The Dynamic Adjustments of Stock Prices to Monetary Shocks

Victor Valcarcel
Texas Tech University

July 2010

Abstract

While asset valuations are mainly determined by the financial health and other characteristics of individual firms, fluctuations in general economic conditions are also a principal determinant of stock prices. The U.S. economy has seen a remarkable moderation in aggregate activity and inflation since the 1980s, however, volatility in stock market returns has remained unabated. Whatever the causes of this moderation, any econometric technique that attempts to measure the contribution made by the usual suspect shocks on economic and financial variables should address the possibility of time variation in the underlying drifts and volatilities of the system. In this paper, I use recent developments in the estimation of structural vector autoregressions in the presence of stochastic volatility (TV-SVAR) to analyze the effects of money supply, productivity and idiosyncratic stock market shocks on the real value of a broad index of US stock prices as well as aggregate economic activity and inflation. This construct allows us to measure how the relative contributions of these shocks have been changing over time since the 1960s. This model indicates that the dynamics of the system seem to be mostly driven by heteroskedastic shocks rather than drifting coefficients in the VAR. Estimates imply a relatively time-invariant relationship between these variables. What has likely changed is their relationship relative to their own volatilities and the size of the structural shocks. Results suggest that the empirical irregularity of the negative stock return-inflation relationship disappears when allowing for time variation in the structural model. Finally, monetary policy seems to have an important expansionary effect on short-run movements in stock prices, however, it is really fluctuations in productivity and stock market conditions that constitute the most important determinants of low-frequency movements in equity returns.

JEL Classification: E44, E50, G12

Keywords: Real stock prices; The Great Moderation; stochastic volatility; Markov Chain Monte Carlo, structural vector autoregressions; parameter instability, structural change.
1. Introduction

While asset valuations are mainly determined by the financial health and other characteristics of individual firms, fluctuations in general economic conditions are also a principal determinant of stock prices. If these valuations reflect the real return of holding these assets, then from money neutrality it follows that real stock prices should not be affected by monetary policy in the long run. While the view that monetary policy and inflation have little long-run impact on real stock returns is widely held, it is also generally agreed that stock prices can be sensitive to monetary policy in the short and medium terms (Rapach 2001 and He 2006). Theoretical finance models typically advocate a positive short-run response in stock prices following a monetary expansion. The Gordon Growth model, for example, shows that stock prices are directly related to current and expected growth rates of dividend returns and inversely related to the required rate of return on the equity. Thus, in this setting, a monetary expansion exerts a positive impact on stock prices through two channels: One, if the Fed monetary easing stimulates the economy, it would likely have a positive impact on the growth rate of dividends. Two, a monetary expansion that depresses bond returns would see an increased demand for equities which would lead the average investor to lower expected rate of returns of equities. Increased dividend returns and decreased expected returns on investment (ROI) both serve to put upward pressures on stock prices. However, historical evidence points to a negative correlation between real stock returns and inflation. A number of explanations have been advanced to account for this irregularity. One is that, in the presence of sustained inflation, agents discount asset valuations at an artificially high rate because such environment makes it difficult to distinguish between real and nominal returns when the latter includes an inflation premium (Modigliani and Cohn 1979). Feldstein (1980) posits that sustained increases
inflation puts downward pressures on real stock prices because the tax code exerts a distortionary effect between depreciation costs and capital gains. This observed negative relationship between inflation and stock returns is dismissed as spurious by Fama (1981). According to his version of the proxy-effect hypothesis (PEH) this negative correlation is induced by a positive relationship between stock returns and expected economic activity (as proxied by inflation) and an inverse relationship between expected economic activity and inflation. Another explanation for this empirical irregularity could be attributed to the mismanagement of monetary policy in the 60s and 70s when under the premise of an exploitable trade-off between inflation and unemployment, the Federal Reserve gives into the temptation to inflate until time-consistent inflation rates were reached (Sargent 1999, Cogley and Sargent 2001). The ensuing higher expectations of inflation would increase long-term rates leading investors to more aggressively discount future dividends. On the other hand the subsequent contractionary actions by the central bank could have also contributed to lower stock returns because these monetary policy actions would tend to slow down economic activity and thus depress current and expected future earnings. While there is strong evidence that stock prices are sensitive to monetary policy and price fluctuations, it is likely these sensitivities are not stable over time. Under different model constructs, Durham (2003) and He (2006) report results that suggest the relationship between monetary policy and stock market returns may be time-varying. Postwar inflation in the U.S. is not well-characterized by constant or smooth volatility. In fact there is abundant empirical evidence of a substantial decline in the volatility of most U.S. macroeconomic aggregates. Most explanations of this volatility reduction fall under two main categories. One view is that there might have been structural changes in the transmission mechanism due to shifts in the views or tools held by the monetary policy authority. This would attribute the lower volatility levels to a “good management” (or at least
better since the late 70s early 80s) of the economy by the Federal Reserve. A second view proposes that there has been a reduction in the underlying heteroskedasticity of the exogenous shocks themselves. This has been dubbed as the “good luck” explanation suggesting that the nature of negative supply shocks has been intrinsically ameliorated since the 80s. Neither explanation can be broached by a traditional structural vector autoregression (SVAR) approach that assumes constant autoregressive coefficients (this rules out the first explanation) or homoskedastic structural shocks based on a constant variance-covariance matrix of the VAR (which would rule out the second explanation). This substantial decrease in the volatilities of major aggregates is not an isolated phenomenon for the U.S. but it has been experienced by other industrialized economies (Summers 2005) and, thus, it has been dubbed The Great Moderation. The corollary of this phenomenon is the “bad policy vs. bad luck” debate that arises when attempting to explain the U.S. stagflation outcomes of the 1970s. Explanations to account for the high volatility in inflation in the 1970s and subsequent reduction hence can range from the bad/good policy as in (Clarida et.al 2000), Cogley and Sargent (CS 2001, 2005) and Summers (2005); adverse/beneficial [underlying heterogeneity in] exogenous supply shocks as in Sims (1999) and Bernanke and Mihov (BM 1998); and improvements in inventory management as in McConnel and Perez-Quiros (MPQ 2000). Whatever the cause, any econometric technique that attempts to quantify the effects of monetary and technology shocks on economic aggregates should address the possibility of time variation in the underlying drifts and volatilities of the system. Table 1 shows standard deviations in the growth of the U.S. postwar GDP, various measures of inflation, and S&P500 composite index. The year generally associated with the structural break in volatility of economic activity is 1984 (MPQ 2000). The table shows that the standard deviation for the post-1984 period is about half that of the earlier period. Measures of the growth of inflation built from the GDP deflator and core CPI see similar decreases in the
latter part of the sample. Measures from the CPI and PCE deflator see a smaller reduction in the post-1984 period. As the third and fourth columns point out, relative to the growth of stock prices, which experience no such decrease, the volatility in the growth of inflation and aggregate economic activity has in most cases substantially reduced since 1984. Given that real stock prices do not seem to exhibit reduction in volatility commensurate with that of the other aggregates it is possible that the underlying relationship between the drift and / or correlations of these variables changes over time.

