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The Influence of Consumer Confidence and Stock Prices on the United States Business Cycle*

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Abstract

This paper explores the relationship between consumer confidence, stock prices and the business cycle in the United States using a Structural Vector Autoregression (SVAR). It finds three key results. First, the addition of confidence and stock price shocks to a small SVAR has important effects on the dynamic responses of the US economy. A confidence shock of four index points changes US GNP by 0.14% (noting that it is not uncommon for confidence shocks to total 20 points in a few consecutive quarters), while a 7% change in the S&P 500 leads to a 0.5% change in GNP. Second, the influence of these two shocks on the US business cycle in the second half of the twentieth century has been important at various times. Confidence shocks accounted for 19% of the total effect of structural shocks to GNP during the early 1990s recession, while stock prices contributed 20% of the effect of structural shocks to GNP in the 2001 recession. Finally, adding confidence and/or stock prices to the benchmark SVAR model leads to a small improvement in out-of-sample forecasting performance of GNP but this is not statistically significant. Nevertheless, confidence and stock prices do provide statistically significant incremental information during recessions.

JEL Classification: E32, E37, E44

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1 Introduction

Events in more recent history, such as the sudden falls in confidence and stock prices before the 1990-1991 recession, and record levels of consumer confidence combined with the large run up in stock

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prices during the subsequent 1991-2001 expansion, suggest that these two factors are potentially important and interrelated influences on the business cycle in the United States.

This paper explores the relationship between consumer confidence, stock prices and the business cycle in the United States over the second half of the twentieth century. The underlying question is: how important are the effects of consumer confidence and stock prices on the business cycle and, therefore, how much weight should we put on shocks to these variables when assessing the current state of the economy and its future direction?

These two potential influences on the business cycle are examined using a small macroeconometric model, a Structural Vector Autoregression (SVAR), which accounts for the endogeneity of key macroeconomic variables and which, at least partially, incorporates assumptions obtained from economic theory. Following Gali (1992), I evaluate the econometric model results by comparing them against the predictions of the IS/LM macroeconomic model to see whether confidence and stock prices operate on the business cycle as the IS/LM model would suggest.

Several issues are examined in the paper. First, how does the United States economy react to confidence and stock price shocks? The multivariate nature of the SVAR means that the effects of these two variables on the business cycle can be examined after controlling for the effect of other influences such as interest rates. The SVAR model also allows us to examine how one variable may partially operate on another via a third variable. Second, what has been the influence of confidence and the stock market on the US business cycle from 1959-2003? Finally, I also examine whether confidence can add incremental predictive information about future output, which has been a key focus of the literature.

The paper proceeds as follows. Section 2 contains a brief description of the main data series. This is followed by a discussion of the SVAR models and their estimation. Section 4 examines the dynamic response of the US economy to various shocks and section 5 discusses the influence of stock prices and confidence. The influence of confidence, stock prices and other shocks on the US economy is examined using a variance decomposition analysis and a decomposition of historical movements in US GNP. This is followed by a forecasting exercise at the end of the paper and a summary of key conclusions that can be drawn from the analysis.

2 Data

Six primary data series (table 1) are used in the model. This data is used to form the 6 main variables in the model, $\Delta y_t, \Delta i_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t), cl_t, \Delta sp_t$. Unit root testing (see appendix A) suggests that $\Delta y_t, \Delta i_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t), cl_t, \Delta sp_t$ are all stationary.

Table 1: Primary Data Series

y: log of seasonally adjusted GNP at 2000 prices
i: yield on 3 month US Treasury Bills
p: log of the consumer price index
m: log of the M1 money supply
cl: University of Michigan overall index of consumer sentiment
sp: log real Standard and Poors 500 index of US stock prices
(nominal S&P 500 index deflated by the CPI)

The data is quarterly in frequency and the sample period is 1959:4-2003:4. Further details on the sources and description of the data are available in appendix B.

3 The Gali SVAR Model and Extensions

3.1 The SVAR Model and Estimation

The model used in this paper is an extension of a four equation SVAR of the US economy originally estimated in Gali (1992). Gali's model consisted of four central macroeconomic variables — output, interest rates, the money supply and prices — and was estimated over the period 1955:1-1987:3. He explored whether the dynamic responses of the post war US economy to various macroeconomic shocks were consistent with the predictions of the IS/LM model and found that the IS/LM's predictions were largely supported by the data. As a first step I re-estimate Gali's four-variable model over the period 1959:4-2003:4 and compare the impulse responses from this re-estimated model with the original responses. This reveals that the responses are similar for both estimation periods, suggesting that the Gali model is robust to sample period and that the original model identified some stable relations in the data.

The original four-variable model is used as a base model in the paper, against which extensions are compared and contrasted. The robustness of the Gali model to changing estimation periods and its broad consistency with a major theory model make it a good foundation from which to examine the incremental effects of adding confidence and stock prices.

The rest of the section discusses the SVAR model and its estimation. The SVAR is a simultaneous equations model with a structural form given by:

$$B(L)z_t = b + \epsilon_t, \tag{1}$$

where $B(L) = B_0 - B_1L - B_2L^2 - ... - B_wL^w$ is a w^{th} order lag polynomial, ε_t is a $(n \times 1)$ vector of structural shocks, w is the number of lags of each variable in the system and B_j is a $(n \times n)$ coefficient matrix at lag j.

B_0 is the matrix of contemporaneous coefficients and a normalisation assumption is that the elements of its main diagonal are equal to 1, i.e. part of the identification restrictions are that each equation in the system is assigned a different dependent variable.

$$B_0 = \begin{bmatrix} 1 & -b_{12}^0 & ... & -b_{1n}^0 \\ -b_{21}^0 & 1 & ... & -b_{2n}^0 \\ ... & ... & ... & ... \\ -b_{n1}^0 & -b_{n2}^0 & ... & 1 \end{bmatrix}$$

where b_{12}^0 is the contemporaneous effect of a change in variable 2 on variable 1, i.e. the superscript indexes time, the first subscript indexes the dependent variable and the 2nd subscript indexes the independent variable. The inverse of B_0 is given by:

$$B_0^{-1} = \begin{bmatrix} b_0^{11} & b_0^{12} & ... & b_0^{1n} \\ b_0^{21} & b_0^{22} & ... & b_0^{2n} \\ ... & ... & ... & ... \\ b_0^{n1} & b_0^{n2} & ... & b_0^{nn} \end{bmatrix}$$

In the following discussion, b_{12}^0 is an element of B_0 while b_0^{12} is an element of the B_0^{-1} matrix (the sub- and superscripts are reversed).

The variance-covariance matrix $cov(\epsilon_t) = \Omega$ is a diagonal matrix. This assumption that the structural shocks, ϵ_t, are uncorrelated is a crucial identification assumption of the SVAR approach.

We can move from the structural model to the reduced form or VAR form by multiplying (1) by $B_0^{-1}$to give:

$$A(L)z_t = a + u_t \tag{2}$$

where $A(L) = B_0^{-1}B(L) = I_n - A_1L-, ... - A_wL^w$ is the w^{th} order lag polynomial of reduced form coefficients, $u_t = B_0^{-1}\epsilon_t$ is a $(n \times 1)$ vector of reduced form errors and $cov(u_t) = \Sigma = B_0^{-1}\Omega(B_0^{-1})$ is the variance-covariance matrix of the reduced form errors. A key point to note is that it is the B_0 matrix that connects the structural and reduced form representations.

The structural model given by (1) cannot be directly estimated with contemporaneous regressors because this would lead to correlation between the structural error terms, ϵ_t, and the regressors in each equation, resulting in biased and inconsistent parameter estimates. We therefore have to adopt a different estimation strategy. All the information that can be obtained from the data is contained in estimates of the reduced form model. One estimation method is to estimate the reduced form model, since regressors and the reduced form errors in each equation are not correlated and unbiased parameter estimates can therefore be found. The structural model parameters are then calculated using the information from the reduced form model. To do this though, we need to impose further identification restrictions on the structural model, as without further restriction we have fewer distinct elements from the reduced form estimation than we require to obtain estimates of the structural parameters.

From the reduced form estimation we obtain the coefficient matrices $A_1..A_w$. These can be used to identify the structural coefficients $B_1...B_w$, as they have the same number of separate elements, n^2, where n is the number of variables in the model. We also obtain Σ, the covariance matrix for the reduced form errors, which can be used to identify B_0 and Ω. The variance-covariance matrix, Σ, is symmetric and so only has $(n^2+n)/2$ distinct elements. With the normalisation restriction of ones on the main diagonal, B_0 has (n^2-n) unknowns and with the restriction of no covariance between the structural errors Ω has n distinct elements, the $var(\epsilon_t)$. There are, therefore, n^2 unknowns which must be identified from $(n^2+n)/2$ known elements, implying that we must impose $n^2 - (n^2+n)/2 = (n^2-n)/2$ further restrictions to exactly identify the structural model.

Another method of estimating the structural model is to estimate it equation by equation using instrumental variable (IV) estimation. The IV estimator is given by:

$$B_{IV} = (M'X)^{-1}M'z \tag{3}$$

where M is a matrix of instruments, X a matrix of regressors and z a vector of the dependent variable.

Instruments are used for the contemporaneous regressors to eliminate the problem of correlation between these variables and the structural shocks. The total number of separate coefficients and variances that can be estimated is still given by the number of separate elements that can be estimated in the reduced form model and so the same number of identifying restrictions must be imposed. This second method, based on Blanchard and Watson (1986) and used in Pagan and Robertson (1998), for estimating the structural model by IV estimation is implemented in this paper.

3.2 Identification Restrictions

The identification restrictions include the normalisation restrictions and restrictions on Ω (i.e. it is diagonal) as described above. There are also restrictions on the contemporaneous effect of some structural shocks on other variables in the system. These are restrictions on the B_0^{-1} matrix (short-run restrictions). Long-run restrictions imposed on the models are that the long-run effect of some structural shocks on other variables in the system are zero — these are restrictions on $C(1)$ (see below). It is also common to impose restrictions on the coefficients on contemporaneous variables in the system, i.e. restrictions on the B_0 matrix.

