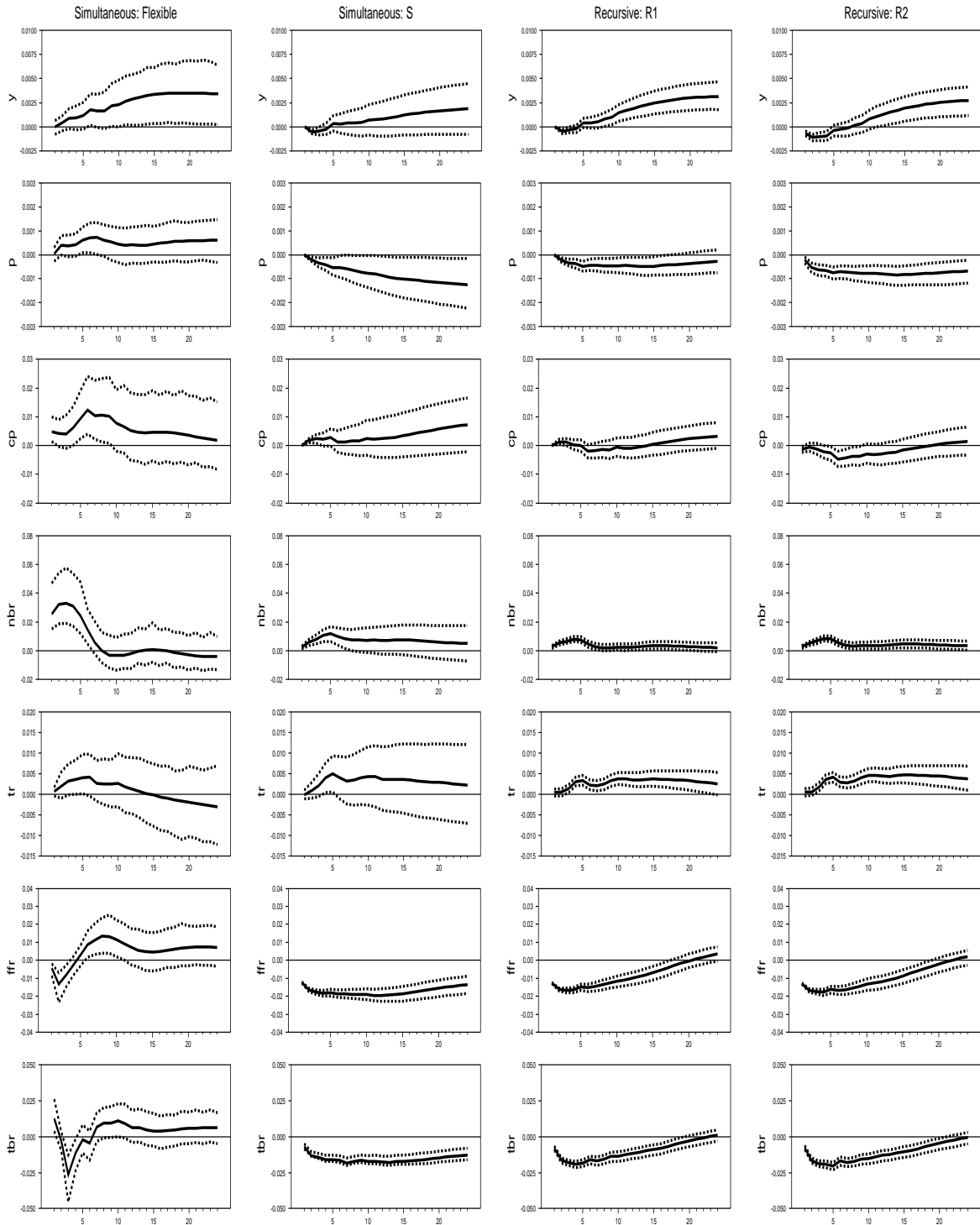
Note: The solid lines correspond to the dynamic responses of selected variables to an expansionary monetary policy shock extracted from the various systems. The dotted lines are the 68% confidence intervals computed from the Sims-Zha (1999) Bayesian procedure.