In this paper, I use recent developments in the estimation of SVAR modeling in the presence of stochastic volatility to analyze the effects of money supply and productivity shocks on the real value of a broad index of U.S. stock prices. The primary objective here is to measure the contribution made by these important macroeconomic shocks to real stock price fluctuations and more importantly, how these relative contributions have been changing over time since the 1960s. The rest of the paper is structured as follows: Section 2 delineates the time-varying volatility construct in the econometric technique, describes the identification strategy and outlines the procedures to carry out innovation analysis. Section 3 presents evidence from a trivariate time-varying VAR of the U.S. postwar data on the growths of output, inflation and stock prices and discusses implications from the time-varying impulse response functions and variance decomposition. Section 4 concludes.
2. The Time-Varying SVAR Model

This section describes a benchmark empirical model consisting of a SVAR with autoregressive coefficients and covariance matrix that are both time-varying. The construct of the time-varying structural vector autoregression (TV-SVAR) follows closely those of Cogley and Sargent (2001, 2005), Primiceri (2005) and Gali et al. (2009). Consider the following covariance stationary VAR process

$$\theta_t(L)x_t = e_t$$  \hspace{1cm} (1.1)

where \(x_t\) is an n-vector of I(0) endogenous (time t) variables; \(\theta_t(L) = \theta_{0t} - \theta_{1t}L - ... - \theta_{pt}L^p\) is a p-th order lag polynomial where \(\theta_{0t} = I_n\) and each \(\theta\) is a matrix of time-varying coefficients; and \(e_t\) is an n-vector of mean-zero VAR innovations with the time-varying covariance matrix \(R_t\).

Thus \(\theta_t\) encompasses all histories of the VAR parameters from 1 to the end of sample T. These autoregressive coefficients evolve according to

$$\theta_t = \theta_{t-1} + u_t$$  \hspace{1cm} (1.2)

where \(u_t \sim iid(0,Q)\) is a Gaussian white noise process with zero mean and constant covariance \(Q\) and independent of \(e_t\) at all leads and lags. I follow a variant of Jaquier et al. (1994) stochastic volatility construct to allow for time variation in the underlying VAR model of (1.1).

Let \(E(e_t'e_t) \equiv R_t = F_tH_tF_t'\) where \(F\) is given by

\[
F_t = \begin{pmatrix}
1 & 0 & ... & 0 \\
\vdots & 1 & ... & \vdots \\
\vdots & \vdots & ... & \vdots \\
f_{nt} & ... & f_{nn-1t} & 1
\end{pmatrix}
\]

and \(H_t = \begin{pmatrix}
h_{1t} & 0 & ... & 0 \\
0 & h_{2t} & ... & \vdots \\
\vdots & \vdots & ... & \vdots \\
0 & ... & 0 & h_{nt}
\end{pmatrix}\)

The diagonal elements of \(H_t\) are independent univariate stochastic processes that evolve according to the following:

$$\ln h_{jt} = \ln h_{jt-1} + \xi_t \hspace{1cm} \forall j = 1,2,...,n$$  \hspace{1cm} (1.3)
Stacking all the off-diagonal elements of $F_t^{-1}$ into a vector $\gamma_t$, I further assume that this vector evolves according to the following drift-less geometric random walk

$$\gamma_t = \gamma_{t-1} + \xi_t$$

(1.4)

Where both $\xi_t \sim iid(0, \Xi)$ and $\zeta_t \sim iid(0, \Psi)$. The covariance matrix $\Psi$ is assumed to be block-diagonal to prevent non-zero covariance of the coefficients among different equations. Finally innovations of the VAR and the state equation ($u_t$, $\xi_t$ and $\zeta_t$) are assumed to be mutually independent.

The moving average representation (MAR) for $x_t$ as a function of the VAR innovations is obtained by inverting (1.1) as follows

$$x_t = \phi(L)e_t = \sum_{s=0}^{\infty} \phi_s L^s e_t$$

(1.5)

Following Gali et.al (2009) I assume that the innovations $e_t$ of the reduced -form VAR vector are a time-varying transformation of the underlying structural shocks in the economy $\varepsilon_t$ as follows

$$e_t = P_t \varepsilon_t \quad \forall t$$

(1.6)

Where $P_t$ is a nonsingular matrix that satisfies $P_t P_t' = R_t$. Given this mapping scheme, changes in the contributions of different structural shocks to the volatility in innovations in the underlying variables of interest are captured by changes in $P_t$. In order to identify the structural shocks and make structural inferences from the data, $P_t$ needs to be identified. It is generally agreed that highly plausible and economically tractable dynamics can often derived by imposing long-run restrictions in a VAR setting (Keating 1992). Therefore, I employ a Blanchard and Quah (1989) -type decomposition as an identification strategy based on tractable and
uncontroversial long-run theoretical predictions. In the next section I estimate the model described by (1.1)-(1.6) with \( x_t = (\Delta y_t, \Delta s_t, \Delta p_t)' \) where \( y_t \) is real output, \( s_t \) is the real price of stocks, and \( p_t \) is (different measures of) the price level. All variables enter the system in log-differences.