To discuss the long-run restrictions and impulse responses coefficients more fully, (1) is rewritten in moving average form:

$$z_t = c + B(L)^{-1}\epsilon_t = c + C(L)\epsilon_t = c + (C_0 + C_1 L + ...)\epsilon_t \tag{4}$$

The $C(L)$ give the impulse responses of the structural system given by (1) to the shocks ϵ_t. C_j gives the impulse response of z_{t+j} to the shocks ϵ_t. We can obtain the $C(L)$ in the following way:

From (1) we obtain:

$$\begin{aligned} z_t &= B_0^{-1}b + B_0^{-1}\epsilon_t + B_0^{-1}B_1 L z_t +, ... + B_0^{-1}B_w L^w z_t \\ &= B_0^{-1}b + B_0^{-1}\epsilon_t + B_0^{-1}B_1 z_{t-1} +, ... + B_0^{-1}B_w z_{t-w} \end{aligned} \tag{5}$$

Now, rewrite (5) in terms of the shocks, ϵ_t, to find the impulse response coefficients, the $C(L)$. For example, the responses of z_t to shocks to ϵ_t at $t = 0$ with $\epsilon_t = 0$ for $t \neq 0$ are:

$$\begin{aligned} z_0^* &= B_0^{-1}\epsilon_0 \\ z_1^* &= B_0^{-1}B_1 z_0 \\ &= B_0^{-1}B_1 B_0^{-1}\epsilon_0 \\ z_2^* &= B_0^{-1}B_1 z_1 + B_0^{-1}B_2 z_0 \\ &= B_0^{-1}B_1 B_0^{-1}B_1 B_0^{-1}\epsilon_0 + B_0^{-1}B_2 B_0^{-1}\epsilon_0 \end{aligned}$$

The C_j are given by the coefficients on ϵ_0, for example, $C_0 = B_0^{-1}, C_1 = B_0^{-1}B_1B_0^{-1}$. These C_j can be quickly calculated in an econometrics package such as R or Gauss. The long-run or cumulated responses are given by the sum of the C_j: $\Sigma C_j = C(1)$. In the models below, restrictions are imposed so that these cumulated responses are zero for some shocks and variables. This type of long-run restriction is imposed by placing the equivalent linear restrictions on the coefficients of $B(L)$. The equivalent linear restrictions can be found in the following way. Since $C(L) = B(L)^{-1}$,

$C(L)B(L) = I$ and $C(1)B(1) = I$, where I is the identity matrix . With the restriction that shocks to variables $2...n$ have no long-run effect on variable 1, i.e. $c_{12}...c_{1n} = 0$, we have the following:

$$\begin{bmatrix} c_{11} & 0 & .. & 0 \\ c_{21} & c_{22} & .. & c_{2n} \\ ... & ... & .. & ... \\ c_{n1} & c_{n2} & .. & c_{nn} \end{bmatrix} \begin{bmatrix} 1 - b_{11}^1 - .. - b_{11}^w & -b_{12}^0 - .. - b_{12}^w & .. & -b_{1n}^0 - .. - b_{1n}^w \\ -b_{21-}^0 .. - b_{21}^w & 1 - b_{22}^1 - .. - b_{22}^w & .. & -b_{2n}^0 - .. - b_{2n}^w \\ ... & ... & .. & ... \\ -b_{n1-}^0 .. - b_{n1}^w & -b_{n2-}^0 .. - b_{n2}^w & .. & 1 - b_{nn}^1 .. - b_{nn}^w \end{bmatrix} = \begin{bmatrix} 1 & 0 & .. & 0 \\ 0 & 1 & .. & 0 \\ ... & ... & .. & ... \\ 0 & 0 & .. & 1 \end{bmatrix}$$

where b_{12}^0 is the contemporaneous effect of a change in variable 2 on variable 1, i.e. the superscript indexes time, the first subscript indexes the dependent variable and the 2nd subscript indexes the independent variable.

From this we obtain $c_{11}(-b_{12}^0 - ... - b_{12}^w) = 0, ..., c_{11}(-b_{1n}^0 - ... - b_{1n}^w) = 0$, which given that $c_{11} > 0$, implies the following linear restrictions on $B(L)$:

$$\begin{aligned} (-b_{12}^0 - b_{12}^1 - ... - b_{12}^w) &= 0 \\ &... \\ (-b_{1n}^0 - b_{1n}^1 - ... - b_{1n}^w) &= 0 \end{aligned}$$

With these linear restrictions on $B(L)$ implied by the long-run restrictions we can write the first equation in the structural system in the following form:

$$\begin{aligned} z_{1t} &= b_{11}^1 z_{1t-1} + ... + b_{11}^w z_{1t-w} + b_{12}^0 (z_{2t} - z_{2t-w}) + ... + b_{12}^{w-1}(z_{2t-w-1} - z_{2t-w}) + \\ & \quad ... + b_{1n}^0 (z_{nt} - z_{nt-w}) + ... + b_{1n}^{w-1}(z_{nt-w-1} - z_{nt-w}) + \epsilon_t \end{aligned} \tag{6}$$

The regressors that have no long-run effect on variable 1 have been written in difference form. Each long-run restriction reduces the number of coefficients to be estimated in (6). With the long-run restrictions we can obtain the b_{1j}^w , $j = 2...n$ by forming a linear combination of the estimated coefficients, i.e.

$$b_{1n}^w = -b_{1n}^0 - b_{1n}^1 - ... - b_{1n}^{w-1}$$

The short-run restrictions that the immediate effect of some structural shocks on variables in the system are zero, i.e. restrictions on the B_0^{-1} matrix, arise as a consequence of using the reduced form errors as instruments for contemporaneous terms in the structural model. We know the reduced form errors, u_t, and the structural errors, ϵ_t, are related by $u_t = B_0^{-1}\epsilon_t$. Also, from above, we know that the immediate effect of structural shocks on z_t is given by $B_0^{-1}\epsilon_0$.

To impose the restriction that the immediate effect of a structural shock to variable 2 on variable 1 is zero, i.e. that $(b_0^{12}) = 0$ (where b_0^{12} denotes the element in the 1st row and 2nd column of the B_0^{-1}matrix), we use the reduced form error from the first equation of the reduced form system (2), u_{1t}, as an instrument for the contemporaneous variable, z_{1t}, in the second structural structural equation. Using u_{1t} an instrument in the second structural equation, which has a structural error, ϵ_{2t}, ensures $cov(u_{1t,}\epsilon_{2t}) = 0$, which since $u_t = B_0^{-1}\epsilon_t$ implies $(b_0^{12}) = 0$, i.e. the IV estimator ensures the moment condition $E(M(Y - X'B)) = E(M\epsilon) = cov(M, \epsilon) = 0$ holds where the instrument, M, in this example is u_{1t} and ϵ is ϵ_{2t}.

3.3 The Gali model of the US economy and 3 extensions with consumer confidence and stock prices

3.3.1 Gali (1992) model

The original Gali model (base model) is a four-variable SVAR with $z_t = [\Delta y_t, \Delta i_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t)]'$ and $w = 4$. With no restrictions other than normalisation, the system of equations can be written as:

$$\Delta y_t = b_1 - b_{12}^0 \Delta i_t - b_{13}^0 (i_t - \Delta p_t) - b_{14}^0 (\Delta m_t - \Delta p_t) + \overline{B_{1z}}(L) z_t + \epsilon_{1t} \tag{7}$$

$$\Delta i_t = b_2 - b_{21}^0 \Delta y_t - b_{23}^0 (i_t - \Delta p_t) - b_{24}^0 (\Delta m_t - \Delta p_t) + \overline{B_{2z}}(L) z_t + \epsilon_{2t} \tag{8}$$

$$(i_t - \Delta p_t) = b_3 - b_{31}^0 \Delta y_t - b_{32}^0 \Delta i_t - b_{34}^0 (\Delta m_t - \Delta p_t) + \overline{B_{3z}}(L) z_t + \epsilon_{3t} \tag{9}$$

$$(\Delta m_t - \Delta p_t) = b_4 - b_{41}^0 \Delta y_t - b_{42}^0 \Delta i_t - b_{43}^0 (i_t - \Delta p_t) - \overline{B_{4z}}(L) z_t + \epsilon_{4t} \tag{10}$$

where $\overline{B_{jz}(L)} = B_{j1}L + B_{j2}L^2 + B_{j3}L^3 + B_{j4}L^4$ (where $B_{j1}L$ is a vector made up of coefficients on the 1st lag of each variable in the vector, z_t, for the j^{th} equation in the system).

Gali interprets the first equation as the aggregate supply function (AS), the second equation as the money supply function (MS), the third as the money demand function (MD) and the fourth as the investment-savings function (IS). The shocks, $\epsilon_{1t}, \epsilon_{2t}, \epsilon_{3t}$ and ϵ_{4t} are regarded as structural shocks to the AS, MS, MD and IS relations respectively. To exactly identify the model and therefore identify the four structural shocks, $\epsilon_{1t}, \epsilon_{2t}, \epsilon_{3t}$ and ϵ_{4t}, six restrictions are imposed:

Table 2: Identifying Restrictions Base Model

Long-Run Restrictions
1. no long-run effects of MS shocks on Δy_t
2. no long-run effects of MD shocks on Δy_t
3. no long-run effects of IS shocks on Δy_t
(B_0^{-1}) Short-Run Restrictions
4-5. no immediate effect of MS or MD shocks on Δy_t
(B_0) Short-Run Restriction
6. contemporaneous prices do not enter the MS rule

There are three long-run restrictions that separate the supply shock from the three demand side shocks (MS, MD, IS). These long-run restrictions are based on the theory that demand shocks have only temporary effects on output and that it is only supply shocks that lead to permanent changes in output. As described in the identifying restrictions section above, these long-run restrictions are imposed through linear restrictions on $B(L)$. For example, we implement restriction 1 by imposing the following linear constraint:

$$b_{12}^4 = -b_{12}^0 - b_{12}^1 - b_{12}^2 - b_{12}^3$$

Each restriction has reduced the coefficients to be estimated by one, as we no longer need to estimate the b_{1n}^4 as these are functions of the other four estimated coefficients on the other lags of each variable. The long-run restriction allows us to rewrite the AS function with $\Delta i_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t)$ in the following difference form:

$$\begin{aligned}\Delta y_t \quad = \quad & b_1 + \sum_{i=1}^{4} b_{11}^i \Delta y_{t-i} + \sum_{i=0}^{3} b_{12}^i (\Delta i_{t-i} - \Delta i_{t-4}) + \\ & \sum_{i=0}^{3} b_{13}^i ((i_{t-i} - \Delta p_{t-i}) - (i_{t-4} - \Delta p_{t-4})) \\ & + \sum_{i=0}^{3} b_{14}^i ((\Delta m_{t-i} - \Delta p_{t-i}) - (\Delta m_{t-4} - \Delta p_{t-4})) + \epsilon_{1t} \qquad (11)\end{aligned}$$

Restriction 6 that prices do not contemporaneously enter the money supply rule eliminates Δp_t from the MS rule, which implies that -$b_{23}^0 = b_{24}^0$. With this restriction we can rewrite the MS function in the following form:

$$\Delta i_t = b_2 - b_{21}^0 \Delta y_t - b_{23}^0 (i_t - \Delta m_t) - \overline{B_{2z}}(L) z_t + \epsilon_{2t} \tag{12}$$

Restrictions 4 and 5 (the B_0^{-1} restrictions) are implemented in the estimation procedure. To estimate the model each structural equation is estimated separately using IV estimation. As described above, the remaining contemporaneous variables after restrictions are imposed must be instrumented. The AS equation is estimated first. The three regressors that contain contemporaneous elements $(\Delta i_t - \Delta i_{t-4}), ((i_t - \Delta p_t) - (i_{t-4} - \Delta p_{t-4}))$ and $((\Delta m_t - \Delta p_t) - (\Delta m_{t-4} - \Delta p_{t-4}))$ are instrumented with $\Delta i_{t-1}, (i_{t-1} - \Delta p_{t-1})$ and $(\Delta m_{t-1} - \Delta p_{t-1})$ respectively. Once the restriction that contemporaneous prices do not enter the MS rule is imposed, there are only two contemporaneous terms to instrument, Δy_t and $(i_t - \Delta m_t)$. Δy_t is instrumented with u_{1t}, the residual from the AS function in the reduced form VAR. Using u_{1t} as an instrument for Δy_t imposes restriction 4 that MS shocks do not have an immediate effect on output i.e. the B_0^{-1} restriction $(b_0^{12}) = 0$. The residuals from the estimation of the structural AS equation, ϵ_{1t}, are used as an instrument for $(i_t - \Delta m_t)$. We then estimate the MD equation using u_{1t} as instrument for Δy_t, which imposes restriction 5, and ϵ_{2t} and ϵ_{1t} as instruments for Δi_t and $(\Delta m_t - \Delta p_t)$ respectively. The fourth equation IS is then estimated using $\epsilon_{1t,}\epsilon_{2t}$ and ϵ_{3t} as instruments for $\Delta y_t, \Delta i_t$, and $(i_t - \Delta p_t)$ respectively.

I estimate a further three models that are extensions of the Gali model. The variables sequentially added to the basic Gali model are confidence, stock prices and, finally, confidence and stock prices. These models and the restrictions used to identify them are summarised below.