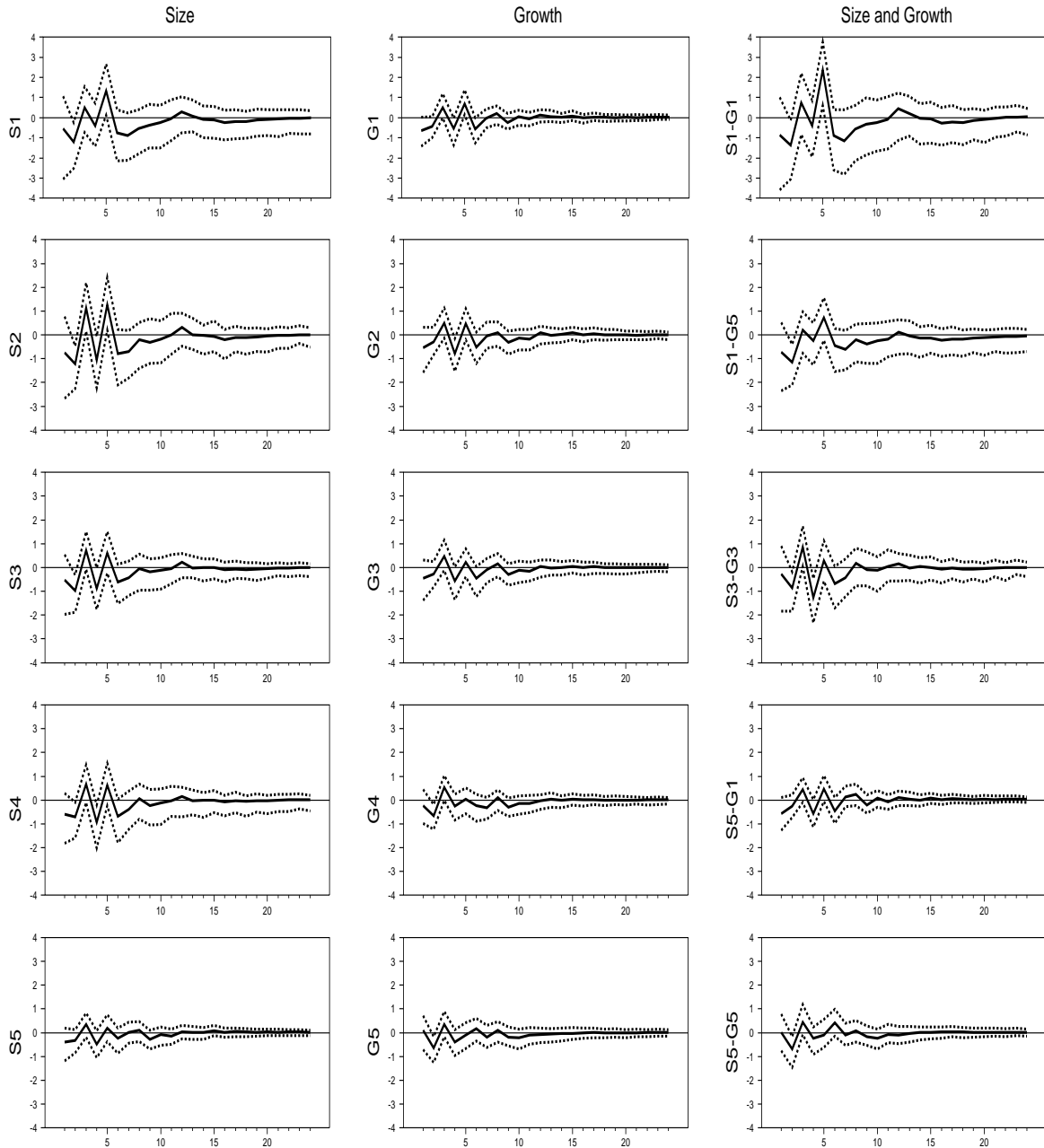
Figure 3. Responses: Stock Returns
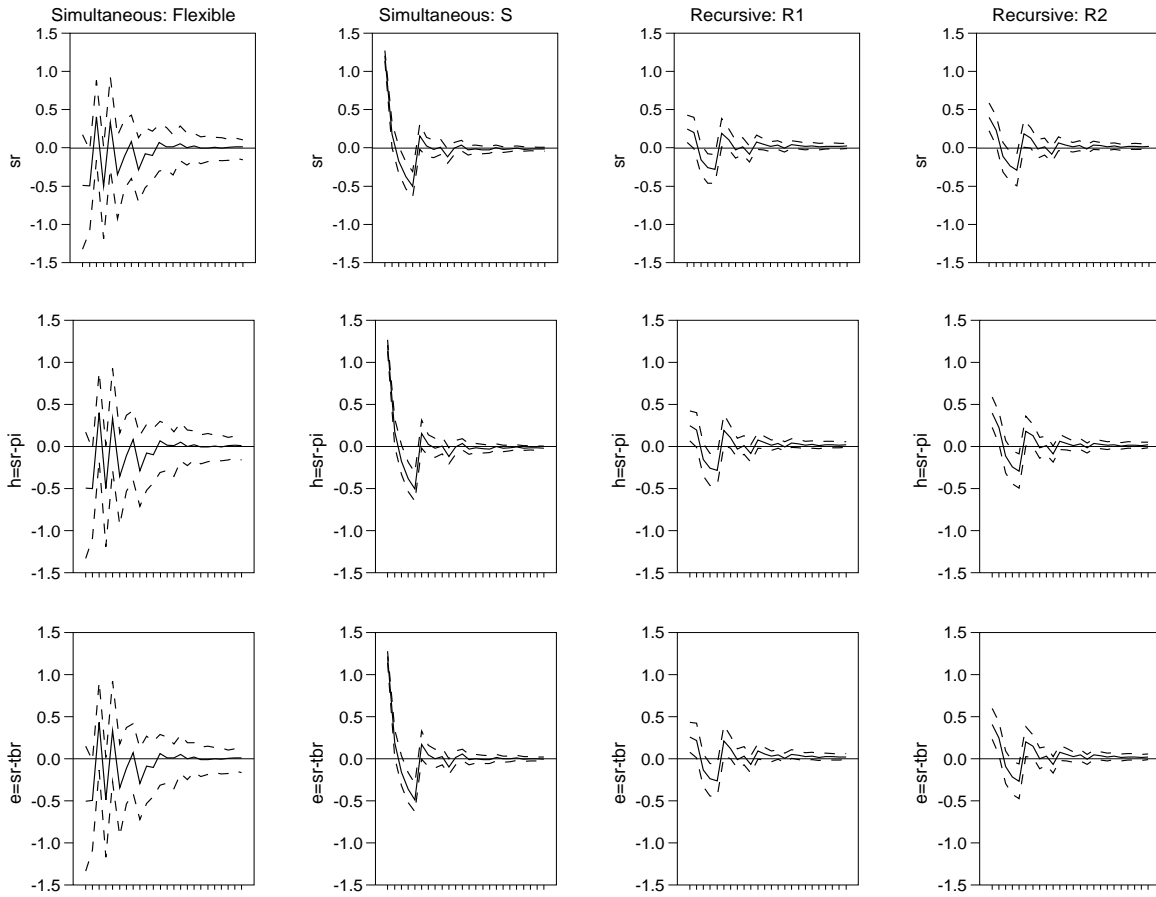
Note: The solid lines correspond to the dynamic responses of stock returns to an expansionary monetary policy shock extracted from the various systems. The dotted lines are the 68% confidence intervals computed from the Sims-Zha (1999) Bayesian procedure.