The underlying structural shocks to this economy \( \varepsilon_t = \{ \varepsilon_{t}^{AS}, \varepsilon_{t}^{PO}, \varepsilon_{t}^{MP} \} \) which consist of an aggregate supply, portfolio and monetary policy shocks are identified according to

\[
\lim_{k \to \infty} \begin{pmatrix} \Delta y_{t+k} \\ \Delta s_{t+k} \\ \Delta p_{t+k} \end{pmatrix} = P_t * \varepsilon_t = \begin{pmatrix} p_{11,t} & 0 & 0 \\ p_{21,t} & p_{22,t} & 0 \\ p_{31,t} & p_{32,t} & p_{33,t} \end{pmatrix} \begin{pmatrix} \varepsilon_{t}^{AS} \\ \varepsilon_{t}^{PO} \\ \varepsilon_{t}^{MP} \end{pmatrix} \tag{1.7}
\]

where the matrix of time-varying long-run multipliers \( P_t \) is identified by the imposition of two long-run restrictions consistent with two well-documented economic hypotheses: one is long-run neutrality and the other is the natural rate hypothesis. The first one obtains from setting \( p_{13,t} = p_{23,t} = 0 \) which implies that permanent exogenous changes to monetary policy have no long-run effect on real variables like output or real stock returns. This long-run structure does allow for monetary shocks to affect inflation in the long-run. The second theory stems from setting \( p_{21,t} = 0 \) which implies that unanticipated exogenous portfolio shocks do not affect output in the long-run. This is assumed to be a “pure” portfolio shock that represents an exogenous disturbance to the demand for stocks which could result from a shock to transaction costs in the stock market (Tobin 1969), or an exogenous “equity-premium” shock that alters the perceived riskiness of stocks. This restriction (along with \( p_{13,t} = 0 \)) connote that only aggregate supply shocks like technology or oil prices that disturb the natural rate of output will have an impact in the long-run level of real output. Both long-run neutrality and the natural rate hypothesis are uncontroversial features of mainstream macro-monetary models. The restrictions
imposed in (1.7) allow us to recover the matrix $P_t$ from estimation of the reduced VAR model (1.1).

The companion form of (1.1) is given by

$$X_t = \Theta_t X_{t-1} + e_t$$  \hspace{1cm} (1.8)

where $X_t \equiv [x'_t, x'_{t-1}, \ldots, x'_{t-p+1}]$, $e_t \equiv [e'_{t}, 0, 0, \ldots, 0]$ and $\Theta_t \equiv \begin{bmatrix} \theta_{1t} & \theta_{2t} & \theta_{3t} & \ldots & \theta_{pt} \\ 1 & 0 & \ldots & 0 \\ 0 & \ddots & \ddots & \ddots \\ 0 & \ldots & 1 & 0 \end{bmatrix}$.

I follow Gali and Gambetti (2009) in the time-varying implementation of the Blanchard & Quah (1989) decomposition. Consider the following k-ahead dynamic multiplier of (1.8)

$$\frac{\partial X_{t+k}}{\partial e'_t} = s_{3,3}(\Theta_t^k) \hspace{1cm} \forall k = 1,2,\ldots \hspace{1cm} (1.9)$$

Where $s_{3,3}$ is a selector function that picks the first three rows and three columns of (in this case) matrix $\Theta_t^k$. An application of the chain rule along with (1.6) and (1.9) renders the following k-period horizon structural impulse response

$$\frac{\partial X_{t+k}}{\partial e'_t} = \frac{\partial X_{t+k}}{\partial e'_t} \cdot \frac{\partial e'_t}{\partial e'_t} = s_{3,3}(\Theta_t^k)P_t \hspace{1cm} \forall k = 0,1,\ldots \hspace{1cm} (1.10)$$

Unlike in the standard VAR models, (1.10) allows that the response of a variable to a structural shock at any given horizon vary over time. Let $C_t \equiv \sum_{j=0}^{\infty} s_{33} (\Theta_t^j) P_t$. Since $P_t P'_t = R_t$ the long-run restrictions established in (1.7) imply that $C_t$ is lower triangular and thus it represents the Cholesky factor of $\sum_{j=0}^{\infty} s_{33} (\Theta_t^j) R_t \sum_{j=0}^{\infty} (s_{33} (\Theta_t^j))^\top$. Given $C_t$, the structural responses to shocks occurring at period t can be mapped into the following function of time-varying parameters of the reduced-form model (1.1)
\[
\frac{\partial X_{t+k}}{\partial \varepsilon_t} = s_{33}(\Theta_t^j) \sum_{j=0}^\infty (s_{33}(\Theta_t^j))' C_t \quad \forall k = 0,1,\ldots
\] (1.11)

A second tool of innovation analysis allows us to write each of the three variables considered in this study as a time-varying moving average representation (MAR) of three underlying structural disturbances. Letting \(x_{it}\) represent each of the variables we have

\[
x_{it} = \sum_{k=0}^\infty [s_{3,3}(\Theta_t^i)P_t]_{i,AS} \varepsilon_{t-k}^{AS} + \sum_{k=0}^\infty [s_{3,3}(\Theta_t^i)P_t]_{i,PO} \varepsilon_{t-k}^{PO} + \sum_{k=0}^\infty [s_{3,3}(\Theta_t^i)P_t]_{i,MP} \varepsilon_{t-k}^{MP}
\]

for \(i = \{\Delta y_t, \Delta s_t, \Delta \pi_t\}\)

So that the time-varying unconditional variance of \(x_{it}\) is given by the sum of the contributions of each shock to the variance of the variable as follows

\[
\text{var}(x_{it}) = \sum_{k=0}^\infty [s_{3,3}(\Theta_t^i)P_t]^2_{i,AS} + \sum_{k=0}^\infty [s_{3,3}(\Theta_t^i)P_t]^2_{i,PO} + \sum_{k=0}^\infty [s_{3,3}(\Theta_t^i)P_t]^2_{i,MP}
\]

Similarly the time-\(t\) covariance of \(x_{it}\) and \(x_{jt}\) conditional on each shock is given by

\[
\text{cov}(x_{it}, x_{jt}) = \sum_{k=0}^\infty [s_{3,3}(\Theta_t^i)P_t]_{i,AS} [s_{3,3}(\Theta_t^j)P_t]_{j,AS}
\]

\[
+ \sum_{k=0}^\infty [s_{3,3}(\Theta_t^i)P_t]_{i,PO} [s_{3,3}(\Theta_t^j)P_t]_{j,PO}
\]

\[
+ \sum_{k=0}^\infty [s_{3,3}(\Theta_t^i)P_t]_{i,MP} [s_{3,3}(\Theta_t^j)P_t]_{j,MP}
\]