3.3.2 The Gali model including consumer confidence

The Gali model with consumer confidence is a five-equation SVAR with $z_t = [\Delta y_t, \Delta i_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t), cl_t]'$ and $w = 4$. With $n = 5$ we require 10 restrictions to identify the structural model. Restrictions 1 to 5 are retained from the original model The main change from the original model are the restrictions placed on the effect of confidence in the model and further B_0^{-1} restrictions on MD.

Confidence is a demand side influence, so like the other demand side influences it is restricted to have no influence on y_t in the long-run. Confidence is also expected to have no immediate effect on y_t or the supply of money, m_t. The central bank is assumed to wait for a while before it reacts to confidence data to be more certain a shift has taken place, and the goods market will increase supply only with a lag in response to a confidence increase, as firms will most likely want confirmation of demand increases before increasing production. Additional restrictions also include no immediate effect of money demand shocks on confidence or the real money supply, $m_t - p_t$.

Table 3: Identifying Restrictions: Confidence Model

Long-Run Restrictions
1-4. no long-run effects of MS, MD, IS or confidence shocks on Δy_t
(B_0^{-1}) Short-Run Restrictions
5-6. no immediate effect of confidence shocks on Δy_t, Δi_t
7-9. no immediate effect of MD shocks on Δy_t, $\Delta m_t - \Delta p_t$ and confidence
10. no immediate effect of MS shocks on Δy_t

With these restrictions the model can be written in the following form. The long-run restrictions implemented via linear restrictions on $B(L)$ eliminate four coefficients in the AS function and allow us to write the AS function with MS, MD, IS and confidence in difference form. The main difference from the base model is the addition of a 5th equation, the confidence function (CL function).

$$\begin{aligned}\Delta y_t &= b_1 + \sum_{i=1}^{4} b_{11}^i \Delta y_{t-i} + \sum_{i=0}^{3} b_{12}^i (\Delta i_{t-i} - \Delta i_{t-4}) + \\ &\sum_{i=0}^{3} b_{13}^i ((i_{t-i} - \Delta p_{t-i}) - (i_{t-4} - \Delta p_{t-4})) \\ &+ \sum_{i=0}^{3} b_{14}^i ((\Delta m_{t-i} - \Delta p_{t-i}) - (\Delta m_{t-4} - \Delta p_{t-4})) \\ &+ \sum_{i=0}^{3} b_{15}^i (cl_{t-i} - cl_{t-4}) + \epsilon_{1t} \end{aligned} \tag{13}$$

$$\Delta i_t = b_2 - b_{21}^0 \Delta y_t - b_{23}^0 (i_t - \Delta p_t) - b_{24}^0 (\Delta m_t - \Delta p_t) - b_{25}^0 cl_t + \overline{B_{2z}}(L) z_t + \epsilon_{2t} \tag{14}$$

$$(i_t - \Delta p_t) = b_3 - b_{31}^0 \Delta y_t - b_{32}^0 \Delta i_t - b_{34}^0 (\Delta m_t - \Delta p_t) - b_{35}^0 cl_t + \overline{B_{3z}}(L) z_t + \epsilon_{3t} \tag{15}$$

$$(\Delta m_t - \Delta p_t) = b_4 - b_{41}^0 \Delta y_t - b_{42}^0 \Delta i_t - b_{43}^0 (i_t - \Delta p_t) - b_{45}^0 cl_t - \overline{B_{4z}}(L) z_t + \epsilon_{4t} \tag{16}$$

$$\begin{aligned} cl_t &= b_5 - b_{51}^0 \Delta y_t - b_{52}^0 \Delta i_t - b_{53}^0 (i_t - \Delta p_t) \\ &- b_{54}^0 (\Delta m_t - \Delta p_t) - \overline{B_{5z}}(L) z_t + \epsilon_{5t} \end{aligned} \tag{17}$$

The structural model is again estimated by IV. The instruments used are summarised in table 4 below. Variables and instruments are in corresponding order. ϵ_{nt} are the structural errors and

u_{nt} are the reduced form errors with $n = 1, 2, 3, 4, 5$ corresponding to AS, MS, MD, IS and CL respectively.

Table 4: Confidence Model Instruments

Equation	Contemporaneous Variable	Instruments
1. AS	$(\Delta i_t - \Delta i_{t-4}), ((i_t - \Delta p_t) - (i_{t-4} - \Delta p_{t-4})),$	$\Delta i_{t-1}, (i_{t-1} - \Delta p_{t-1})$
	$((\Delta m_t - \Delta p_t) - (\Delta m_{t-4} - \Delta p_{t-4})), (cl_t - cl_{t-4})$	$(\Delta m_{t-1} - \Delta p_{t-1}), cl_{t-5}$
2. MS	$\Delta y_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t), cl_t$	$u_{1t}, \epsilon_{3t}, \epsilon_{1t}, \epsilon_{5t}$
3. MD	$\Delta y_t, \Delta i_t, (\Delta m_t - \Delta p_t), cl_t$	$u_{1t}, \epsilon_{1t}, u_{4t}, u_{5t}$
4. IS	$\Delta y_t, \Delta i_t, (i_t - \Delta p_t), cl_t$	$\epsilon_{1t}, \epsilon_{2t}, \epsilon_{3t}, \epsilon_{5t}$
5. CL	$\Delta y_t, \Delta i_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t)$	$u_{1t}, u_{2t}, \epsilon_{3t}, \epsilon_{1t}$

The choice of restrictions and instruments means that the equations must be estimated in a particular order. The actual estimation order is AS, MD, CL, MS and IS. For example, IS uses structural residuals from the other four equations, $\epsilon_{1t}, \epsilon_{2t}, \epsilon_{3t}, \epsilon_{5t},$ so it must be estimated last. Throughout the paper though, the ordering of equations and residuals for descriptive purposes will remain: AS, MS, MD, IS, CL, DSP(stock price function) so that ϵ_{1t} and ϵ_{2t} always refer to the structural residuals from the AS and MS functions and so on.

3.3.3 The Gali model including stock prices

Again the SVAR has five variables with $z_t = [\Delta y_t, \Delta i_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t), \Delta sp_t]'$ and $w = 4$. Δsp_t denotes the first difference of the real stock price, sp_t. Ten restrictions other than the normalisation and the diagonal restriction on $cov(\epsilon_t) = \Omega$ are required again. The main difference from the original model and the confidence model is that there are now six long-run restrictions. In theory we would expect long-run changes in real stock prices to be driven by changes in the discount factor and changes in real earnings, with the latter being a function of the supply-side of the economy. Therefore, shocks that affect demand (such as MS, MD and confidence) would not be expected to affect real stock prices in the long-run.

Table 5: Identifying Restrictions Stock Price Model

Long-Run Restrictions
1-3. no long-run effects of MS, MD or IS shocks on Δy_t
4-6. no long-run effects of MS, MD or IS shocks on Δsp_t
(B_0^{-1}) Short-Run Restrictions
7. no immediate effect of MS shocks on Δy_t
8-9. no immediate effect of MD shocks on Δy_t or $\Delta m_t - \Delta p_t$
(B_0) Short-Run Restrictions
10. no immediate effect of stock price shocks on Δy_t

The tenth restriction, that stock price shocks do not affect $\triangle y_t$ in the short-run, separately identifies the AS function from the DSP function, as both have in common that they are not affected by the demand side variables in the long-run. While an actual or expected increase in AS may be immediately priced into stock prices, an increase in stock prices reflecting future productivity and earnings growth may take some time to be reflected in actual aggregate supply. All variables in the model are left free to have immediate effects on Δsp_t. The stock market is relatively a very efficient market from an information perspective, with all news being incorporated into prices extremely quickly, and certainly inside a quarter, which is the shortest time period in the model.

The model is estimated with IV using the instruments detailed in table 6, where ϵ_{nt} are the structural errors and u_{nt} are the reduced form errors, with $n = 1, 2, 3, 4, 5$ corresponding to AS,MS,MD, IS and DSP respectively.

Table 6: Stock Price Model Instruments

Equation	Contemporaneous Variable	Instruments
1. AS	$(\Delta i_t - \Delta i_{t-4}), ((i_t - \Delta p_t) - (i_{t-4} - \Delta p_{t-4})),$	$\Delta i_{t-1}, (i_{t-1} - \Delta p_{t-1})$
	$((\Delta m_t - \Delta p_t) - (\Delta m_{t-4} - \Delta p_{t-4}))$	$(\Delta m_{t-1} - \Delta p_{t-1})$
2. MS	$\Delta y_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t), \Delta sp_t$	$u_{1t}, \epsilon_{3t}, \epsilon_{1t}, \epsilon_{5t}$
3. MD	$\Delta y_t, \Delta i_t, (\Delta m_t - \Delta p_t), \Delta sp_t$	$u_{1t}, \epsilon_{1t}, u_{4t}, \epsilon_{5t}$
4. IS	$\Delta y_t, \Delta i_t, (i_t - \Delta p_t), \Delta sp_t$	$\epsilon_{1t}, \epsilon_{2t}, \epsilon_{3t}, \epsilon_{5t}$
5. DSP	$\Delta y_t, (\Delta i_t - \Delta i_{t-4}), ((i_t - \Delta p_t) - (i_{t-4} - \Delta p_{t-4})),$	$\epsilon_{1t}, \Delta i_{t-1}, (i_{t-1} - \Delta p_{t-1})$
	$((\Delta m_t - \Delta p_t) - (\Delta m_{t-4} - \Delta p_{t-4}))$	$(\Delta m_{t-1} - \Delta p_{t-1})$

The choice of restrictions and instruments means the actual ordering of the equations for estimation is AS, DSP, MD, MS, IS.

3.3.4 The Gali model with confidence and stock prices

The largest model estimated in the paper is a six equation SVAR with $z_t = [\Delta y_t, \Delta i_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t), cl_t, \Delta sp_t]'$ and $w = 4$. The model includes both confidence and stock prices to investigate what effects these variables have on the business cycle once we control for both influences. With six variables in the model, 15 restrictions are required for identification. The restrictions from the first three models are all used in this larger model. There are eight long-run restrictions, with the demand side variables, MS, MD, IS and confidence having no effect in the long-run on $\triangle y_t$ or stock prices, which are both regarded as being functions of the long-run supply-side potential of the economy and influenced by such things as technology. Again, the DSP and AS functions are separately identified by the short-run restriction that stock prices do not have an immediate effect on $\triangle y_t$. The same short-run restrictions apply to MS, MD and confidence as in the confidence only model, with MD and confidence shocks having less immediate effects than MS shocks.

Table 7: Identifying Restrictions: Confidence & Stock Price Model

Long-Run Restrictions	
1-4.	no long-run effects of MS, MD, IS or confidence shocks on Δy_t
5-8.	no long-run effects of MS, MD, IS or confidence shocks on Δsp_t
(B_0^{-1}) Short-Run Restrictions	
9.	no immediate effect of MS shocks on Δy_t
10-12.	no immediate effect of MD shocks on Δy_t,$\Delta m_t - \Delta p_t$ or confidence
13-14.	no immediate effect of confidence shocks on Δy_t or Δi_t
(B_0) Short-Run Restriction	
15.	no immediate effect of stock price shocks on Δy_t

The instruments used in estimating the model are summarised in table 8, where ϵ_{nt} are the structural errors and u_{nt} are the reduced form errors, with $n = 1, 2, 3, 4, 5, 6$ corresponding to AS, MS, MD, IS, CL and DSP respectively.