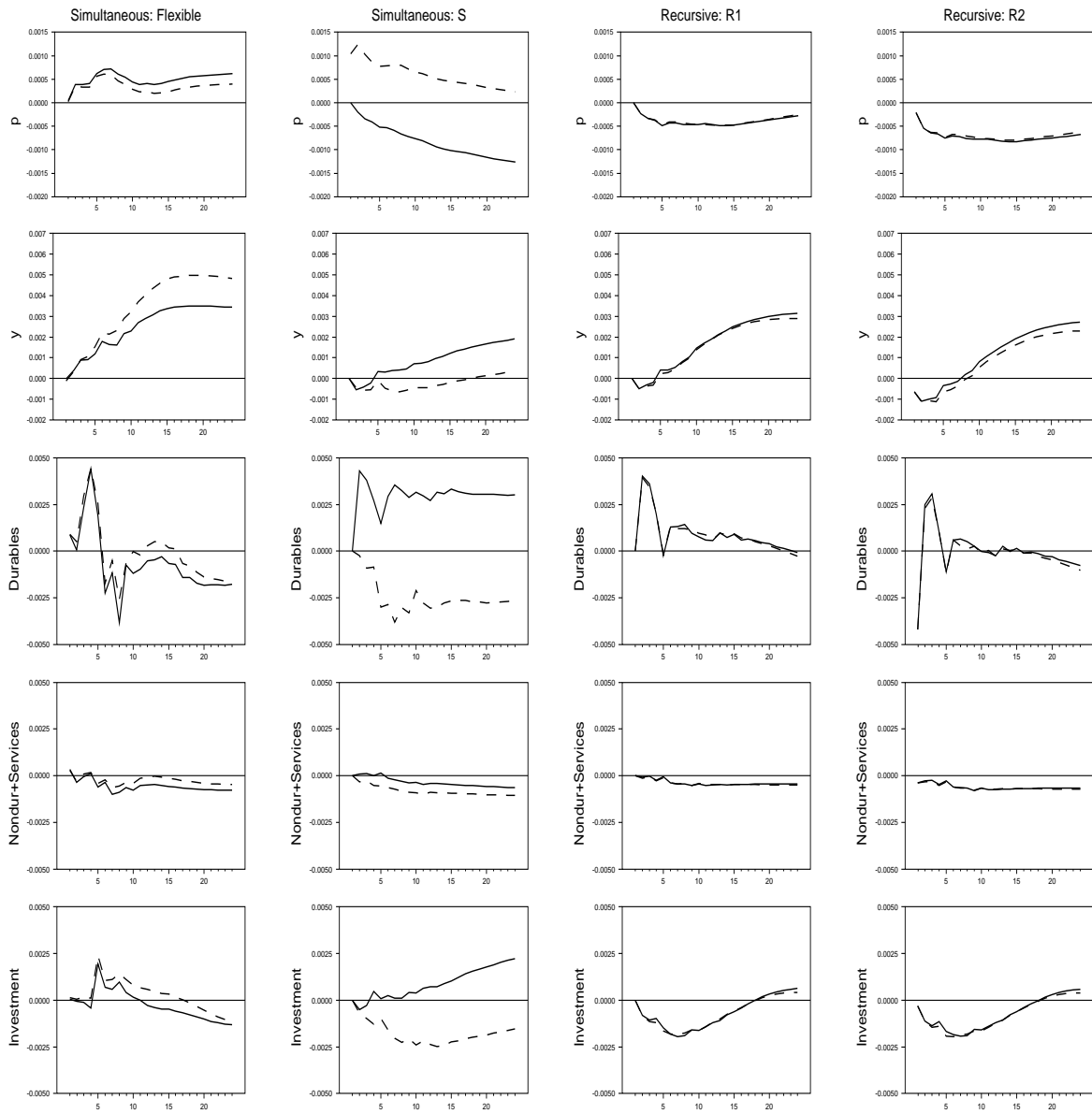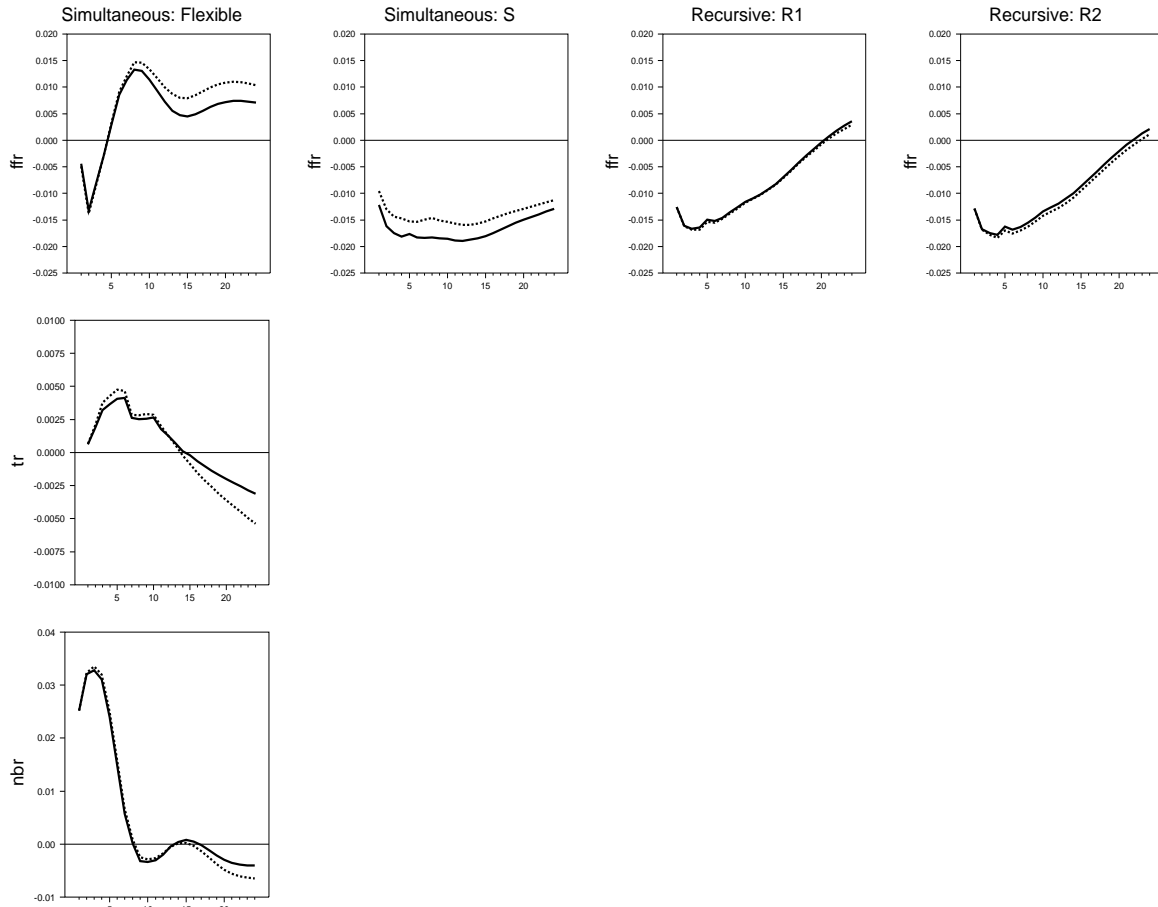**Figure 4. Responses: Stock Returns for Industry Portfolios**

Note: The solid lines correspond to the dynamic responses of stock returns to an expansionary monetary policy shock extracted from the flexible system. The dotted lines are the 68% confidence intervals computed from the Sims-Zha (1999) Bayesian procedure.

Figure 5. Responses: Stock Returns for Size and Growth Portfolios

Note: The solid lines correspond to the dynamic responses of stock returns to an expansionary monetary policy shock extracted from the flexible system. The dotted lines are the 68% confidence intervals computed from the Sims-Zha (1999) Bayesian procedure.