Time-varying unconditional and conditional correlations follow tractably from the expressions above. For example, the unconditional correlation between any two variables \(x_{it}\) and \(x_{jt}\) is related to their conditional (on \(s\) shock) correlations \(\text{corr}_s(x_{it}, x_{jt})\) where \(s = \{AS, PO, MP\}\) according to
\[ \text{corr}(x_{ijt}, x_{ijl}) = \mu_A \text{corr}_A(s_{ijt}, s_{ijl}) + \mu_P \text{corr}_P(s_{ijt}, s_{ijl}) + \mu_M \text{corr}_M(s_{ijt}, s_{ijl}) \]

where \( \mu_s \equiv \left( \frac{\sigma_s(x_{ij})}{\sigma(x_{ij})} \right) \left( \frac{\sigma_s(x_{ijl})}{\sigma(x_{ijl})} \right) \)

and where \( \sigma_s \) denotes the standard deviation conditional on \( s \) shocks. The weight given to each conditional correlation in the above expression is proportional to the average of the shares of the corresponding conditional variances in each variable’s unconditional variance. Thus, this weight will be small so long as the underlying shock accounts for a small fraction of the volatility of at least one of the variables (even if it explains a large portion of the second variable).

The reduced-form model (1.1) is estimated by employing the MCMC algorithms introduced by Cogley and Sargent (2001, 2005) and Primiceri (2004). Implementation of Gibbs sampling consists of four steps: step1 makes use of the Carter and Kohn (1994) algorithm to draw conditional posteriors of the states \( \theta_t \) (or time-varying coefficients of the reduced-form model), steps 2 and 3 use Carter and Kohn as well as Jacquier et.al (1994) to draw conditional posteriors of the hyper-parameters \( \gamma_t \) and \( h_{jt} \) respectively that introduce time variation in the disturbances of the measurement equation. Finally step 4 generates posteriors of the volatilities associated with measurement and state equations. All these posteriors are contingent on the available data and all the remaining hyper-parameters. A detailed outline of the MCMC algorithm is available upon request.
3. Estimation Results

I use U.S. data from the first quarter of 1955 through the fourth quarter of 2009. The data are from the USECON and SPM databases provided by HAVER. Real output \( y_t \) is seasonally adjusted chain-weighted GDP with a 2005 base (HAVER series GDPH). Two measures of the price level \( p_t \) are used (with nearly identical results) either the GDP deflator (2005=100 seasonally adjusted HAVER series JGDP) or the CPI for all urban consumers (HAVER series PCU77). The S&P 500 index (HAVER series PC5COM) deflated by the appropriate price measure serves as the real stock price measure \( s_t \). All variables are in log-levels. Standard tests fail to reject the null of a unit root in each endogenous variable. Evidence reported below is derived from estimation of a TV-SVAR model applied log real GDP, real stock prices and inflation. The assumption that the single source of non-stationarity in real output comes from aggregate supply AS shocks allows us to identify these as the only shocks (typically technology or the price of oil) that exert long-run effects in that variable. This derives from the natural rate hypothesis. Furthermore, long-run neutrality restricts monetary policy MP shocks from having any impact on real stock prices or output in the long term. This allows us to determine that whatever portion in the long-run movement of real stock prices that does not come from AS shocks cannot come from MP shocks and must therefore be an idiosyncratic shock to the stock market itself, the PO shock. Hence, money neutrality and the natural rate hypothesis, two well established theories allow us to identify the underlying structural shocks affecting this economy under minimal restrictions. These restrictions impose no constraint on the constancy of either the autoregressive parameters or the covariance matrix of the TV-VAR. Consequently all inference drawn from the analysis of the second moments of the system allows for time
variation. Thus, in what follows, I report correlation and innovation analysis conditional on
data spanning the 1960s through 2009 for the U.S.

Figure 1 reports the time-varying evolution of the unconditional second moments of the
growths of output and inflation (panel a) and real stock prices (panel b). The volatility of output
sees a twenty percent increase between 1960 and 1980, while the volatility in inflation doubles
over the same period. Consistent with *The Great Moderation*, both variables show a substantial
reduction in variance starting around 1980 which continues well into the mid 1990s. Volatility
in both variables seems to settle to an all-time low (at least in the postwar period) around 1994.
For output, this volatility level remains low for a decade and it is only recently that we see an
increase in volatility. For inflation, however, this moderation period seem much more short-
lived so that by 2002 we get back to the same levels as those of the early-to-mid 1960s and the
estimated volatility continues to increase in the later part of the sample toward the troubling
levels of the 1970s. In contrast to this evidence, panel b of figure 1 shows evidence of no such
*persistent* decrease in the volatility of real stock prices over the same period. It is worth
mentioning that the lowest estimated levels of volatility in this variable also take place around
1994. These volatility patterns, however, show some pro-cyclical behavior (high in the mid-
1970s, low in the mid-1990s with an added decrease between 2002 and 2005), but unlike the
standard deviations of output and inflation, the volatility of real stock prices show substantial
mean-reversion qualities.

The three panels of figure 2 report again the unconditional time-varying standard
deviations of output (panel a), real stock prices (panel b) and inflation (panel c) as well as the
conditional standard deviations contingent on each structural shock. Figure 2(a) shows that the
decrease in volatility of aggregate economic activity can be explained by a decrease, in order of
contribution, of aggregate supply, portfolio, and inflation shocks to the volatility of output. The
standard deviation of output conditional on the AS shocks seems to decrease by roughly 50% over the same time span as the unconditional variance (1980 through 1994). The decrease in output volatility contingent on the PO shock starts a bit earlier around the mid-1970s and again culminating around the mid 1990s. The volatility of output conditional on the MP shock experiences the same decrease in timing and magnitude as all the others but it represents a smaller portion of the estimated unconditional standard deviation. It is worth mentioning that while the relative contributions of supply and portfolio shocks explain a larger portion of the volatility of output, all three shocks seem to track well short-term movements in the unconditional variance. Overall, the contribution of monetary policy seems to explain the overall trends in output volatility while remaining less important in explaining higher frequency movements in short-term output volatility. Figure 2(b) shows that the overall pattern in the time-varying volatility of real stock prices is fairly well explained by the portfolio shock with supply shocks doing a particularly good job of explaining volatility peaks in this variable. Stock price volatility contingent on MP shocks remains much smoother and less important in explaining the unconditional volatility fluctuations of real stock returns. Not surprisingly, this chart suggests that it is stock market demand that drives the overall high frequency movements in equity prices. It is worth noting that AS shocks have done a particularly good job of tracking increases in volatility of stock returns throughout the sample. Finally, this chart is particularly interesting with regard to the MP shock, suggesting that the while monetary policy is shown to have contributed to the high stock market volatility of the mid 1970s/early 80s, it is demand and aggregate supply shocks (and not monetary policy) that seem to drive the subsequent stock volatility spikes of the mid 1980s and mid-to-late 90s. Figure 2(c) shows that the trends in the volatility of inflation are best explained by monetary policy and supply shocks although the portfolio shocks track fairly well. Thus the bulk of the volatility patterns in inflation are
explained by monetary policy; those of stock prices are well explained by the portfolio shocks, and finally, all three shocks seem to exhibit the same behavior in terms of the timing and magnitude of volatility breaks in output, with AS shocks contributing the lion’s share. Overall the AS shocks seems an important contributor to the volatility of all three variables.