Table 8: Confidence & Stock Price Model Instruments

Equation	Contemporaneous Variable	Instruments
1. AS	$(\Delta i_t - \Delta i_{t-4}), ((i_t - \Delta p_t) - (i_{t-4} - \Delta p_{t-4})),$	$\Delta i_{t-1}, (i_{t-1} - \Delta p_{t-1})$
	$((\Delta m_t - \Delta p_t) - (\Delta m_{t-4} - \Delta p_{t-4})), (cl_t - cl_{t-4})$	$(\Delta m_{t-1} - \Delta p_{t-1}), \Delta y_{t-5}$
2. MS	$\Delta y_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t), cl_t, \Delta sp_t$	$u_{1t}, \epsilon_{3t}, \epsilon_{1t}, \epsilon_{5t}, \epsilon_{6t}$
3. MD	$\Delta y_t, \Delta i_t, (\Delta m_t - \Delta p_t), cl_t, \Delta sp_t$	$u_{1t}, \epsilon_{1t}, u_{4t}, u_{5t}, \epsilon_{6t}$
4. IS	$\Delta y_t, \Delta i_t, (i_t - \Delta p_t), cl_t, \Delta sp_t$	$\epsilon_{1t}, \epsilon_{2t}, \epsilon_{3t}, \epsilon_{5t}, \epsilon_{6t}$
5. CL	$\Delta y_t, \Delta i_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t), \Delta sp_t$	$u_{1t}, u_{2t}, \epsilon_{3t}, \epsilon_{1t}, \epsilon_{6t}$
6. DSP	$\Delta y_t, (\Delta i_t - \Delta i_{t-4}), ((i_t - \Delta p_t) - (i_{t-4} - \Delta p_{t-4})),$	$\epsilon_{1t}, \Delta i_{t-1}, (i_{t-1} - \Delta p_{t-1})$
	$((\Delta m_t - \Delta p_t) - (\Delta m_{t-4} - \Delta p_{t-4})), (cl_t - cl_{t-4})$	$(\Delta m_{t-1} - \Delta p_{t-1}), cl_{t-5}$

The restrictions and choice of instruments require that the actual order of estimation is AS, DSP, MD, CL, MS and IS.

4 Dynamic responses of the US economy to macroeconomic shocks

In this section I discuss and compare the dynamic responses of the US economy in the various models and how similar these are to the predictions of the IS/LM model. The original Gali model is used as benchmark for comparison throughout. As discussed above, we can obtain C_j, the impulse response of the system z_t at $t = j$ to shocks at $t = 0$, ϵ_0. Elements of C_j are denoted c_j^{ik}, where c_j^{ik} is the response of variable i at $t = j$ to a shock to variable k, ϵ_k at $t = 0$. The plots below show the c_j^{ik}

plotted against time and therefore show the response of different variables to the different structural shocks that have been identified in the estimated models.

4.1 Aggregate Supply Shocks

Figure 1 contains a summary of the effect of an aggregate supply shock on the US economy. The impulse responses of eight variables: real GNP (level), nominal interest rates (level), inflation, M1 growth, real interest rates (level), real money balances (level), confidence (level) and the stock price (level) to a positive AS shock are shown. Changes in GNP, interest rates and money balances are expressed in percentage points. The level of confidence and stock prices are expressed in units of their original indices. The size of the shock is one standard deviation of the residual in the AS function in the stock price and confidence model (approximately a shock of 0.7% to real GNP). The same size shock is imposed on all four models described above, and the responses are given by: original Gali model (grey lines), confidence only model (dashed lines), stock prices only model (dotted), and stock prices and confidence model (black lines).

In all four models the level of output rises permanently and prices fall initially, consistent with the prediction of the IS/LM model for a positive supply shock. The dynamic response of the economy is similar to the original Gali model (grey lines) for all four models. In terms of the business cycle, the key difference is that the effect of the AS shock is larger once we add in stock prices and confidence than in the original model. With the addition of stock prices and confidence there are two more channels by which the positive AS shock will lead to increases in demand and output. The AS shock increases output, which in turn leads to higher incomes and the jump in the level of confidence and stock prices, which lead to greater increases in demand and output than in the base model. This results in higher inflation and interest rates than in the original model.

4.2 Money Supply Shocks

The effect of a money supply shock is shown for all four models in figure 2. The money supply shocks have been scaled so they are approximately the same in all four models, i.e. an increase of around 0.6% in the M1 money supply. Again the dynamic responses are similar across the models and reasonably consistent with the predictions of the IS/LM model — there is a temporary increase in output but the shock is ultimately inflationary. The MS shock leads to a fall in the nominal and real interest rates, which drive a temporary increase in output. However, the shock is inflationary and interest rates rise over the medium-term. A difference between the original model and the confidence and stock price models is that the liquidity effect (i.e. nominal interest rates initially fall

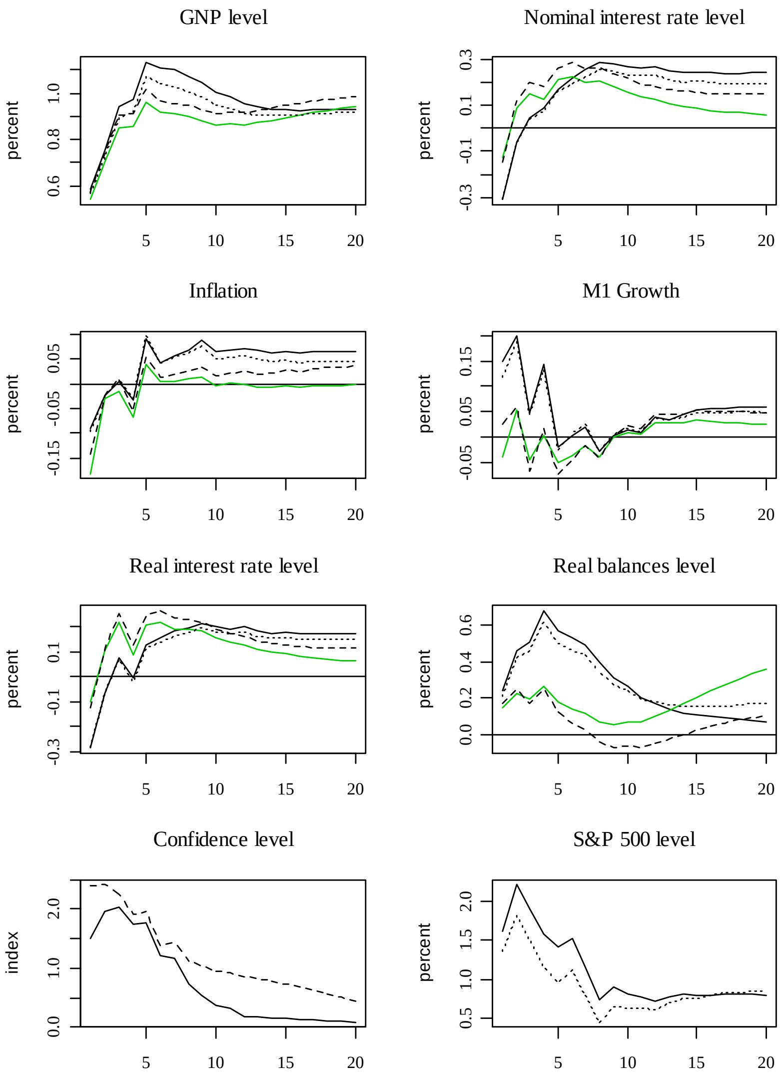

Figure 1: Dynamic Response to an Aggregate Supply Shock. Original Gali model (grey lines), confidence only model (dashed lines), stock prices only model (dotted) and stock prices and confidence model (black lines).

in response to the rise in the money supply) is smaller or does not occur at the quarterly frequency in the models.

The effect on GNP is more muted in the extended models than in the original model. The liquidity effect on interest rates is smaller in these models but confidence and stock price effects also play a role. For confidence, the inflationary consequences of the MS shock and related interest rate increases outweigh any initial liquidity effect induced decrease in interest rates, at least in the quarterly frequency observed here, and confidence falls. The confidence channel acts to dampen demand and results in a smaller overall cycle in output than in the original model. Initially the MS shock leads to a rise in stock prices. However, the rise in inflation and interest rates leads to a reversal of this stock price rise, and output declines more quickly from its peak in the models with stock prices as the wealth channel to demand and output reverses.

4.3 Money Demand Shocks

The impulse response functions in figure 3 show an increase in money demand without a completely offsetting increase in the money supply leads to an increase in nominal and real interest rates and a fall in output, as would be theoretically expected. A shock of one standard deviation of the money demand residual in the confidence and stock price model has been imposed on all four models. A difference from the original model is that while in the original model the money supply (M1) is increased in response to the demand shock, partly accommodating the increased demand for money, this does not occur in the extended models. This leads to higher interest rates and a greater fall in demand and output in the extended models. The confidence and stock price channels also have an influence in the extended models. If the MD shocks are scaled so that the interest rate increase is the same in all four models, output still declines in the extended models by more than in the original model. This is because the interest rate increase acts to decrease confidence and the stock price and therefore the confidence and wealth effects reduce demand and output initially. Once interest rates fall to offset the decrease in output and inflation, the confidence and stock price/wealth channels reverse and contribute to faster growth in GDP. Overall, the cycle is more exaggerated after an MD shock once confidence and stock price are added to the model.

4.4 IS Shocks

The response of the economy to an IS shock (e.g. an increase in government spending) is shown in figure 4. The dynamic response of the economy is similar across all four models. As predicted by the IS/LM model an IS shock leads to an increase in interest rates and, as it is a demand side influence, inflation. It also generates a temporary increase in output. The main difference between the original model and the extended models is that interest rates operate to crowd out activity through the confidence and stock price/wealth channels. Output and inflation rise by less in the extended

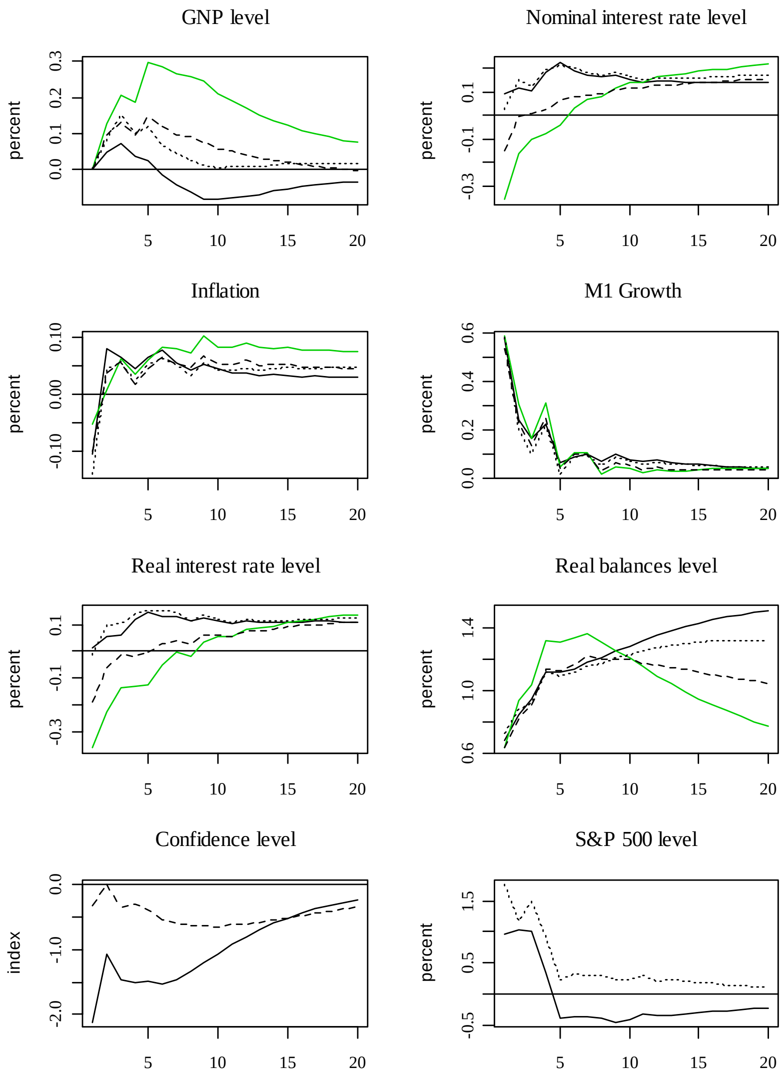

Figure 2: Dynamic Response to a Money Supply Shock. Original Gali model (grey lines), confidence only model (dashed lines), stock prices only model (dotted) and stock prices and confidence model (black lines).