Figure 6. Responses: Price Level, Output, and Components of Aggregate Expenditures
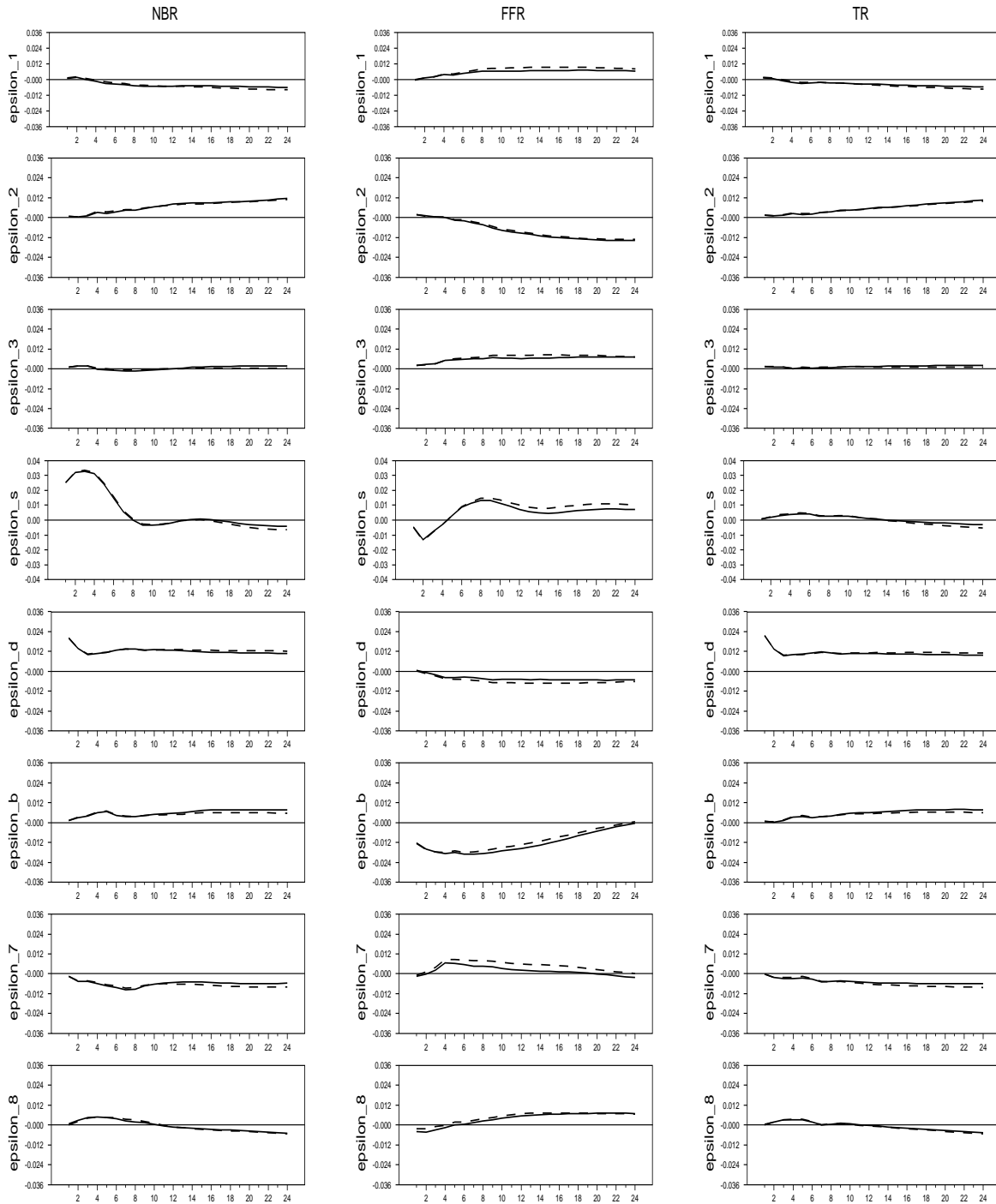

Note: The solid lines correspond to the dynamic responses of selected variables to an expansionary monetary policy shock extracted from the various systems. The dotted lines represent the dynamic responses of selected variables to an expansionary monetary policy shock obtained by imposing certain restrictions on each system which imply that the response of nominal stock returns is nil.

Figure 7. Responses: Monetary Policy Indicators

Note: The solid lines correspond to the dynamic responses of the reserve variables to an expansionary monetary policy shock extracted from the various systems. The dotted lines represent the dynamic responses of the reserve variables to an expansionary monetary policy shock obtained by imposing certain restrictions on each system which imply that the response of nominal stock returns is nil.

Figure 8. Responses: Reserve Variables

Note: The solid lines correspond to the dynamic responses of the reserve variables to an expansionary monetary policy shock extracted from the flexible systems. The dotted lines represent the dynamic responses of the reserve variables to an expansionary monetary policy shock obtained by imposing certain restrictions on the flexible system which imply that the response of nominal stock returns is nil.