Figure 3 shows estimates of the time-varying correlations of the three endogenous variables of interest. The correlation between stock prices and inflation remains slight and it looks to flip from the negative in the earlier part of the sample until about the mid 80s when it seems to switch to the positive region. Similarly, there is a negative relationship between output and stock returns which peaks at around 1980. After that, the negative correlation begins a very gradual but persistent decrease toward zero. The output-stock return correlation looks to be a shifted down version of the stock return-inflation correlation. Finally, the model estimates a negative correlation between output and inflation peaking around -0.5 in 1973 and 1978. Since then, a gradual but unabated decrease of the negative relationship takes place here as well. Since the 1980s, the correlation among these variables seems to have decreased.

The three panels of figure 4 report again the unconditional time-varying correlations of output and stock prices (panel a), output and inflation (panel b) and stock prices and inflation (panel c) as well as the corresponding conditional correlations contingent on each structural shock. Figure 4a shows that the weak negative correlation between output and stock prices is the result of a strong positive correlation conditional on supply shocks counter-balancing the strong negative relationship between these variables contingent on the portfolio shocks. While the Y-SP500 correlation is also positive when conditioning on the monetary policy shock, it does not serve to further shift up the unconditional correlation given the low contribution this shock seems to exert in explaining the variance in both output (see figure 2a) and real stock prices (see figure 2b). Figure 4b shows that the negative correlation between inflation and
output conditional on the supply shock closely tracks the unconditional correlation. This coupled with the prevalent role the supply shock seems to have in explaining fluctuations in output volatility likely accounts for the behavior of the unconditional correlation between the two series. It is interesting to note that when conditioning on the portfolio shock the correlation between output and inflation seems to experience a break in structure to lower levels occurring around the mid 1980s. This highlights the conclusion that the portfolio shock does not track the long-term behavior of the unconditional correlation between these two variables. As figure 4c depicts, there is a very low but stable correlation between stock prices and inflation which seems counterbalanced between the by the supply and monetary shocks. This correlation contingent on the portfolio shock seems to be a mirror image of the earlier correlation with a break to a lower level (from the negative side) since the mid 1980s. The strongly negative correlation conditional on the supply shock likely exerts less influence (relative to the MP shock) on the unconditional correlation given its little influence on stock price volatility (see figure 2c). Taken together figures 2, 3 and 4 imply that while the variances of these variables have changed substantially over time, the correlations among them appear to have remained relatively low trending to even lower levels toward the end of the period.

Next I discuss the evolution of the time-varying impulse response functions of each endogenous variable. These were constructed according to the methodology described in the preceding section. Figure 5 shows the response for output, stock prices and the price level (first, second, and third row respectively) to the equivalent of a normalized one standard deviation impulse in the AS, PO, and MP structural shocks (column-wise). Each response is estimated up to 20 quarters ahead for each year between 1960 and 2009.

Figure 5a shows a positive response of real output to an exogenous supply shock. This is consistent with standard VAR predictions. What is more informative here, relative to those
models, is that the predicted positive response of output to AS shocks is much more muted in the mid-to-late 1990s than in the 1970s and 1980s. While the long-run effect on output from this shock is permanent throughout the sample, the magnitude of the long-term response is much higher in the late 1970s and early 1980s. The long-term effects have gradually and substantially decrease since the mid 1980s bottoming out by the mid 1990s.

Figure 5d shows that the time-varying response of real stock returns to an exogenous AS shock is positive both in the short-run and the long-run. The permanently higher output levels described earlier likely raise real earnings which in turn may serve to increase demand for asset claims which would put upward pressure on their returns. Thus, this result is consistent with the present value equity valuation models of finance.

Figure 5g generally shows a short-run negative response of the price level to the AS shock. The graph suggests that in the 1960s, the negative response is not permanent getting back to zero about two and a half years after the shock. The negative response is substantially larger, and longer lived, in the U.S. high inflation periods of the mid 1970s to early 1980s. Since the mid 1980s, the negative response of the price level to a beneficial supply shocks is less severe finally bottoming out by the mid-to-late 1990s. The long term effect evident in the 1970s and 1980s seems to have all but vanished by the end of the sample considered. The responses to the aggregate supply shock described in figures 5a, 5d and 5g seem consistent with the evidence from standard macro models and theoretical predictions of finance.

The second column in figure 5 shows the time-varying responses of each variable to an exogenous portfolio shock. As interpreted in the previous section, this PO shock represents an exogenous increase in demand for equities. This could be due to an exogenous reduction in transaction costs associated with stock trades (Tobin 1969) or perhaps due to an exogenous decrease of the risk premium as perceived by claimants to financial assets. Not surprisingly, a
PO shock leads to positive and permanent increases in stock returns (see figure 5e). While consistently positive, this response shows substantial fluctuations throughout the sample, undoubtedly a result of the inherent volatility in stock prices. Figure 5h shows a negative short-run response of the price level to the PO shock. This response is many times larger in magnitude in the high inflation period of the late 1970s and early 1980s. The impact of stock demand on inflation has gradually reduced ever since. The price level seems to respond in a very similar fashion to the AS and PO shocks.