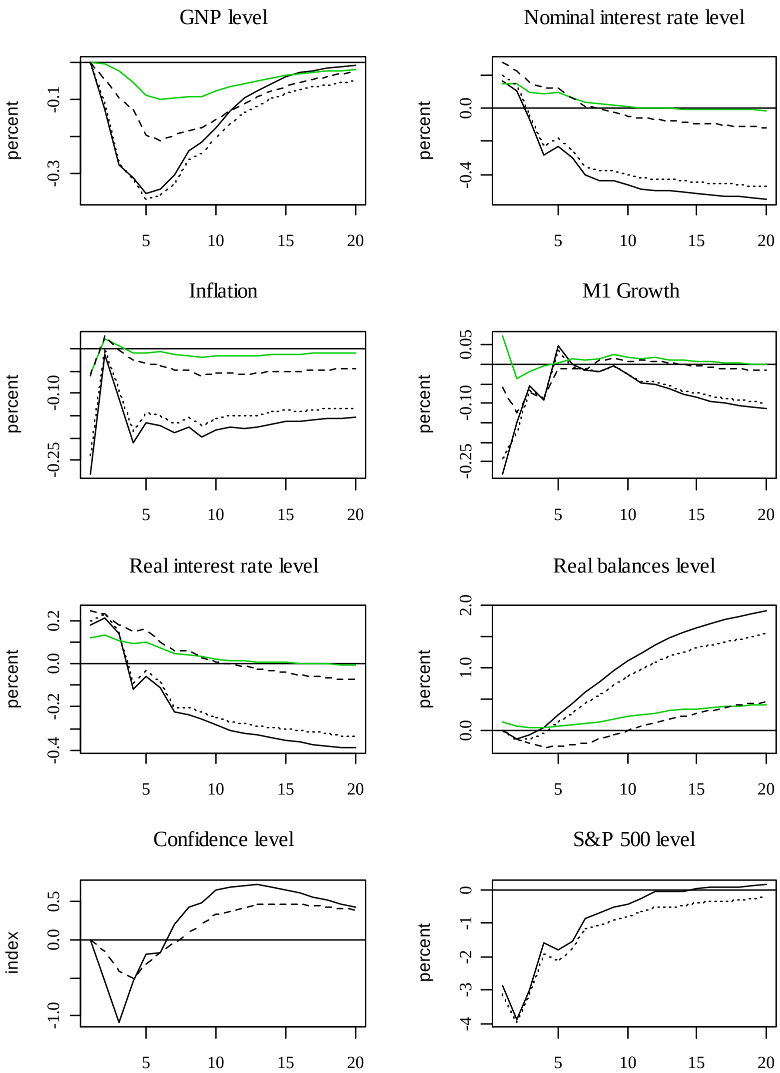

Figure 3: Dynamic Response to a Money Demand Shock. Original Gali model (grey lines), confidence only model (dashed lines), stock prices only model (dotted) and stock prices and confidence model (black lines).

models because of the dampening effect of interest rate rises on spending through confidence and stock prices. In this case, the addition of confidence and stock prices leads to a dampened response of the business cycle to IS shocks.

4.5 Confidence Shocks

Figure 5 shows the response of the economy to a 4 point confidence shock. In an IS/LM framework, an increase in confidence should lead to an increase in demand, spending and output in the short-run. The impulse responses support this prediction, with output initially rising by 0.14% in response to the confidence shock in the confidence and stock price model. The response of GNP to a confidence shock is larger in the confidence only model because confidence will capture some of the stock price effect on output in the absence of stock prices in the model. In the confidence and stock price model, the rise in interest rates in response to the shock appears to be enough to contain any inflation arising from the increase in demand. As would be expected, stock prices also rise with the increase in confidence. This is a result of the temporary increase in output and therefore higher expected profits. It may also be a result of better expectations of future earnings prospects associated with higher confidence.

4.6 Stock Price Shocks

A real stock price shock is theoretically expected to increase output. This is for two reasons: first, the increase in stock prices is expected to increase demand via wealth effects and confidence; and second, real stock prices are a summary of future earnings prospects which are function in part of the supply side potential of the economy. A real stock price increase should therefore be predicting increases in aggregate supply and a long-run increase in the level of output.

The impulse responses in figure 6 show an initial deflation consistent with stock prices reflecting an increase in the supply side of the economy. As would be expected, confidence also rises increasing demand and output by more than in the stock price only model (dotted lines). There is an increase in interest rates which may reflect central bank moves to keep the demand side effects from the increase in wealth in line with the supply response of the economy, especially in the short-term. The supply response is likely to be slower than increases in demand, as it takes time for new capital to be built and combined with labour and technology to fully contribute to greater supply, while the stock price increase brings all this future earnings gain to the present to be spent now, generating more rapid demand increases.

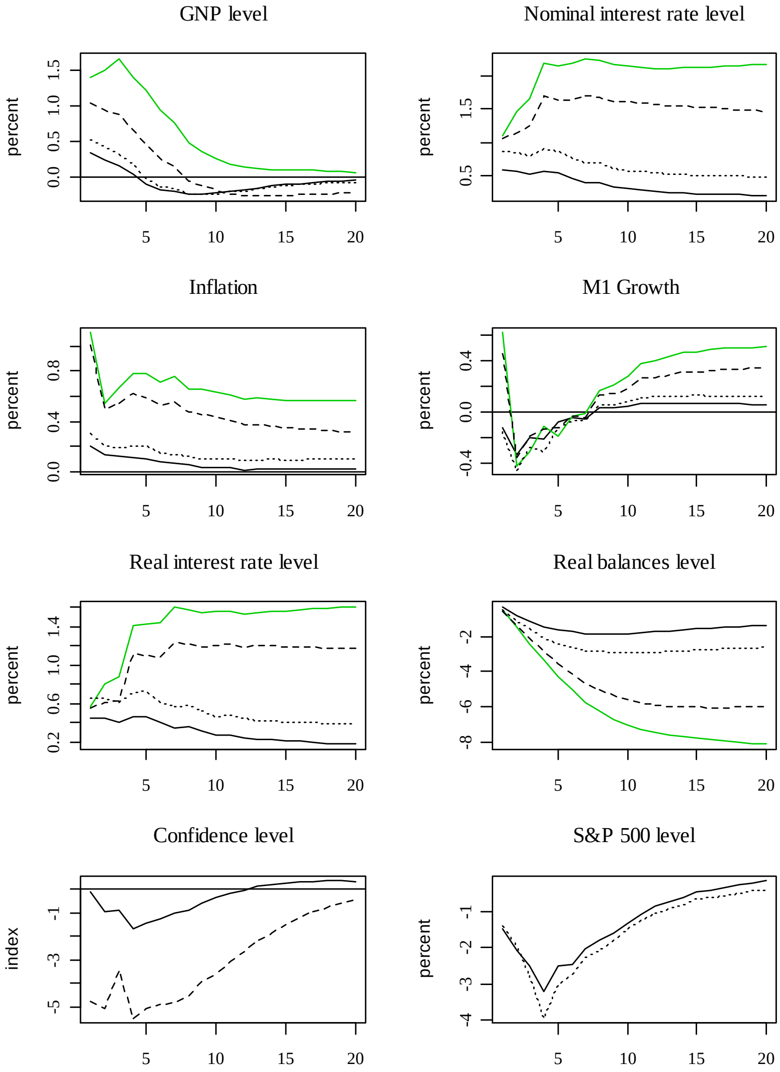

Figure 4: Dynamic Response to a IS Shock. Original Gali model (grey lines), confidence only model (dashed lines), stock prices only model (dotted) and stock prices and confidence model (black lines).

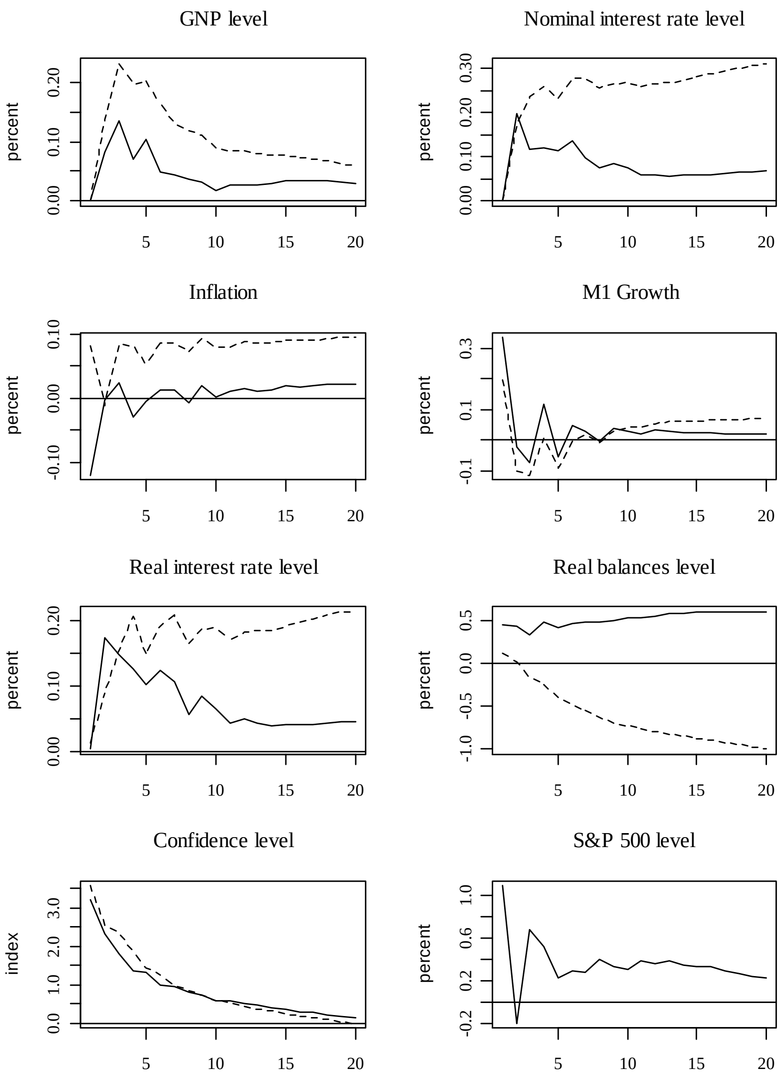

Figure 5: Dynamic Response to a Confidence Shock. Confidence only model (dashed lines), Stock prices and confidence model (black lines).

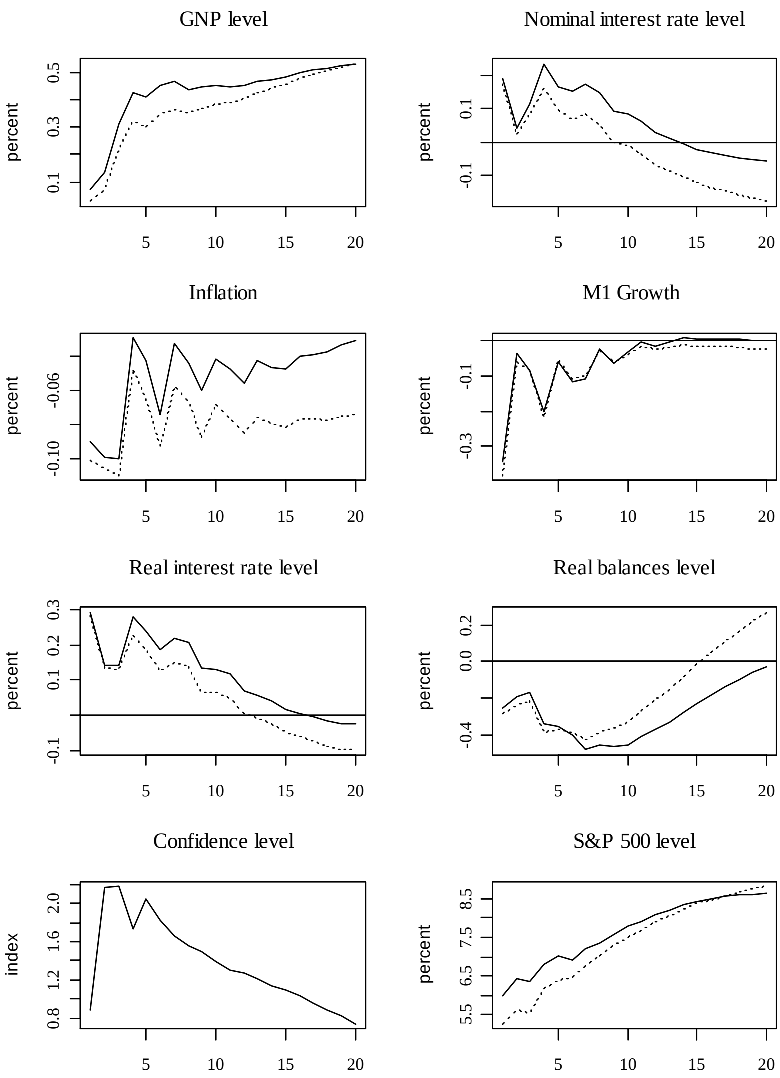

Figure 6: Dynamic Response to a Stock Price Shock. Stock price only model (dotted lines), Stock prices and confidence model (black lines).

5 The influence of consumer confidence and stock prices

This section discusses the influence of confidence and stock prices on the US business cycle. Two methods are used: variance decomposition of the forecast error and a historical decomposition of the US business cycle.

5.1 Variance Decomposition

One method commonly used to assess the influence of various shocks on variables in the system is to conduct a decomposition of the forecast error variance.

The vector autoregressive representation of the structural model is given by (1). The structural model can also be expressed in vector moving average (VMA) form where the coefficients, $C(L)$, on the error terms, ϵ_t, are obtained as described above:

$$z_t = c + C(L)\epsilon_t \tag{18}$$

The VMA form implies that the h-step ahead forecast errors for the $(n \times 1)$ vector, z_t are given by:

$$z_{t+h} - E_t z_{t+h} = \sum_{j=0}^{h-1} C_j \epsilon_{t+h-j} \tag{19}$$

where the $(n \times n)$ matrix C_j contains the impulse of z_{t+j} to the shocks $(n \times 1)$ vector of shocks ϵ_t.

The vector of total forecast error variances, σ_z^2, are then given by:

$$\sigma_z^2 = diag(\sum_{j=0}^{h-1} C_j V\epsilon C_j') \tag{20}$$

where $V\epsilon$ is the variance-covariance matrix for the error vector ϵ_t. The total forecast error variances rise as the forecast period extends, as the error variances are non-negative. We can then decompose this total forecast error into the proportions of the error due to the various structural shocks. These proportions are given by:

$$\sigma_{zn}^2 = \frac{diag(\sum_{j=0}^{h-1} C_j V_{\epsilon n} C_j')}{diag(\sum_{j=0}^{h-1} C_j V_\epsilon C_j')} \tag{21}$$

where σ^2_{zn} is the proportion of forecast error variance of z_t due to shocks to the n^{th} error and the variance-covariance matrix ,$V_{\epsilon n}$, has zeros elements except for $var(\epsilon_n)$.

If the proportion of the forecast error variance of variable in z_t, y_t, explained by a structural shock to x_t is zero, then y_t is regarded as exogenous to shocks in x_t. The higher the proportion of the total forecast error variance due to a shock, the more important it is as an influence on that variable.

The results for the decomposition of the GNP forecast error at horizons from 1 to 20 quarters in the confidence and stock price model are given in Table 9. They show that approximately 80% of the total forecast error of GNP is due to AS shocks in all future periods up 20 quarters. At very short horizons of 1-2 quarters, IS shocks explain most of the remainder of the error variance of GNP but then their influence tapers off to be only 4% after 5 quarters. This is consistent with IS shocks being a temporary demand influence on the business cycle. Money demand shocks appear to explain a modest amount of the forecast error of GNP, accounting for a maximum of 6% of the total forecast error at a forecast horizon of 5 quarters. The influence of stock prices increases as the forecast horizon increases. Stock prices explain a maximum of 16% of the total variance of GNP over the forecast horizon considered. MS and confidence shocks appear to explain very little of the forecast error of GNP, only 0.3 and 1.1% respectively of the total GNP forecast error.

Table 9: Forecast Error Variance Decomposition of GNP

Shock	AS	MS	MD	IS	CL	SP
1 quarter	74.2	0	0	24.6	0	1.2
3 quarters	80	0.3	4.2	9	1.1	5.4
5 quarters	79.3	0.2	6.3	4.2	0.8	9.3
10 quarters	78.5	0.2	5.4	3.4	0.4	12
20 quarters	77.9	0.3	3	2.3	0.2	16.3

From the variance decomposition it appears that supply shocks are the most important influence on GNP, with 4/5 of the total forecast error being attributable to AS shocks, with money demand, stock prices and IS shocks having a modest influence. It also would appear that MS and confidence shocks have very little influence on GNP. Overall the variance decomposition results are contrary to the Keynesian view that demand-side shocks are the key influences on the business cycle. However, a decomposition of the business cycle in the US in the next section indicates that confidence and the other shocks besides AS have a much more important role at some points in time than the variance decomposition suggests. The variance decomposition gives some indication of the relative importance of the shocks on average, but if large movements in some types of shocks are irregular and clustered together, then they may have a much bigger effect at those points in time than the variance decomposition would indicate.

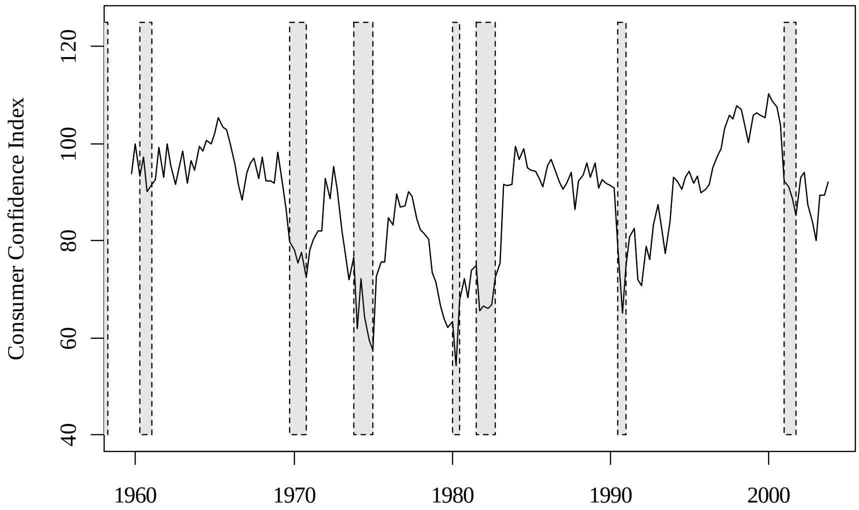

Figure 7: United States Consumer Confidence 1959-2003. Business cycle turning points are given by the vertical dashed lines, with grey areas representing recessions.

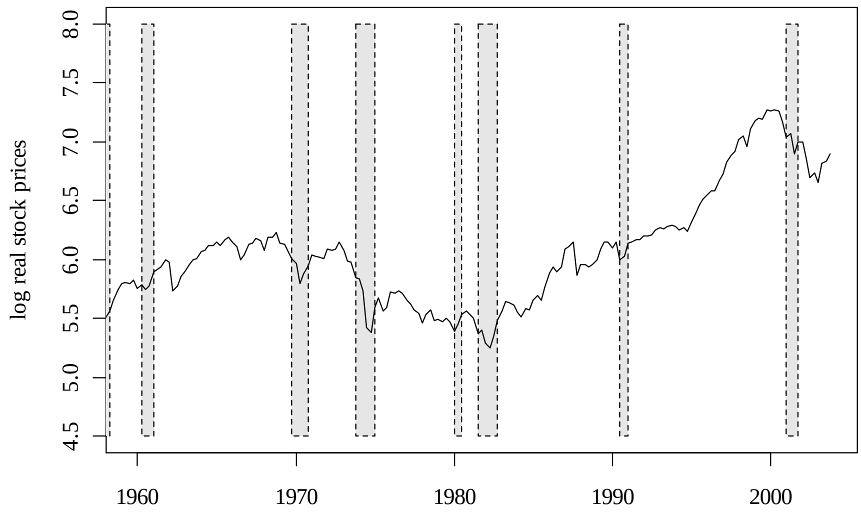

Figure 8: Real Standard and Poors 500 Stock Index 1959-2003. Business cycle turning points are given by the vertical dashed lines, with grey areas representing recessions.

This irregularity and clustering is an important feature of both confidence and stock price shocks. As shown in figure 7, confidence oscillates in a relatively small range until it makes a large movement to a new level, and it is at these points that it may have a large influence on the business cycle. Stock prices, shown in figure 8, can also exhibit very large movements at irregular intervals, for example, from the mid 1990s through to the early 2000s. The next section decomposes US GNP from 1961-2003 to determine the relative influence of the various shocks in the six recessions and six completed expansions in the period.

5.2 Decomposition of the US business cycle 1961-2003

As noted in the variance decomposition section above, the structural model can be expressed in vector moving average (VMA) form. To decompose the series in the system, $z_t = [\Delta y_t, \Delta i_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t), cl_t, \Delta sp_t]'$, into parts attributable to the separate shocks we separate the moving average representation (18) into components. Each component, z_{it}, is given by:

$$z_{kt} = \sum_{j=0}^{t} C_j \epsilon_{kt-j} \tag{22}$$

where z_{kt} is the part of z_t due to the k^{th} shock and ϵ_{kt-j} is an $(n \times 1)$ vector of errors with zero elements in all rows except the k^{th} in the time period $t = t - j$. Note that:

$$z_t = \sum_{k=1}^{n} z_{kt} \tag{23}$$

Figure 9 shows a decomposition of GNP into the components of the GNP moving average due to each of the structural shocks. The plots show the effect that each of the shocks has on the level of GNP in percentage points. As a positive constant has already been extracted from the GNP growth rate, the effects of these shocks on the GNP level are around a drift in the GNP level equal to quarterly growth of 0.8%. The dotted vertical lines represent the turning points (peaks and troughs) in the business cycle with periods of recession shaded in grey.

The plots reveal a number of notable features in the role of these six separately identified influences on the US business cycle over the last 40 years. First is the important effect during the long 1960s expansion, of a strong series of positive supply shocks in the early to mid 1960s, which increased the level of GNP by around ten percent. The negative supply shocks caused by the OPEC-driven oil price increases in the 1970s are also visible during the 1974:1-1975:1 recession and before the 1980:3-1981:3 recession.