Finally, figure 5b shows a drop in real output after an exogenous positive PO shock hits the economy. This is an interesting result as one would think that increases in the demand for stocks would be pro-cyclical. However, this result can still be reconciled with standard theoretical predictions through the following mechanism: an exogenous decrease in the risk premium associated with stocks would be followed by a drop in demand for substitute assets which would undoubtedly lead to a fall in bond prices and an increase in interest rates thereby lowering aggregate demand. This interpretation is consistent with the evident temporary decrease in the price level following the same shock (see figure 5h). This decrease seems to be largely temporary taking place only over the first five quarters and again much more muted in the early-to-mid 1990s.

The third column in figure 5 shows the responses to an exogenous increase in the money supply. The MP shock seems to have a short-run positive impact on real output (see figure 5c). Again the response in much larger in magnitude (and longer lasting) in the high inflation periods of the late 1970s/early 1980s and the response is substantially reduced in the early-to-mid 1990s. According to figure 5f, the money supply shock brings about a short-run increase in real stock prices (though the increase nearly disappears in the mid 1990s). This result is consistent with Lastrapes (1998) and Rapach (2000). A plausible explanation is that news about
expansionary policy would lead investors to anticipate an increase in short-run earnings while the ensuing reduction in interest rates would lower the discount rate for future cash flows. Both of these would serve to increase real stock prices following a monetary expansion. Not surprisingly, figure 5i shows that an expansionary monetary policy is followed by an increase in the short-run levels of inflation. The model predicts that a higher, and again longer lasting, response of the price level to the MP shock takes place in the high inflation periods and then gradually reducing and bottoming out by the mid 1990s. The positive response starts increasing again in the late 1990s and continues through to the end of the sample.

A summary of figure 5 sheds light on a number of interesting relationships. First, the short-run effects of all three shocks AS, PO and MP in this economy seem to have consistently reduced in the 1990s. Second, both AS and PO shocks seem to lead to permanent increases in real stock prices. The magnitude of this positive response, however, fluctuates widely over the sample under study. Third, as expected, an expansionary aggregate supply shock lead to increases (decreases) in real output (inflation). The increase in real output, along with expectations of boosts in real earnings, serves to prop up real stock prices (notice that stock prices respond positively to every shock specified in this model). This result is undoubtedly driven by the correlation patterns described in figure 3 which can be reconciled with Fama’s (1981) PEH only if, in the correlation between real activity in and stock returns, we let inflation be a proxy for the former. Under those conditions, inflation and real activity are negatively related while inflation (as a proxy for real activity) and stock returns are positively correlated. These are the factors used by the PEH to explain the negative correlation between stock returns and inflation as a spurious irregularity. This model, however, finds little evidence of the irregularity and in fact based on an estimated small but stable positive relationship between inflation and stock return, it predicts a positive stock market response to an expansionary
monetary policy which is more consistent with fundamental models of finance. Fourthly, monetary expansions bring about short-run increases in real stock prices, inflation and aggregate economic activity. Finally, each shock seems to exert its largest impact in the late 1970s and early 1980s and a substantially reduced effect, both in the short-run and the long-run, in the early-to-mid 1990s. This is consistent with, and offers an explanation for, The Great Moderation.

Tables 2-4 report the conditional standard deviations of the estimated supply, portfolio and policy components of the growth rates of output, stock prices and inflation respectively. Table 2 shows a decrease in the volatility of output conditional on AS or MP shocks since 1990. Conversely, output volatility conditional on the PO shock seems to have actually increased post-1990. These results do not settle the “good luck” vs. “good policy” debate. To the contrary, they would seem to imply that The Great Moderation (at least) in U.S. output can be explained by a “perfect storm” marked by the reduction of both adverse supply shocks and monetary shocks to economic activity that seems to have characterized the 1990s. While table 1 shows real stock prices experienced no such volatility decrease, table 3 shows a marked decrease in their volatility conditioning on AS or MP shocks. However, stock price volatility conditional on the PO shock is much more muted. Finally, table 4 underscores how the substantial (nearly 50%) reduction in volatility of inflation (as measured by the GDP deflator, see table 1) can be well-explained by a reduction in volatility of every component (52% reduction contingent on AS shocks, 60% contingent on PO shocks and 45% conditional on MP shocks). The information from tables 2-4 complement the story we get from figures 1-3. First, we do not see evidence of a “great moderation” in Stock Prices commensurate with that of output and inflation in the U.S. The model suggests that this must be because demand for equities has continued to remain highly volatile throughout the postwar period. Second, the model estimates that all three
endogenous variables are at their most volatile when conditioned on PO shocks throughout the sample. Third, the moderation in output cannot be well-explained by stock price fluctuations but by a combination of lower volatility in output when subjected to AS or MP shocks. Evidence from these tables does not settle the “good luck” vs. “good management” debate. In fact, the Great Moderation in inflation (and output) seems to have come about from a combination of fewer adverse supply shocks and better policy anchoring since the 1990s. These would seem to have been no help in reducing volatility in stock returns due to large idiosyncratic fluctuations in the demand for equities.

Figures 6-8 show the mean response of each endogenous variable to each of the shocks for the pre and post-1990 period. Each figure has three panels corresponding to the response to each of the three shocks. Each panel shows a cluster of four graphs: the top-left chart shows the mean response of the relevant variable to the relevant shock pre-1990. The top-right shows the post-1990 response. The bottom-left combines both responses in the same graph for comparison purposes and, finally the bottom-right shows the differential response (or the gap) between the post and the pre-1990 periods. Thus a positive response above (below) the axis here would imply a larger (smaller) average response after 1990. These responses reduce the three-dimensional IRFs of figure 5 to more standard two-dimensional responses by averaging the former around the time-axis. Thus the reader is encouraged to insert the term “on average” to every predictive statement drawn from the analysis. It is for brevity only that I omit the term throughout the discussion. Each response has been normalized to one standard deviation shock and 68% and 95% confidence bounds were constructed from a standard bootstrap procedure based on 1,000 replications.

Figure 6 shows that a beneficial supply shock leads to a permanent increase in real output. The positive response, however, has significantly decreased since 1990. Further, an
expansionary monetary shock seems to have a positive impact in economic activity peaking within the first year. This response has also significantly reduced since 1990. Finally, there is also evidence of a significant drop in real output for the first year-and-a-half following an exogenous increase in the demand for equities. This response would seem to be driven by the strong negative correlation between output and stock prices conditioned on portfolio shocks. It is worth mentioning that there has been a statistically significant reduction in the magnitude of the contemporary response of output to the PO shock since 1990. This would serve to imply that unexpected movements in the stock market seem to exert less influence in the more diversified U.S. economy of the 1990s (relative to that of the 1960s, 1970s, and 1980s).