Money supply shocks were small up until the 1970s but appear to have played a role in a number of expansions and contractions since then. Monetary policy tightening appears to have had a clear role in the recessions in the mid 1970s and early 1980s. Money demand shocks also had significant influence on the business cycle in the late 1970s and in the 1980:3-1981:3 recession, where money demand shocks lifted the level of GNP by 1% in the 1970s and then reversed, with money demand becoming a negative influence of around 3% on the GNP level by 1982.

In contrast to supply shocks, IS shocks were relatively muted up until the end of the 1970s, but have had a more important role since then, with a clearly visible effect in all the expansions since the end of 1970. Negative consumer confidence shocks had a clear influence on recessions in the early 1970s, the second recession in the early 1980s and the 1990s recession. Confidence has contributed, mainly positively, to expansions, except in the 1970s when its negative influence tended to lessen during expansions.

Finally, real stock prices were a positive influence on GNP in the 1960s, but then became a negative influence until the mid 1990s. This is consistent with the very favorable supply-side shocks experienced in the US in the 1960s and the subsequent difficulties in the 1970s and 1980s, which would have influenced earnings expectations significantly positively and then negatively. The largest effect of stock price shocks on GNP occurred in the late 1990s and into the early 2000s, when stock

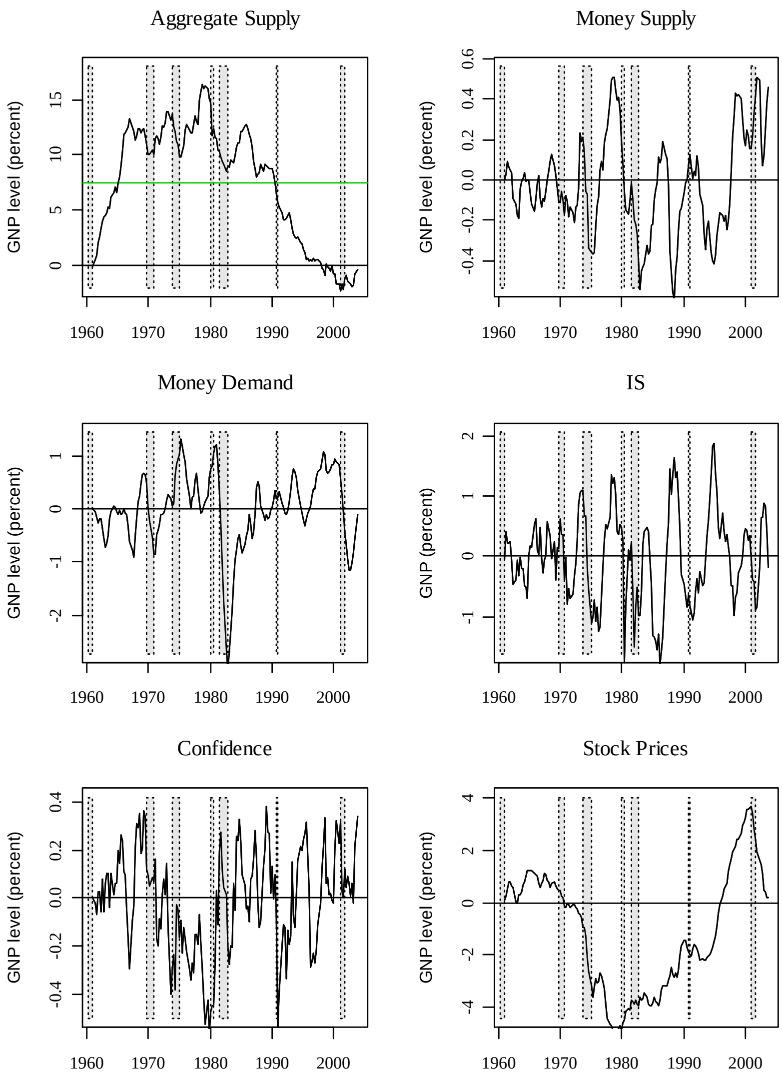

Figure 9: Decomposition of GNP into components due to each shock. The dotted vertical lines represent the turning points (peaks and troughs) in the business cycle with periods of recession shaded in grey.

prices were at first a large positive influence on GNP, but later reversed with the bursting of the US stock market bubble.

The plots show that while all shocks have had at least some influence on the cycle, and that expansions and contractions have had a number of causes, it is also important to know the relative importance of each shock. The table below gives the proportion of total GNP change due to each of the shocks arising in each of the six recessions and six expansions from 1961-2001 as dated by the NBER. They show that confidence and stock prices have had a much more important influence on the US business cycle at some points in time than the variance decomposition results indicated.

Table 10: Proportion of GNP growth due to structural shocks 1961-2001

Period	Rec/Exp	AS	MS	MD	IS	CL	SP
1961:2-1969:4	E	0.45	0.04	0.11	0.21	0.07	0.12
1970:1-1970:4	R	0.33	0.03	0.23	0.27	0.02	0.11
1971:1-1973:4	E	0.45	0.05	0.09	0.22	0.10	0.09
1974:1-1974:4	R	0.36	0.05	0.09	0.21	0.07	0.22
1975:1-1980:1	E	0.42	0.05	0.13	0.19	0.06	0.15
1980:2-1980:3	R	0.53	0.04	0.04	0.33	0.00	0.06
1980:4-1981:3	E	0.28	0.04	0.14	0.31	0.12	0.11
1981:4-1982:4	R	0.21	0.04	0.32	0.31	0.05	0.06
1983:1-1990:3	E	0.31	0.06	0.16	0.27	0.08	0.13
1990:4-1991:1	R	0.55	0.04	0.05	0.11	0.19	0.08
1991:2-2001:1	E	0.33	0.06	0.11	0.24	0.10	0.16
2001:2-2001:4	R	0.39	0.04	0.16	0.14	0.07	0.20

The variance decomposition results at horizons up to two years suggested that stock price shocks were responsible for around 5-10% of the total forecast error in GNP. However, in the late 1990s and in the subsequent 2001 recession, stock prices had a more important role in the US business cycle. Stock price shocks were responsible for 16% of the total movement of GNP in the 1991:2-2001:1 expansion. They had an important role in the subsequent 2001 recession, producing 20% of the movement in GNP. This important role is due to the large size of the 1990s stock price bubble and subsequent crash. The price earnings multiple reached a peak of 43 in 2000 compared to 24 in 1966, 32 in 1929 and 24 in 1901 and an average over 1881-2004 of 16. Stock prices fell nowhere near as far as in the 1929 crash, but the fall in 2000-2001 was still significant, with the real S&P 500 index falling 24% from August 2000 to November 2001. While stock prices may not always be an important influence on the business cycle, it is occasions such as the 1990s bubble that suggest that, at irregular intervals, they can become a key influence.

Consumer confidence shocks have in the past often had a more important influence on the business cycle than the variance decomposition results would suggest. The strongest role of confidence was in the early 1990s recession where 19% of the total movement in GNP due to shocks was due to confidence shocks. Confidence has been identified in the literature (see Blanchard,1993) as being a potentially important influence on the early 1990s recession, but confidence has also had a significant influence (10% and over) on a number of other phases of the cycle including the early expansion in the 1970s and 1980s and in the 1990s. This stronger historical influence than the variance decomposition might suggest arises from the clustering of large movements in confidence at certain points in time.

While it appears that confidence shocks have had a significant effect on the US business cycle historically, another key issue, which has been a central focus of the consumer confidence literature, is whether confidence assists in forecasting US output. In the next section I conduct an out-of-sample forecasting exercise to examine this question.

6 Do confidence and stock prices help forecast US GNP?

Forecasting output and, more particularly, the turning points in the business cycle is a difficult exercise, because as the historical decomposition shows, the switches from one phase (expansion/contraction) to another occurs due to a combination of shocks that vary in type and relative strength over time.

A key question in the empirical literature has been whether confidence data provides incremental predictive information beyond that contained in other macroeconomic variables considered determinants of consumption and total output. The underlying question is whether confidence is an independent cause of fluctuations in the economy or whether it just forecasts future economic activity using various economic indicators and is not a separate cause. The approach of most of the literature is to add lags of consumer confidence to a model explaining consumption or GDP or probability of recession with a variety of controls such as lags of the dependent variable, interest rates and stock prices. The latter two are particularly popular controls because they have been shown to be useful in predicting output (see Estrella and Mishkin, 1998) and are available at high frequency. The aim of most exercises is to test for Granger-causality from confidence to consumption or output. This approach focuses on the average effect of lagged confidence on consumption.

The main finding for the United States is that there is, on average, a small amount of significant predictive information in confidence for consumption spending and total output (see Carroll, Fuhrer and Wilcox, 1994; Kumar, Leone, Gaskins, 1995; Howey, 2001; Ludvigson, 2004; and Slacalek, 2004) Matsusaka and Sbordonne (1995) and Howrey (2001) show that confidence contains incremental predictive information about GNP and the probability of recession respectively. However there are some contrary findings. Chopin and Durrat (2000), Ivanova and Lahiri (2001) and Mehra and Martin (2003) find there is on average no significant incremental predictive information in confidence for consumption spending. These conflicting results most likely arise from using different sample periods, data frequency and components of both consumption and the two main consumer confidence series, the Conference Board and University of Michigan series.

Overall, the evidence from the United States suggests that consumer confidence data does contain some incremental predictive information about consumption and total output, and therefore that it may be an independent source of fluctuations in the U.S. economy. The finding in the literature of a small size for this effect may arise because confidence does not always play a role in fluctuations and that some potentially important predictive information is being averaged with small noisy movements in confidence that have no information content.

In this section I conduct an out-of-sample forecasting exercise with all four models discussed above and compare these to forecasting with an AR(2). The AR(2) was estimated using the general to specific estimation strategy, dropping lags until the last one is significant at the 5% level. The issue is whether confidence and stock prices provide additional information in predicting output beyond that contained in output itself and other key variables such as interest rates. Given that stock prices and confidence shocks have been a significant influence on the business cycle, at least at some points in time, it is expected they will provide some additional assistance in forecasting output.

The forecasts are one quarter ahead out-of-sample forecasts of Δy_t over the period 1979:1-2003:4. All reduced form equations are estimated from 1959:4-1978:4 and a forecast is constructed for 1979:1. The equations are then re-estimated from 1959:1-1979:1 and forecasts are constructed for 1979:2, and so on. Forecasting is done with the reduced form equations, as it is not necessary to identify particular structural shocks in a forecasting exercise because we are interested in $e_t = \Delta y_t - E_{t-1}\Delta y_t$, the one step ahead forecast errors for the growth rate of GNP. The forecasts are assessed using the root mean square error (RMSE)[1] over different forecast periods.

Interest in the business cycle and forecasts of future growth is usually at its highest during extremes of the cycle around recessions and periods of very high growth (booms). Confidence has previously been found to be significant in forecasting recessions, so the RMSE is calculated separately for these events in the out-of-sample forecast period. Recessions, as dated by the NBER, occur in 1980:2-1980:3, 1981:4-1982:4, 1990:4-1991:1 and 2001:1-2001:4. Booms are defined as periods when there are two or more quarters where quarterly GNP growth exceeds 1.1% (the upper quartile for the period 1979:1-2003:4). These high growth quarters must be consecutive, or separated by no more than one quarter where growth is below the 1.1% threshold. The boom periods occur in 1980:4-1981:3, 1983:1-1984:2, 1987:4-1988:4, 1994:1-1994:4, 1996:2-1997:3, 1999:4-2000:2 and 2003:3-2003:4.

[1]
$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(\Delta y_t - E_{t-1}\Delta y_t)^2}$$

The results are summarised in table 11 below, which gives the ratio of the RMSE for the forecast from the various models to the RMSE from the original Gali model. Columns 1 to 4 contain results from an AR(2) and autoregressive distributed lag models (ARDL) with 2 lags of confidence and 2 lags of GNP (column 2) and so on. Columns 5 to 8 contain results from the four VARs described earlier. An AR(2) of US GNP is estimated and compared to other models to determine the effect of additional information beyond that contained in the series itself. In the forecasting exercise only 2 lags of each variable are used so that the effect of adding variables can be identified separately from increasing the lag order to four.

Table 11: Out-of-sample forecast performance RMSE Model/RMSE Gali

	1	2	3	4	5	6	7	8
Model	AR(2)	Δy_t & cl_t	Δy_t & Δsp_t	Δy_t, Δsp_t & cl_t	Gali	Conf.	S.P.	Conf. & S.P
1979:1-2003:4	0.87	0.83	0.84	0.86	1	0.98	0.97	0.98
1979:1-1983:4	1.21	1.10	0.94	1	1	1.03	0.94	0.98
1984:1-1989:4	0.40	0.45	1.06	0.64	1	0.96	1.06	1.05
1990:1-1994:4	0.76	0.78	0.96	0.69	1	0.95	0.96	0.91
1995:1-1999:4	0.71	0.73	0.91	0.83	1	0.86	0.91	0.87
2000:1-2003:4	0.99	1.10	0.88	0.97	1	1.08	0.88	0.96
recessions	1.14	0.98	1	0.88	1	0.98	0.81	0.78
booms	1.08	1.03	1	1.05	1	0.98	1.12	1.21

Over the whole out-of-sample forecast period, the AR(2) has a better forecast performance than the VAR models. However, confidence does contain additional information that improves out-of-sample forecast performance. This can be seen by comparing the AR(2) results with the $\Delta y_t, cl_t$ column. If two lags of confidence, $cl_{t,}$ are added to the AR(2) the RMSE falls from 87% to 83% of the Gali model's RMSE over the whole period. Comparing the confidence and Gali columns shows that adding confidence to the Gali VAR model, which has a number of controls including real interest rates and the real money supply, also lowers the RMSE over the whole period.

When stock prices and stock prices and confidence are added to the AR(2) (columns 3 and 4 respectively) there is a small improvement in forecast performance over the whole sample. The stock price and confidence and stock price models also show a small improvement over the Gali model if compared over the whole forecast period. During recession periods, when there is intense interest in the business cycle from economists and policy makers, adding confidence, stock prices and stock prices and confidence to the Gali model and the AR(2) leads to lower RMSEs. This is particularly the case for the VAR models including stock prices. During booms, also periods of heightened interest in the business cycle, adding confidence improves the forecasts compared to the

Gali model and the AR(2). Adding stock prices or stock prices and confidence together improves the forecast compared to an AR(2), but worsens performance compared to the Gali model during boom periods.

The significance of these changes in forecast performance are tested using the test proposed by Diebold and Mariano (1995). The null hypothesis given by (24) of equal expected forecasting performance is tested against the alternative of different forecasting ability Forecasting performance is measured as a function of the forecast errors, e_t, from the model. In this exercise the mean squared error is used.

$$d_t = E[mse_t^x - mse_t^y) = 0 \tag{24}$$

where mse_t^x is the out-of-sample mean squared error for model x.

The Diebold-Mariano test statistic is given by:

$$DM = \frac{\overline{d}}{\sqrt{\widehat{V}\left(\overline{d}\right)}} \tag{25}$$

where

$$\overline{d} = \frac{1}{n}\sum_{t=m+h}^{m+n} d_t \tag{26}$$

and m is the number of observations in the estimation sample, n is the total number of periods that are forecast and h is the number of steps ahead the forecast is for. The variance, $\widehat{V}\left(\overline{d}\right)$, is given by:

$$\widehat{V}\left(\overline{d}\right) = \frac{1}{n}(\widehat{\gamma}_0 + 2\sum_{k=1}^{h-1}\widehat{\gamma}_k) \tag{27}$$

where

$$\widehat{\gamma}_k = \frac{1}{n}\sum_{t=k+1}^{n}(d_t - \overline{d})(d_{t-k} - \overline{d}) \tag{28}$$

The test statistic, DM, is normally distributed under the null hypothesis of equal forecast accuracy. The results from the Diebold Mariano tests are shown in table 12. The tests are made between the AR(2) and ARDL models that contain lags of output and one or both of confidence and stock prices (columns 1-3 of table 12) and between the Gali VAR and the VARs containing confidence and/or stock prices (columns (4 to 6)). A positive test statistic indicates that the model including confidence and/or stock prices is better than the benchmark AR(2) or Gali model and vice versa. The tests that are significant at the 5 and 10 percent levels level are marked by asterixes. Despite the fall in the RMSE seen in table 11 when confidence and/or stock prices are added to the benchmark models (AR(2) and Gali), the tests show that over the whole forecast period the difference is not statistically significant.

Table 12: Diebold Mariano Tests

	Model vs AR(2)			Model vs Gali		
Model	Δy_t & cl_t	Δy_t & Δsp_t	Δy_t, Δsp_t & cl_t	Conf.	S.P.	Conf. & S.P
	1	2	3	4	5	6
1979:1-2003:4	0.59	0.89	0.24	1.01	0.71	0.46
1979:1-1983:4	1.68(*)	1.43	3.22(**)	-0.99	0.76	0.24
1984:1-1989:4	-1	-3.68(**)	-2.38(**)	2.62(**)	-0.91	-0.70
1990:1-1994:4	-0.20	-1.12	-0.99	0.95	1.52	1.71(*)
1995:1-1999:4	-0.28	-2.34(**)	-1.45	1.94(*)	1.13	1.20
2000:1-2003:4	-1.24	0.97	0.32	-0.99	1.10	0.36
recessions	2.38(**)	2.25(**)	2.5(**)	0.54	1.95(*)	2.28(**)
booms	0.44	0.60	0.2	0.35	-1.54	-1.42

(*) indicates significance at the 10% level

(**) indicates significance at the 5% level

There are some periods when adding confidence and/or stock prices does result in a statistically significant increase in forecasting performance. This is particularly the case during recession periods.

Because the type and intensity of shocks varies over time, the usefulness of variables in forecasting will also vary. This suggests caution in dismissing an indicator or model because it has not improved forecast performance in the past. For example, while the forecasts from models that only add stock prices to the benchmark models are not always the best predictor of output growth, on the basis of the RMSE they do out-perform all other forecasts in the 2000:1-2003:4 period when stock price shocks were having a large influence on the business cycle.

Overall, adding confidence and/or stock prices to the benchmark models leads to a fall in the RMSE over the whole out-of-sample period, but this is not statistically significant. However, confidence and stock prices do seem to provide significant incremental predictive information during recessions, when interest in the business cycle is normally high. This is consistent with Estrella and Mishkin (1998), who found that stock prices were useful in predicting the probability of recession.

7 Conclusion

The results in this paper show that adding consumer confidence and stock prices to a small SVAR model of the US economy has important effects on the dynamic response of the US economy. A positive shock to consumer confidence of 4 index points will temporarily increase the level of GNP by 0.14% and it is not uncommon for confidence shocks to total a net of 20 points in one direction in a few consecutive quarters. Stock prices also have an effect on the business cycle with a 7% shock leading to a permanent 0.5% increase in the level of GNP. Adding confidence and stock prices to the model also provides two further channels through which other shocks can affect the economy. MS and IS shocks have a more moderate influence on the business cycle with the confidence and stock price/wealth channels operating, while the effect of AS and MD shocks are more exaggerated.

Although the variance decomposition analysis reveals that shocks to confidence and stock prices explain a maximum of 1.2% and 16% respectively of the forecast error variance of GNP, a historical decomposition of US GNP shows that at certain times the influence of confidence and stock prices has been larger. Confidence shocks were responsible for 19% of the total effect of structural shocks on GNP growth in the early 1990s recession, and the proportion of total shocks to GNP attributable to confidence has often been close to or above 10% in various phases of the US business cycle between 1961 and 2001. Stock prices have also been somewhat more important than the variance decomposition would suggest, especially in the mid 1970s recession and in the late 1990s and early 2000s at the time of the stock-price bubble. The more important historical influence of these shocks has arisen because large shocks to consumer confidence and stock prices often cluster in irregular short periods, and this leads to a greater effect on GNP than an experiment where the shocks to these variables is the same in every period, as is the case with the variance decomposition.

The out-of-sample forecasting exercise shows that on the basis of the RMSE over the whole forecast period, 1979:1- 2003:4, the addition of confidence and/or stock prices to the Gali model and AR(2) models leads to a small, but not statistically significant improvement in forecasting performance. However, both confidence and stock prices do appear to contain significant incremental predictive information during recession periods, when there is heightened interest of policy makers in the business cycle. Finally, the relative forecasting performance of the various models/methods varies across time depending on the relative importance of various shocks. This indicates that a variable's importance for forecasting cannot be dismissed on the basis of one historical period.

Overall, the above analysis provides evidence that both consumer confidence and stock prices have an important role in the United States business cycle, especially at times when a cluster of large shocks to either of them occurs.

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A Unit Root Tests

This appendix summarises unit root tests on the main variables in the model, $\Delta y_t, \Delta i_t, (i_t - \Delta p_t), (\Delta m_t - \Delta p_t), cl_t, \Delta sp_t$. Augmented Dickey Fuller (ADF) tests suggest that all series are I(0).

The general form of the ADF test is given by:

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_2 t + \sum_{i=2}^{j} \beta_i \Delta y_{t-i+1} + \varepsilon_t \tag{29}$$

The final form of the test equation is selected using the general to specific method. The lag length is selected by reducing the number of lags from a maximum of five until the longest lag is significant at the 5% level using the usual t-test. The deterministic regressors are included if their coefficients are significant at the 5% level using the critical values provided by Enders (1997) for testing these coefficients in the presence of a unit root. Once the final form of the test equation is determined the null hypothesis of a unit root ($\gamma = 0$) is tested using the Dickey Fuller critical values appropriate for that functional form. If γ is significantly different from zero at the 5% level we conclude there is no unit root, i.e. the series is stationary or I(0).

Augmented Dickey Fuller Unit Root Tests								
Variable	α_0	γ	α_2	β_1	β_2	β_3	β_4	β_5
Δy_t	0.05	-0.68						
t statistic	6.54(*)	-10.15(*)						
Δi_t		-1.04						
t statistic		-14.83(*)						
$(i_t - \Delta p_t)$		-0.14						
t statistic		-2.65(*)						
$(\Delta m_t - \Delta p_t)$		-0.38(*)		-0.21	-0.08	0.18		
t statistic		-4.96(*)		-2.6(*)	-1	-2.4(*)		
cl_t	8.27	-0.09						
t statistic	3.12(*)	-3.14(*)						
Δsp_t		-0.90						
t statistic		-11.93(*)						

(*) indicates significance at the 5% level, critical values vary depending on the coefficient being tested and the functional form.

B Data Description and Sources

Name	Symbol	Description	Source
GNP	y	Log of real seasonally adjusted chain-linked GNP at 2000 prices	Bureau of Economic Analysis Table 1.7.6
Interest Rate	i	Yield on 3 month Treasury Bills	1959:4-2000:2 Federal Reserve, 2000:3-2003:4 U.S. Treasury
Price Level	p	Log of the seasonally adjusted Consumer Price Index	U.S. Department of Labor: Bureau of Labor Statistics
Money Supply	m	log of the M1 money supply	Federal Reserve, Rasche (1987)
Confidence	cl	University of Michigan overall Index of Consumer Sentiment	University of Michigan Survey Research Centre
Stock Prices	sp	Log of the Real Standard and Poors 500 Index of U.S. stock prices (Nominal SP Index deflated by the CPI)	Professor Robert Schiller www.econ.yale.edu