Figure 7 shows that both AS and PO shocks have substantial positive and permanent effects on stock prices. However, according to figure 5, these positive responses showed substantial fluctuations in magnitude throughout the period. This is reflected in the size of the confidence bounds so that when averaged, the magnitude of the responses seem to not have changed (in a statistically significant way) since 1960. An exogenous monetary expansion is associated with a temporary increase in real stock prices. The positive response is largest on impact and remains at this high level over the first two quarters. Before 1990, the impact declines gradually in accordance with money neutrality suggesting that monetary effects on stock returns are not permanent but fairly persistent. Since 1990 this response drops by nearly 50% on impact. This decrease is statistically significant over the first two periods and shorter-lived where the effect dies out in less than half the horizon span.

Figure 8 shows that an exogenous AS shock brings about a negative response in the price level. While in the pre-1990 period, this negative response is fairly persistent, it only last for two periods in the post-1990 period. The magnitude of the effect has also declined since 1990 and this decline is statistically significant for the first year and a half. Similarly, the price level
seems to react negatively to an exogenous increase in the demand for equities. This negative impact, again, has significantly decreased since 1990. Finally and not surprisingly, the price level has a positive and permanent response to an exogenous monetary expansion. Since 1990, the response has reduced on impact, and even more so at longer horizons. The reduction of this effect post 1990 is statistically significant at all horizons.

Figures 9-11 show the mean response of each endogenous variable to each shock for various horizons. Each figure has three panels corresponding to the response to each of the three shocks. For clarity of visualization, a smaller panel of bar charts displaying the same responses, but without confidence bounds, is provided on the right. Each panel shows a cluster of three graphs: the top chart shows the mean response of the relevant variable to the relevant shock for the first two quarters. The middle chart shows the second and third year (quarters 5 through 12) average responses of the relevant variable to the relevant shock. The bottom chart averages the response over the fourth and fifth years post shock. It is worth pointing out that these graphs are derived from the time-ordered IRF for each year where we then average this response over a specified horizon. Therefore, these responses constitute an “independent” point estimate for each year. This yearly point estimate has an implied variance associated with it which was extracted from a standard bootstrap procedure. Thus these graphs allow us to glimpse how the average effects for the short, medium and long term might have changed throughout the sample where each point estimate, and confidence bound associated with it, is discrete in a time sense.

Figure 9 shows the AS and MP shocks having positive effects on output. In the case of the AS shock the effect is permanent while the effect of the MP shock seems fairly persistent and substantially larger in the high inflation periods with a substantial reduction hence. The PO
shock has a negative short-run response that again peaks around the high inflation period and substantially decreases in the 1980s with the lowest response taking place in the mid 1990s.

Figure 10 shows that the AS and PO shocks have positive and permanent effects on stock prices. The responses show considerable time variation likely due to the inherent idiosyncratic volatility in stock returns. An exogenous monetary expansion has a positive effect on stock returns in the short term. The response peaks in the mid 1970s and early 1980s and decreases after that period finally bottoming out in the mid 1990s.

Finally, figure 11 shows the price level response at multiple horizons. The AS and PO shocks have a statistically significant negative short-run response in the U.S. high inflation period. Both responses seem to be permanent and in fact increase at longer horizons. The MP shock has a highly statistically significant permanent positive effect on the price level in every year of the sample. There is evidence congruent with the Great Moderation here where the effect has reduced since the mid-1980s with the lowest impact of monetary shocks on the price level taking place in the mid-1990s. The positive response seems to begin increasing again hence.

As a robustness check, the model was re-estimated with a different price level measure. To address the debatable point that the price level might be an I(1) or I(2) process, I allowed for the price level to enter the TV-VAR in second differences instead (not reported). Qualitatively, the results were largely unchanged. The effect of AS shocks on output and stock prices remained permanent under this specification. This model is also consistent with the permanent response of stock prices to the portfolio shock. All other responses die out more quickly under this alternative model. Finally, we find evidence of super-neutrality under a differenced-inflation specification.
4. Conclusion

Fluctuations in general economic (in addition to idiosyncratic characteristics of individual firms) are a main determinant of stock prices. Relying on theoretically motivated and relatively uncontroversial long-run restrictions, I use recent developments in the estimation of structural vector autoregressions in the presence of stochastic volatility (TV-SVAR) to analyze the effects of shocks in policy, productivity and market demand for equities on the real value of a broad index of US stock prices. In light of the substantial volatility reduction of major macroeconomic aggregates of the mid-1980s, I provide time-varying impulse response functions of a three-variable VAR of real output, real stock prices and the price level to monetary, portfolio and aggregate supply shocks. Each of these shocks seem to have a positive effect—substantial on the part of AS and PO shocks, less so in MP shocks—on real stock prices. While the model estimates a substantial reduction in the volatility of output and inflation since the mid 1980s / early 1990s (consistent with the large literature on the Great Moderation), the volatility in stock returns has continued unabated throughout the postwar period. Results are consistent with the argument that the reduced severity of adverse AS and MP shocks in the 1990s is a likely explanation for the concomitant moderation in economic activity. Further, this paper shows that allowing for time variation in both the drift and covariance matrix of the system yields some insights in the empirical irregularity of a negative relationship between real stock prices and inflation. It is only later in the sample that evidence against Fama’s (1981) PEH (unless some tenuous interpretations are assumed) and in favor of standard predictions in the financial literature (as in the Gordon growth model or the present value equity returns model) is derived. These seem due to this model’s results, that while the correlation between inflation and stock prices is small, it seems to generally change signs since the mid-1980s. Results derived
from figures 2-4 and tables 2-4 imply that the dynamics of the system are mostly driven by heteroskedastic shocks (time-variation in the covariance matrix) rather than drifting coefficients in the VAR. Estimates of the time-varying correlations among these variables imply that the GDP-stock price, GDP-inflation and inflation-stock return correlations have slowly and gradually degraded over time. Estimates seem generally against substantial structural shifts in the time-varying relationship among these variables. What has likely changed, is their relationships relative to their own variances and the sizes of the structural shocks. Importantly, while monetary policy has an important positive effect on stock price fluctuations, it is really aggregate supply and stock market conditions that explain the bulk of the variation in stock returns. Some final features of the model worth highlighting are the apparent importance of AS shocks in driving long-run output and the price level, and they do so in the traditional way. The positive price level response to the MP shock follows economic theory and is consistent with results from standard models as well. The super-neutrality result (not shown) here is not surprising due to the combination of long-run neutrality restriction and differencing the price level twice. Results seem to indicate that productivity, stock market demand and monetary policy are important determinants of low-frequency movements in equity returns, all exerting a positive short-run response. However, the apparent reduction in magnitude of adverse supply shocks that helps explain *The Great Moderation* in output cannot offer an explanation for the lack of moderation in stock prices. While the salient need to solve the “good luck” vs. “good policy” debate seems vital to our understanding of inflation persistence, it also seems woefully inadequate in explaining stock price volatility.
References


Cogley, T; Sargent, T.J. “Evolving post World War II US Inflation Dynamics” NBER Macroeconomics Annual 16 (2001), pp.331-373


### TABLE 1: Relative Standard Deviations

<table>
<thead>
<tr>
<th></th>
<th>Standard Deviation</th>
<th>Relative Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Output</td>
<td>0.0051</td>
<td>0.0026</td>
</tr>
<tr>
<td>2. Stock Prices</td>
<td>0.0326</td>
<td>0.0364</td>
</tr>
<tr>
<td>3. GDP deflator</td>
<td>0.0021</td>
<td>0.0010</td>
</tr>
<tr>
<td>4. PCE deflator</td>
<td>0.0021</td>
<td>0.0017</td>
</tr>
<tr>
<td>5. CPI</td>
<td>0.0026</td>
<td>0.0027</td>
</tr>
<tr>
<td>6. core–CPI</td>
<td>0.0019</td>
<td>0.0007</td>
</tr>
</tbody>
</table>

Notes: Output is expressed in log first differences. S&P500 composite index is deflated by GDP deflator and log differenced. Each price measured was log transformed and differenced twice to serve as a measure of inflation growth.

### TABLE 2: Estimates of Conditional Volatilities for Output

<table>
<thead>
<tr>
<th></th>
<th>Standard Deviation</th>
<th>est. %</th>
<th>Rel. Standard Deviation</th>
<th>est. %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-1990</td>
<td>Post-1990</td>
<td>decrease</td>
<td>Pre-1990</td>
</tr>
<tr>
<td>1. Supply</td>
<td>0.0072</td>
<td>0.0054</td>
<td>25</td>
<td>0.21</td>
</tr>
<tr>
<td>2. Portfolio</td>
<td>0.0352</td>
<td>0.0585</td>
<td>(66)</td>
<td>1.00</td>
</tr>
<tr>
<td>3. Policy</td>
<td>0.0032</td>
<td>0.0011</td>
<td>65</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Notes: The DGP for each endogenous variable takes the MA components in (1.11) as the true coefficients which are contingent on the realizations of the structural shocks for each period.
**TABLE 3: Estimates of Conditional Volatilities for Stock Prices**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Supply</td>
<td>0.0056</td>
<td>0.0027</td>
<td>52</td>
<td>0.08</td>
<td>0.05</td>
<td>28</td>
</tr>
<tr>
<td>2. Portfolio</td>
<td>0.0632</td>
<td>0.0513</td>
<td>19</td>
<td>1.00</td>
<td>1.00</td>
<td>–</td>
</tr>
<tr>
<td>3. Policy</td>
<td>0.0022</td>
<td>0.0006</td>
<td>72</td>
<td>0.03</td>
<td>0.01</td>
<td>67</td>
</tr>
</tbody>
</table>

Notes: The DGP for each endogenous variable takes the MA components in (1.11) as the true coefficients which are contingent on the realizations of the structural shocks for each period.

**TABLE 4: Estimates of Conditional Volatilities for Inflation**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Supply</td>
<td>0.0024</td>
<td>0.0011</td>
<td>52</td>
<td>0.07</td>
<td>0.07</td>
<td>–</td>
</tr>
<tr>
<td>2. Portfolio</td>
<td>0.0348</td>
<td>0.0138</td>
<td>60</td>
<td>1.00</td>
<td>1.00</td>
<td>–</td>
</tr>
<tr>
<td>3. Policy</td>
<td>0.0038</td>
<td>0.0021</td>
<td>45</td>
<td>0.11</td>
<td>0.15</td>
<td>(36)</td>
</tr>
</tbody>
</table>

Notes: The DGP for each endogenous variable takes the MA components in (1.11) as the true coefficients which are contingent on the realizations of the structural shocks for each period.
FIGURE 2

(a) Conditional Standard Deviations for Real GDP: 1960-2009

(b) Conditional Standard Deviations for Real Stock Prices: 1960-2009

(c) Conditional Standard Deviations for Inflation: 1960-2009
FIGURE 3

Time Varying Unconditional Correlations: 1960-2009

Y&S
Y&PI
SS&PI
FIGURE 4

(a) Conditional Correlation for Real GDP & Stock Prices: 1960-2009

(b) Conditional Correlation for Real GDP & Inflation: 1960-2009

(c) Conditional Correlation for Stock Prices & Inflation: 1960-2009
FIGURE 6: Average Output Response

(AS Shock)
FIGURE 7: Average Stock Price Response

(AS Shock)

Pre-1990 Response of variable 2 to shock in variable 1

Post-1990 Response of variable 2 to shock in variable 1

Response of variable 2 to shock in variable 1

(PO Shock)

Pre-1990 Response of variable 2 to shock in variable 1

Post-1990 Response of variable 2 to shock in variable 1

Response of variable 2 to shock in variable 1

(MP Shock)

Pre-1990 Response of variable 2 to shock in variable 3

Post-1990 Response of variable 2 to shock in variable 3

Response of variable 2 to shock in variable 3

Pre-1990 Response of variable 2 to shock in variable 3

Post-1990 Response of variable 2 to shock in variable 3

Response of variable 2 to shock in variable 3
FIGURE 8: Average Price Level Response

(AS Shock)

(PO Shock)

(MP Shock)
FIGURE 9: Output Response (at multiple horizons)

(AS Shock)

(PO Shock)

(MP Shock)
FIGURE 10: Stock Price Response (at multiple horizons)

(AS Shock)

(PO Shock)

(MP Shock)
FIGURE 11: Price Level Response (at multiple horizons)

(AS Shock)

(PO Shock)

(MP Shock)